

The Application of Time Series Models to Examine the Factors that Impact Auction Prices and to Perform Qualitative Squad Analysis for Franchises in the IPL.

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ABSTRACT Ever since the first half of the 18th Century, cricket established itself as a leading sport in London and the south-eastern counties of England. Popularly known as the Gentlemen's game, modern day cricket is the second most followed sport in the world. Due to the fast paced nature of cricket's limited-overs formats, the sport has become increasingly popular among the spectators. Further, it seems plausible that analytical work on cricket shall be attended by researchers interested in quantitative issues due to the data-rich nature of the sport. The Indian Premier League (IPL) which is a franchise based T20 cricket tournament is perhaps the most viewed sports league in India and is the flagship event of the shortest format of cricket. From a franchise's perspective, the auctions that precede an IPL season are just about as important as anything else to the franchise's success in that season. Just as with all other auction settings, the IPL auctions too present numerous opportunities for game theoretic developments and statistical discussions around them. This report progresses chronologically through the steps taken to develop various time series models to study the relationship between auction prices and non-cricketing attributes for players participating in the IPL. Furthermore, a very detailed qualitative squad analysis has been done for some franchise teams leading to a number of valuable insights. The analysis may be used by franchise teams to determine optimal auction strategies at the IPL auctions as well as help them design their squads better leading to better overall team combinations.

I. INTRODUCTION

BASIC RULES OF CRICKET

- Professional cricket is played between two teams. Each team consists of eleven players.
- Cricket matches comprise of at least one innings where each team will take turns in batting and bowling(fielding).
- The fielding team will have a bowler bowl the ball to a batter who tries to hit the ball with their bat.
- The batters try to score as many runs as possible before getting out by
 - Hitting the ball and running between the wickets (22 yards) and making it to the other end before the fielders can hit the wickets with the ball. Each time this is done, you score 1 run.
 - Hitting the ball to the boundary along the ground is 4 runs.
 - Hitting the ball over the boundary on the full equals 6 runs.
- The fielding team tries to get the batsmen out or dismissed as follows

- Catch a batter's shot on the full
- Hit the wickets with the ball when bowling
- Hit the batter's leg in front of the wicket (LBW)
- Hit the stumps before the run is complete

CRICKET FORMATS

The three main formats in cricket are - Test Cricket, One-day International Cricket (ODI) and Twenty20 Cricket (T20). Additionally, in the recent past, new formats such as the T10 have emerged too. However, they are not part of the mainstream yet. A Test match can last up to a maximum of five days. This format, widely considered the most difficult of all formats, allows each team to bat a maximum of two times (known as innings). However, there is no upper bound on the number of overs a team is allowed to bat in an innings in Test cricket. One Day International Cricket and T20 cricket formats are together referred to as limited overs cricket. In both these formats, there is only batting and bowling innings for each team. An innings in limited overs cricket has an upper bound on the number of overs that can be bowled. It is 50 overs for ODI cricket whereas it is 20 overs for T20 cricket.



(6 deliveries make an over). In Test cricket, an innings is completed when either all the ten batsmen are dismissed or the batting team voluntarily “declares” the innings whereas in limited overs cricket, an innings is completed when either all the ten batsmen are dismissed or the limit on the number of overs is reached. A team has to score more aggregate runs than the opposition in order to win a match.

INTERNATIONAL CRICKET

International cricket matches are played between teams representing their nations. These matches are organised by the International Cricket Council (ICC). Most games in international cricket are played as parts of tours, when a national team travels to another nation for a certain period of time and plays a number of matches against the sorts. The tour may or may not include a series for all formats of the game. Furthermore, the ICC also hosts the ICC ODI World Cup and the ICC T20 World Cup which are the biggest events in limited overs international cricket. In addition to tours, nations may organise one-day matches at neutral venues. The ICC World Test Championship final too is played at neutral venues. Currently India, New Zealand, Australia, England, Pakistan, South Africa, Sri Lanka, West Indies, Bangladesh, Zimbabwe are the top ten teams in international cricket.

INDIAN PREMIER LEAGUE

Owing to the fast paced nature and popularity of the T20 format, the Indian Premier League was founded by the Board of Control for Cricket in India (BCCI) in 2007 following the final of the first ever ICC T20 cricket World Cup. Teams were auctioned and ownership rights were won by leading Business tycoons and Bollywood celebrities which ensured pumping in of a lot of money. The IPL, formerly known as the DLF IPL, had been rated the 4th largest sporting property by Forbes in 2009. The IPL had generated revenue of nearly \$ 2 billion dollars in the period from 2008 to 2019, including proceeds from rights (\$ 918 million), promotions (\$ 108 million), and franchises (\$ 724 million). The cash rich Indian T20 league has reached two kinds of agreements with players when it gets them on board. Under the first arrangement — called the “firm agreement”, the IPL commits a certain fee to the player. If a franchisee bids more for that player in the auction between franchisees for different players, the IPL gets to keep the excess. Under the other - the “basic agreement” – the player gets whatever is bid for him. As one might expect, most players opt for the basic agreement.

OBJECTIVES OF STUDY

Now that the background is set, we may delve into the objectives of this study. Firstly, we use time series modelling to study the determinants that affect auction prices for players participating in the IPL. Secondly, we analyse IPL squads using common squad design principles such as the one-for-one or like-for-like replacements. We then motivate the concept of match-ups which have been a backbone of not only fantasy sports but team combinations too in all formats of cricket.

We then examine the extent to which different franchises use match-ups during team selection as well as between overs in an innings. Lastly, we present a template based on our results from time series modelling and squad analysis which can help franchises to revise their auction strategies as well as help them design teams using the principles mentioned above.

II. LITERATURE REVIEW

In this section, we provide a theoretical justification for performing time series modelling to predict the optimum auction prices. Subsequently, we defend our stance on the importance of the squad design paradigms discussed earlier through the use of scholarly articles.

TIME SERIES MODELLING

The problem of predicting optimum player prices for players participating in the IPL has been visited by many quantitative researchers starting from 2008. [6] (Swartz, Tim B) proposed the use of drafts instead of auctions in order to achieve the same. The paper explores the draft procedure in the context of the IPL auction and in various sports including basketball, highland dance, golf, tennis, car racing and distance running and makes an argument that the auctions were less than satisfactory and that future auctions be replaced by a draft where player salaries are determined by draft order. [4] (Karnik, Ajit) produced some of the earliest works in the field. Using the bids made for players in the 2008 edition of the IPL, the author has estimated the hedonic price equations. [5] (Rastogi, Siddhartha K) studies the results of the year 2011 English-style auction of cricketers and recalibrates one of the most accurate models presented by Rastogi and Deodhar (2009). Both the models use ordinary least square method of regression albeit with different variable. [3] (Karnik) examines whether the hedonic price equations estimated in 2008 remained valid in 2011. The author also established that for players who had an IPL record, their performance in IPL matches dominated the importance of their performances in One Day International (ODI) cricket and T20 International cricket. [2] (Denduluri) interestingly is the one of the few authors who had used panel data from 2008 to 2015 in order to estimate the player prices as well as various other important characteristics based on real statistics for both international and domestic players. Most of the previous works in the field before this particular paper had used only cross sectional data for a given year. [1] (Bhattacharya, Sonali and Bhattacharya, Shubhaseesh) have instead used time series modelling coupled with their understanding of the game to develop ten different price equations for all teams that had played in the 2011 edition of the IPL.

In our time series analysis, we have analysed all the scholarly articles that have discussed English style IPL auctions and designed models with the variables or determinants that most authors have established as the important ones. Among the many variables that are typically used by researchers to predict auction prices, probably the simplest ones are

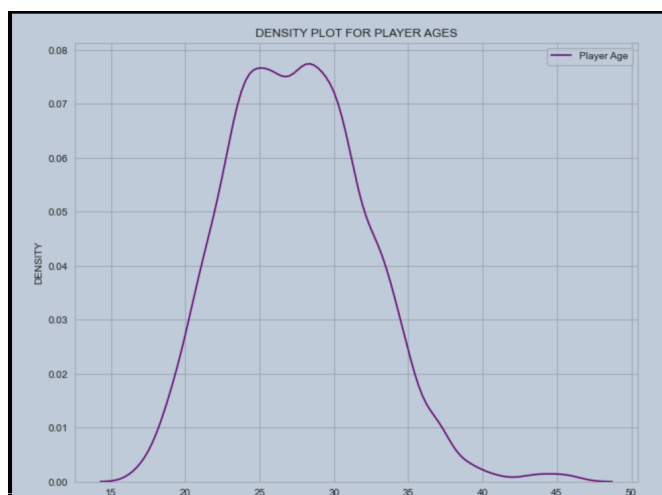


FIGURE 1: Density Plot for Player Ages

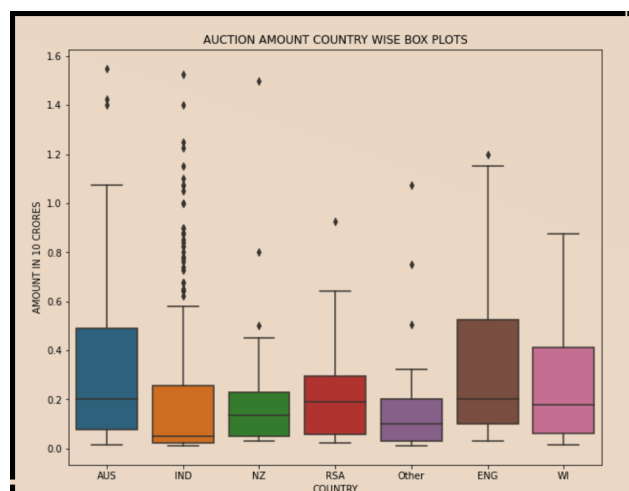


FIGURE 2: Price v/s Country Box Plots

age, nationality and capped status (for Indian players). We establish the importance of these variables as follows:

AGE

Age of an athlete is one of the most important variables in the context of sport in general. In the context of cricket, as an example, for a fast bowler, with increasing age, we expect his pace to reduce drastically due to an increased risk of injuries as the body gets older as well as injuries that may have plagued his bowling career sometime in the past. For a batsman, an increase in age may translate into slow running between the wickets as well as a decrease in his power-hitting prowess. Furthermore, the IPL is a pretty long tournament. Hence, it is plausible to assume that senior players may find it more difficult to manage travel and their fitness regimes as compared to younger players having the same fitness level.

NATIONALITY

IPL team managements generally need to perform extensive data analysis in order to determine the right set of overseas players for their franchise going into an IPL season. Such analysis is easily possible for players competing in some of the well developed contemporary T20 leagues in the world. Examples of such leagues include the Big Bash League, the Caribbean Premier League and so on. Furthermore, countries such as Australia, South-Africa, England, New Zealand and West Indies have the reputation of producing the most talented cricketers in the world owing to the quality of their domestic tournaments and the stability of their cricket board in managing international players. Hence, nationality of a player is perhaps one of the most important factors when it comes to buying overseas players at the IPL auctions.

CAPPED STATUS - INDIAN PLAYERS

Team managements are convinced about the skill level and game changing ability of Indian players that have received

an international call and might even want to consider some of these players as long term options. As far as IPL auctions are concerned, capped Indian players are auctioned in an altogether different session. Hence, one can intuitively reason that there is indeed some inherent difference between the two categories of players. Furthermore, there are plenty of examples to justify this claim. Some of the famous ones in the recent past include names such as Rishabh Pant, Manish Pandey and Ishan Kishan to list a few.

SQUAD ANALYSIS

One can discern buying patterns of the teams at the IPL auctions via qualitative squad analysis. Squad analysis is very important especially in the IPL context for the following set of reasons. The IPL is a two month long tournament. Hence, team managements need to be absolutely sure about the availability of players, especially overseas players. Team managements also expect certain first choice players to get injured or struggle to find their form. In that case, they need to have the correct set of players as reserves or replacements. Furthermore, analysts can use squad analysis to identify teams with similar auction strategies and team combinations. They can examine the team combinations for successful franchises and use backtracking in order to relate that to their performance at the IPL auctions for that year. Secondly, they can also study the design of the squads of two successful teams in two different years. Using analysis for different years, analysts can figure out common squad building principles that teams generally follow which improves their chances of succeeding in the tournament. The results obtained can be used by other franchise teams in order to refactor their existing buying template and team selections. Some of the most important factors in the design of squads for a high pressure tournament such as the IPL are as follows:



ONE-FOR-ONE REPLACEMENTS

To understand this principle, one needs to understand tightly coupled team designs. A tightly coupled design is one in which considerable amount of effort is needed to stick to a certain style of playing. It means that it is difficult for a team to play a certain combination if certain first choice players need to be replaced. The team will have no choice but to devise an altogether new plan in order to account for the replacements. As an example, consider the DLF IPL 2012 final. KKR went into the finals after beating Delhi in Qualifier 1. Lakshmipathy Balaji was the man of the match in that match. As a result of a hamstring injury, he had to be replaced for the final. KKR had no choice but to play Brett Lee as the replacement in order to strengthen the bowling. Now playing Brett Lee meant that they had to drop another overseas player from their ranks owing to the constraint of being able to play only 4 overseas players in any game. This meant that they had to drop Brendon McCullum and replace him with Manvinder Bisla who did not have the experience of playing high pressure matches. In fact Gautam Gambhir and Brendon McCullum were among the most successful batting pairs in the 2012 season. Imagine if KKR had an Indian bowler with probably the same bowling profile as Lakshmipathy Balaji. In that case, they could have easily brought in that player for the injured Balaji without affecting the rest of their successful setup. This is a classic example of a one-for-one replacement. In an ideal scenario, if a squad has one player in the reserves for every player in the playing eleven, they can easily handle replacements in the events such as injury, non-availability or lack of form without having to alter their winning combination. This is one concept that is explored in detail in this study.

MATCH-UPS

Match-ups are basically analysis of how effective a batter or bowler is against a specific type of opponent in each phase of the game. Examples of some of the most famous match-ups that have developed in the IPL are Virat Kohli vs Jasprit Bumrah, Varun Chakravarthy vs MS Dhoni and so on. Match-ups are an integral aspect in selecting the playing eleven for every game for a number of teams in the IPL. According to cricket experts on Cricbuzz, except for CSK, almost all decisions by teams and captains in the IPL are based on the respective match-ups. As we show later in our study, there are three kinds of match-ups. These are the Type v/s Type, Player v/s Type and Player v/s Player. They are also an integral part of a number of fantasy sports and fan engagement activities. Hence, it is very important to understand match-ups and their impact in the context of overall squad design and team selection of franchise teams.

III. PROBLEM STATEMENT

The problem at hand is best explained chronologically.

- Develop time series algorithms to study the effect of non-cricketing attributes that affect the auction price of a player.

- Analyse IPL squads across multiple seasons to discern common squad design patterns such as the one-for-one replacement pattern and study the effect of match-ups on team selections.

IV. IMPLEMENTATION - TIME SERIES MODELLING DATA

In order to conduct our analysis effectively, it is very important that our data should be appropriate. Data from the 2008 season is pretty unreliable as all the squads back then were built based on past international performances for players. Moreover, for purchasing domestic players, teams had to satisfy the local catchment area restriction policy which made it customary for them to have four local players in the team. As an example, Delhi had to buy Rajat Bhatia, Pradeep Sangwan, Shikhar Dhawan and Mithun Manhas before they could buy other Indian players such as Dinesh Karthik. Data from 2009 and 2010 is not reliable too as there were about only 10-15 inter team swap deals in that season. Further, we had to discard data for the 2011 season for the fact that there were 2 new franchises that season, one of which played only in that season. Hence, we downloaded auction data for all IPL editions from 2013 to 2022. The data has information about the player name, role and auction amount as columns. Further, the advantage of using pooled data is that we could capture multiple distributions for the independent and the dependent variables.

CORE IDEAS

It is really important to note that the data is heavily skewed. It contains information about 398 bids on Indian players, 95 bids on Australian players, 40 players from New Zealand, 30 from South Africa, 49 from England, 42 from West Indies and 25 from all other countries. On application of T test for the difference of means between two groups, the p-value results are as follows.

- Group 1 - Batsmen v/s Bowlers
- Group 2 - India v/s Overseas

Group	P-Value
Group 1	0.3994
Group 2	≈ 0

Hence, there is no significant difference in the average pay-scale of a batsman compared to that of a bowler. However, our plots reveal that the average auction price of an Indian player is much less than that of any overseas player. Hence, we deal with both these categories of players differently. These ideas are explored further when we apply different econometric time series models.

IMPUTING AND ENCODING

The data-set was imputed with the ages for all players from 2013 to 2022. Age as we see it is perhaps one of the most important determinants of auction price. Teams do not want to invest as aggressively on players that are probably about

to retire from international cricket or have retired from international cricket. Further, the nationalities of all players were imputed in the data-set as well. After this, the data-set was divided into two parts. The first of these data-sets represented the auction data for all Indian players. The second data-set consisted of the data for overseas players. On the second data-set, label encoding was performed on the nationalities of the players. In an ideal world, player nationalities do not represent any sort of natural ordering and hence should be one-hot-encoded. However, largely speaking, to an average Indian, an Australian player should most likely be better than a player from say Zimbabwe. The example taken is slightly contrived but serves the purpose well.

MODELS - PART ONE

In this section, we apply the ordinary least squares model (OLS) to examine the variability in the dependent variable that is explained by the dependent variables.

ORDINARY LEAST SQUARES

We select 2013 as our base year. Hence, we create year dummies for all other years except the base year from 2014 all the way up to 2022. Year dummies help us model the situation appropriately. Further, the sign and magnitude of the coefficients attached to the year dummy variables included in our model help us determine whether those variables are significant or not.

For Indian players, as we can see from the results obtained on performing regression, a player's age is significant at 95% confidence interval. One of the reasons why this might be the case is that teams can buy young talented players at a cheaper price. At the same time, not all teams would bid for most players who are above say 33 years of age. Such players would have specific roles to play in their teams. Also, one needs to consider the fact that the number of Indian players auctioned is way more than all overseas players combined. Most of the Indian players auctioned will most likely not have received an international call. Hence, we can reason why age is an important variable when we consider the average auction bids for Indian players.

For overseas players, one can observe that as expected, a player's nationality is significant. This was discussed while setting up the problem. Also, quite interestingly, the year dummy y21 is significant as well. The auctions for the year 2021 were preceded by the first wave of the pandemic. In 2020, franchises had faced a lot of problems in getting the players on-board due to travel restrictions and availability issues when the IPL had moved to the UAE in October. This event may have changed the overall perception of teams going into the 2021 auctions. Furthermore, teams may have had a way of figuring out which players would be available for the entire tournament and would be willing to stay in the bio bubble. This may have contributed to teams bidding more aggressively for players who were definitely going to fulfil the above requirements.

```
. import delimited C:\Users\hp\Downloads\Indian.csv, clear
(18 vars, 398 obs)

. reg amount playerage y14 y15 y16 y17 y18 y19 y20 y21 y22
```

Source	SS	df	MS	Number of obs	=	398
Model	2.9248e+16	10	2.9248e+15	F(10, 387)	=	4.68
Residual	2.4186e+17	387	6.2496e+14	Prob > F	=	0.0000
Total	2.7111e+17	397	6.8289e+14	R-squared	=	0.1079
				Adj R-squared	=	0.0848
				Root MSE	=	2.5e+07

amount	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]
playerage	874540.8	271276.4	3.22	0.001	341180.7 1407901
y14	-2.41e+07	1.79e+07	-1.34	0.180	-5.93e+07 1.12e+07
y15	-2.57e+07	1.85e+07	-1.39	0.166	-6.22e+07 1.07e+07
y16	-2.56e+07	1.81e+07	-1.41	0.158	-6.11e+07 9969649
y17	-3.23e+07	1.82e+07	-1.77	0.077	-6.82e+07 3546681
y18	-1.64e+07	1.79e+07	-0.92	0.359	-5.16e+07 1.88e+07
y19	-2.48e+07	1.84e+07	-1.35	0.179	-6.10e+07 1.14e+07
y20	-2.78e+07	1.85e+07	-1.50	0.134	-6.42e+07 8587211
y21	-3.10e+07	1.84e+07	-1.68	0.093	-6.73e+07 5247740
y22	-1.15e+07	1.79e+07	-0.64	0.522	-4.67e+07 2.37e+07
_cons	1.61e+07	1.90e+07	0.85	0.396	-2.12e+07 5.35e+07

FIGURE 3: OLS - Indian Players

```
. reg amount playerage country y14 y15 y16 y17 y18 y19 y20 y21 y22
```

Source	SS	df	MS	Number of obs	=	281
Model	2.7066e+16	11	2.4605e+15	F(11, 269)	=	3.14
Residual	2.1049e+17	269	7.8248e+14	Prob > F	=	0.0005
Total	2.3755e+17	280	8.4840e+14	R-squared	=	0.1139
				Adj R-squared	=	0.0777
				Root MSE	=	2.8e+07

amount	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]
playerage	16479.4	404942.6	0.04	0.968	-780780.5 813739.3
country	5690534	2016333	2.82	0.005	1720733 9660334
y14	-3545382	8290107	-0.43	0.669	-1.99e+07 1.28e+07
y15	-1.16e+07	9317463	-1.25	0.213	-3.00e+07 6719338
y16	-8713194	8921799	-0.98	0.330	-2.63e+07 8852240
y17	-4948959	9126961	-0.54	0.588	-2.29e+07 1.30e+07
y18	3949728	8299356	0.48	0.635	-1.24e+07 2.03e+07
y19	-5576252	9618600	-0.58	0.563	-2.45e+07 1.34e+07
y20	8830363	8987048	0.98	0.327	-8863534 2.65e+07
y21	2.24e+07	9792136	2.29	0.023	3124021 4.17e+07
y22	8312820	8074501	1.03	0.304	-7584435 2.42e+07
_cons	1790058	1.43e+07	0.13	0.900	-2.63e+07 2.99e+07

FIGURE 4: OLS - Overseas Players

MODELS - PART TWO

In the previous section, with the use of the OLS model, we established that except for the year 2021, no year from 2014 to 2022 was significantly different from the base year in terms of the IPL auctions. Hence, we need not account for time specific effects in our econometric analysis and should only consider individual specific one way error component models where the only unobserved effects vary across individuals and do not vary with time.

Mathematically, we want to model the equation,

$$y_{it} = \beta_0 + \beta_1 x_{it1} + \dots + \beta_k x_{itk} + a_i + \mu_{it} - (1)$$

In the above equation, a_i represents the individual specific time constant unobserved effect.

FIXED EFFECT MODEL

A natural way of dealing with the situation presented by equation (1) would be to use the first difference model and model the situation as follows:

$$\Delta y_i = \beta_0 + \beta_1 \Delta x_i + \mu_i - (2)$$



Where we take the difference between two time periods in order to get rid of individual specific unobserved effects. But this model suffers from certain limitations. Some of which are as follows:

- There should be enough variation in Δx across several cross sections.
- There should not be any time constant explanatory variable in our model.
- There should not be any lag dependent variable in our model

The 3rd point in the limitations is of particular interest to our problem. Because, quite intuitively, we expect that a player's auction price in a certain season should necessarily be a function of the impact that his past performances have created on the IPL franchises. Hence, based on our expectation, we model the situation using fixed/within effects transformation. We model the situation as follows:

$$y_{it} - \bar{y}_i = \beta_1(x_{it} - \bar{x}_i) + (\mu_{it} - \bar{\mu}_i) - (3)$$

Where $\bar{y}_i = \frac{1}{T} \sum_{t=1}^T y_{it}$ and $\bar{x}_i = \frac{1}{T} \sum_{t=1}^T x_{it}$.

Modelling equation (3) using fixed effects model yields the following results.

Nationality	F-stat	p-Value
Indian	1.23	0.0755
Overseas	1.89	0.0001

Our fixed effect model or within effect transformation model performs an F-test against the null hypothesis that all a_i are 0. In essence, there is no significant individual specific unobserved effect. Thus, from the data in the table above, based on the F-test statistic values, for a 90% confidence interval, the unobserved effects for Indian players are significant. For overseas players, the unobserved effects are significant even when we consider a 99% confidence interval. Here, our implicit assumption is that all the a_i are correlated with the x_{it} .

That is, for the validity of a fixed effects model, we should have,

$$Cov(a_i, x_{it}) \neq 0$$

JUSTIFICATIONS - Consider the example of Yuvraj Singh. He was bought by the Royal Challengers Banagalore in 2014 for 14 Cr. and by Delhi Daredevils for 16 Cr. in 2015 at a time when his chances of making an international comeback were pretty slim. Thus, intuitively, one can argue that Yuvraj Singh has a perceived stardom or hot streak which impacts franchises to think highly of him despite his string of bad performances. Similarly, consider the example of English captain Eoin Morgan. Morgan's performance was terrible with the bat in the entirety of IPL 2021. However, under his captaincy, KKR managed to reach the finals of the tournament. Hence, one can argue that a captain's worth cannot be judged based on his batting/bowling numbers alone. Attributes such as captaincy and being a team man have their

```
. xtreg amount playerage,fe
Fixed-effects (within) regression      Number of obs   =      397
Group variable: fcode                 Number of groups =      203

R-sq:                                Obs per group:
    within = 0.0587                    min       =        1
    between = 0.0332                    avg       =       2.0
    overall  = 0.0364                    max       =        9

corr(u_i, Xb)  = -0.2688                F(1,193)        =      12.04
                                           Prob > F         =     0.0006
```

amount	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]
playerage	2187774	630422.2	3.47	0.001	944372 3431175
_cons	-4.03e+07	1.69e+07	-2.39	0.018	-7.36e+07 -7027237
sigma_u	19694003				
sigma_e	24300075				
rho	.39643766				(fraction of variance due to u_i)

```
F test that all u_i=0: F(202, 193) = 1.23                Prob > F = 0.0755
```

FIGURE 5: FE - Indian Players

```
. xtreg amount playerage country,fe
note: country omitted because of collinearity
Fixed-effects (within) regression      Number of obs   =      281
Group variable: fcode                 Number of groups =     151

R-sq:                                Obs per group:
    within = 0.0716                    min       =        1
    between = 0.0000                    avg       =       1.9
    overall  = 0.0042                    max       =        7

corr(u_i, Xb)  = -0.3478                F(1,129)        =       9.95
                                           Prob > F         =     0.0020
```

amount	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]
playerage	2532412	802699.7	3.15	0.002	944250.8 4120573
country	0 (omitted)				
_cons	-4.53e+07	2.31e+07	-1.96	0.052	-9.10e+07 448163.2
sigma_u	27834485				
sigma_e	23968445				
rho	.57421641				(fraction of variance due to u_i)

```
F test that all u_i=0: F(150, 129) = 1.89                Prob > F = 0.0001
```

FIGURE 6: FE - Overseas Players

own intrinsic value. Consider the example of Parthiv Patel. Patel managed to score 450+ runs in IPL 2019. Despite his performances, he was overlooked for selection as the first choice keeper next year. From a statistics point of view, even when certain domestic players perform really well, they are still not talked about as much. A valid reason for that could be that they perhaps lack the X-factor or the game and temperament which is required to produce match winning performances.

LEAST SQUARES DUMMY VARIABLES MODEL

Based on our F-test results obtained from fixed effects regression, we conclude that not all a_i are 0. For Indian players, we rejected the null hypothesis for a 90% confidence interval, whereas for overseas players, we rejected the null hypothesis for a 99% confidence interval. We explore this idea further by performing least squares dummy variables regression. Here, the only difference is that we include $n - 1$ dummy variables to represent the various cross sections in our data where n is the total number of observations available to us.

Thus, we have,

```
. xtset fcode year
      panel variable: fcode (unbalanced)
      time variable: year, 2013 to 2022, but with gaps
      delta: 1 unit

. regress amount playerage i.fcode
```

Source	SS	df	MS	Number of obs	
Model	1.5628e+17	203	7.6985e+14	F(203, 193)	= 1.30
Residual	1.1397e+17	193	5.9049e+14	Prob > F	= 0.0316
				R-squared	= 0.5783
				Adj R-squared	= 0.1347
				Root MSE	= 2.4e+07
Total	2.7025e+17	396	6.8244e+14		

FIGURE 7: LSDV - Indian Players

```
. xtset fcode year
      panel variable: fcode (unbalanced)
      time variable: year, 2013 to 2022, but with gaps
      delta: 1 unit

. regress amount playerage country i.fcode
note: 150.fcode omitted because of collinearity
```

Source	SS	df	MS	Number of obs	
Model	1.6344e+17	151	1.0824e+15	F(151, 129)	= 1.88
Residual	7.4109e+16	129	5.7449e+14	Prob > F	= 0.0001
				R-squared	= 0.6880
				Adj R-squared	= 0.3229
				Root MSE	= 2.4e+07
Total	2.3755e+17	280	8.4840e+14		

FIGURE 8: LSDV - Overseas Players

Nationality	R-sq.	Adjusted R-sq
Indian	0.5783	0.1347
Overseas	0.6880	0.3229

The set of Indian players for which the regression coefficients obtained are significant is as follows:

Player	p-value
Ishan Kishan	0.018
Prasidh Krishna	0.016
Shreyas Iyer	0.046
Washington Sundar	0.027

The set of Overseas players for which the regression coefficients obtained are significant is as follows:

Player	p-value
Ben Laughlin	0.016
Brad Hogg	0.021
Glenn Maxwell	0.000
Jhye Richardson	0.004
Jofra Archer	0.006
Kyle Jamieson	0.0001
Pat Cummins	0.0001
Sam Curran	0.012
Shimron Hetmyer	0.041
Tim David	0.035
Tymal Mills	0.037
Wanindu Hasaranga	0.045

The results for Indian as well as overseas players are in agreement with one's intuitive understanding of the sport and IPL auctions.

```
. xtreg amount playerage, re theta
```

Random-effects GLS regression

Group variable: fcode

Number of obs = 397

Number of groups = 203

R-sq:

within = 0.0587

between = 0.0332

overall = 0.0364

Obs per group:

min = 1

avg = 2.0

max = 9

corr(u_i, X) = 0 (assumed)

Wald chi2(1) = 14.91

Prob > chi2 = 0.0001

	min	5%	theta	median	95%	max
amount	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
playerage						
_cons						
sigma_u						
sigma_e						
rho						

	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]
playerage	1053252	272744	3.86	0.000	518683.6 1587820
_cons	-1.00e+07	7396826	-1.35	0.175	-2.45e+07 4475591
sigma_u	0				
sigma_e	24300075				
rho	0				(fraction of variance due to u_i)

FIGURE 9: RE- Indian Players

RANDOM EFFECTS MODEL

Consider the fundamental model equation,

$$y_{it} = \beta_0 + \beta_1 x_{it1} + \dots + \beta_k x_{itk} + a_i + \mu_{it}$$

We can decompose the term a_i as $a_i = \gamma_0 + \epsilon_i$. Here γ_0 represents the average or common unobserved effect measures across all individuals and the term ϵ_i represents a random deviation from γ_0 . Hence, we can refactor the equation as,

$$y_{it} = \rho_0 + \beta_1 x_{it1} + \dots + \beta_k x_{itk} + \epsilon_i + \mu_{it}$$

. Suppose we hypothesize that $Cov(\epsilon_i, x_{it}) = 0$. In essence, we hypothesize that the unobserved effects have no correlation with the individual attributes. Thus, we might want to apply the pooled OLS model in this case. However, the composite error term for the refactored equation is given as $\nu_{it} = \epsilon_i + \mu_{it}$. We cannot apply the pooled OLS because the term ϵ_i will appear in the error term for all time periods which will make the error terms serially correlated leading to auto-correlation. Hence, we transform our refactored equation as follows,

$$y_{it} - \lambda \bar{y}_i = (1 - \lambda) \rho_0 + \beta_1 (x_{it} - \lambda \bar{x}_i) + (\nu_{it} - \lambda \bar{\nu}_i) \quad (4)$$

The model represented by the equation (4) is referred to as the quasi-time demeaning model or the random effects model. Here λ represents a compromise between the fixed effects model and the pooled OLS model. If $\lambda = 1$, equation (4) will represent the fixed effects model. On the other hand, if $\lambda = 0$, the equation will represent the pooled OLS model. Tabulating the R-squared values and the value of the hyper-parameter λ obtained on performing regression using random effects model,

Nationality	R-sq.	Lambda
Indian	0.0587	0.032
Overseas	0.0716	0.1615

FINAL MODEL

In order to choose between the fixed effects model and the random effects model, we perform a statistical test known as the Hausman test which evaluates the difference between the common coefficients obtained for the variables in the models



Random-effects GLS regression		Number of obs	=	281	
Group variable: fcode		Number of groups	=	151	
R-sq:		Obs per group:			
within	= 0.0716	min	=	1	
between	= 0.0167	avg	=	1.9	
overall	= 0.0257	max	=	7	
corr(u_i, X) = 0 (assumed)		Wald chi2(2)	=	6.48	
		Prob > chi2	=	0.0392	
<hr/>					
min	5%	theta	median	95%	max
0.1615	0.1615	0.1615	0.3902	0.4973	
<hr/>					
amount	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]
playerage	577821.2	423520.1	1.36	0.172	-252262.9 1407905
country	4438452	2319000	1.91	0.056	-106704.7 8983609
_cons	-8823300	1.44e+07	-0.61	0.540	-3.70e+07 1.94e+07
<hr/>					
sigma_u	15577720				
sigma_e	23968445				
rho	.2969649	(fraction of variance due to u_i)			

FIGURE 10: RE - Overseas Players

and tests the null hypothesis $H_0 : Cov(a_i, x_{it}) = 0$. The distribution is a chi-squared distribution with the number of time-varying variables as the degrees of freedom. The test yields the following results,

Nationality	Test stat.	p-value
Indian	3.98	0.0459
Overseas	8.22	0.0042

Thus, if we consider a 95% confidence interval, we reject both the null hypothesis and conclude that the unobserved effects are correlated with the player attributes. Thus, the Least Squares Dummy Variables Model is our final model.

V. IMPLEMENTATION - SQUAD ANALYSIS

Before performing our squad analysis, it is important to consider the set of constraints that a team is potentially faced with before buying a certain player. Teams typically look to address some of the following key questions in this regard.

PLAYER CATEGORY - UNCAPPED INDIAN PLAYERS

Teams typically like to bucket uncapped Indian players into one of the two categories - Green and seasoned campaigner. A Green is typically a player with not much game time in the IPL and has often been used as a utility player even when included. Such players are expected to bowl an economical spell as bowlers, to probably just hang in a partnership or to score at a considerably good scoring rate when asked to bat down the order. Good examples of such players are Gurkeerat Singh, Shreevats Goswami, Laxmi Ratan Shukla and so on. A seasoned campaigner is a player who has a wealth of experience of delivering in crunch moments and is even expected to win the team some matches on his best days. Examples include the likes of Rahul Tripathi, Suryakumar Yadav (until he was capped) and so on. Teams typically have to work a lot in order to find the right balance when it comes to the uncapped Indian players.

EXPERIENCE FOR OVERSEAS T20 PLAYERS

While it is easy to gauge the performances of recognized capped overseas players, the case is somewhat tricky when

. hausman fixed random				
	Coefficients			
	(b)	(B)	(b-B)	sqrt(diag(V_b-V_B))
	fixed	random	Difference	S.E.
playerage	2187774	1053252	1134522	568368.6
b = consistent under Ho and Ha; obtained from xtreg				
B = inconsistent under Ha, efficient under Ho; obtained from xtreg				
Test: Ho: difference in coefficients not systematic				
chi2(1) = (b-B)'[(V_b-V_B)^(-1)](b-B)				
= 3.98				
Prob>chi2 = 0.0459				

FIGURE 11: Hausman Test - Indian Players

. hausman fixed random				
	Coefficients			
	(b)	(B)	(b-B)	sqrt(diag(V_b-V_B))
	fixed	random	Difference	S.E.
playerage	2532412	577821.2	1954591	681877.9
b = consistent under Ho and Ha; obtained from xtreg				
B = inconsistent under Ha, efficient under Ho; obtained from xtreg				
Test: Ho: difference in coefficients not systematic				
chi2(1) = (b-B)'[(V_b-V_B)^(-1)](b-B)				
= 8.22				
Prob>chi2 = 0.0042				

FIGURE 12: Hausman Test - Overseas Players

it comes to the not so popular or uncapped overseas players. Hence, franchises need for such players to play in a number of competitive T20 leagues around the world. This is important for franchises to not only conduct the necessary video analysis but also to gain confidence that the player is indeed mentally ready for a tournament as challenging as the IPL. Examples include the buying of players such Sherfane Rutherford, Keemo Paul, Rashid Khan, Tim David and so on.

CRICKET PLAYED IN THE LAST SEASON

From the perspective of an IPL team, this is perhaps one of the most important points to consider while wanting to sign retired international players or players who have not been part of the national team for a while. The amount of cricket played in the entire domestic season convinces a franchise of the player's form as well as fitness levels. Players who do not actively play cricket find it difficult to find their rhythm in the IPL right off the bat. As an example, CSK did not sign Suresh Raina for the 2022 season due to a lack of actual game time in the preceding season and dropping fitness levels.

SERVICES OFFERED BY PLAYER

This is particularly important for players that are in the 34-40 age group. These players may need to provide additional services with time in order to increase their chances of getting picked as they do not have age on their side. For example, Ambati Rayudu offered to play as a wicket keeper batsman in 2022. This is in contrast to the previous seasons in which he played as a specialist batsman.



PAST WORKING EXPERIENCE WITH PLAYER

This is best understood with the help of an example. Consider the buying strategy of Lucknow Supergiants (LSG). They have Gautam Gambhir and Vijay Dahiya in the top management. As soon as Manish Pandey was auctioned, LSG immediately bid for him. One good reason for this bid could be the fact that Manish Pandey had previously played in KKR under the captaincy of Gautam Gambhir. At that time, Vijay Dahiya was the assistant coach. Hence, it is plausible to reason that both Gambhir and Dahiya were fully aware of Pandey's strength and weaknesses and knew exactly what to expect from him. Furthermore, the fact that they had a previous working relationship would make matters easier for all three of them.

WILLINGNESS TO PLAY FOR A CERTAIN FRANCHISE

This is perhaps one of the most important considerations for any franchise. Certain players may not want to play with certain managerial groups and immediately inform the franchise not to retain them or bid for them. As an example, KL Rahul informed Punjab Kings that he did not want to continue playing for them. Similarly, Shreyas Iyer had asked Delhi Capitals not to retain him or bid for him as he had not been offered captaincy by the Delhi franchise for the 2022 season. Hence, teams need to be aware of these scenarios and prepare for them well in advance going into an auction.

ONE-FOR-ONE REPLACEMENT DESIGN ANALYSIS

We conduct our analysis as follows. Firstly, we analyse two successful teams in two different editions of the IPL in order to establish that this paradigm is indeed popular and will most likely be considered by franchises to make their teams in future as well. Secondly we examine two IPL franchises from the period 2019-2021 and demonstrate how the lack of flexibility or tight coupling can cause a lot of problems with team selection especially in the most important stages of the tournament.

PART ONE

For the purpose of analysis, we consider the Rajasthan Royals (RR) squad of 2022 and Mumbai Indians (MI) squad of 2020.

RAJASTHAN ROYALS (2022)

The one-for-one replacements that RR have this season are listed below:

- 1) Yashasvi Jaiswal → Karun Nair. Both these batsmen can open the innings and have the shots to accelerate when required.
- 2) Trent Boult → Obed McCoy. Both these bowlers are overseas bowlers. While Trent Boult gets the ball to swing both ways, McCoy's change of pace is often really deceptive. In fact because both are left arm bowlers, McCoy enjoys the same advantage against right handed batsmen as Boult does.

- 3) James Neesham → Nathan Coulter-Nile. Both are overseas cricketers. While Neesham is more of a batting all-rounder, Coulter-Nile is a pretty handy bowling all-rounder.
- 4) Shimron Hetmyer → Rassie van der Dussen. Overseas middle-order batsmen. Both have the game to play the difficult middle overs as well as shots to finish a game well.
- 5) Prasidh Krishna → Navdeep Saini. Indian fast-bowlers of almost the same profile. Both are genuinely fast and offer a similar set of services.

MUMBAI INDIANS (2020)

The one-for-one replacements that MI had in the 2020 season are as follows:

- 1) Ishan Kishan → Saurabh Tiwary. Both are left handed top order batsmen with a similar range of shots.
- 2) Nathan Coulter-Nile → James Pattinson. As a right arm as fast bowler, Nathan Coulter-Nile could easily replace James Pattinson. This is one replacement which MI used often.
- 3) Mitchell McClenaghan → Trent Boult. Both these bowlers are left arm bowlers and get the ball to move both ways.
- 4) Chris Lynn → Quinton de Kock. Considering the fact that Ishan Kishan can keep wickets well, Chris Lynn could replace Quinton de Kock if the latter was to play as a pure batter.
- 5) Jayant Yadav → Rahul Chahar. Rahul Chahar was used against teams with more right handed batsmen whereas Jayant Yadav was used against teams having a strong left handed batting line-up.

Thus, quite evidently, the one-for-one replacement design paradigm gave the teams multiple options to go with without having to change their winning combinations.

PART TWO

In this section, we analyse RCB and DC squads from 2019 to 2021 and examine interesting patterns that relate to our one-for-one replacement theory. Firstly, we list the starting eleven that was most frequently used by the teams in that season. This is because that team is likely to be the best team for the franchise in that particular season. Secondly, we list the set of reserve players that could have been used in events such as injury. Lastly, we analyse the main team and the reserves in order to discover one-for-one or like-for-like replacement squad design patterns

ROYAL CHALLENGERS BANGALORE (RCB)

Royal Challengers Bangalore were led by Virat Kohli in all the three seasons discussed. In the 2019 season, they had Gary Kirsten as the head coach of the team. Mike Hesson was the at the helm of all affairs in the 2020 and 2021 seasons respectively.

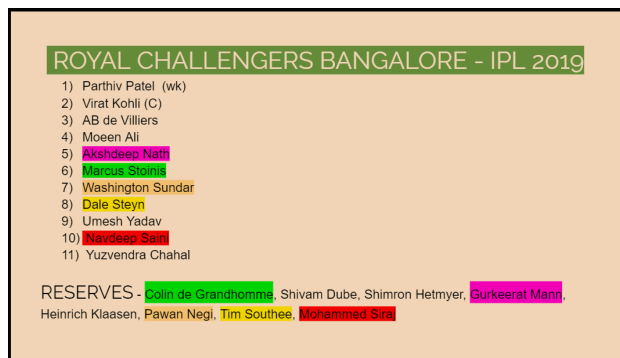


FIGURE 13: RCB in 2019

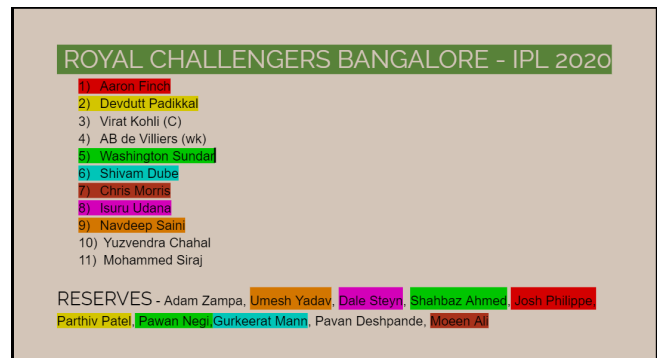


FIGURE 14: RCB in 2020

2019 SEASON ANALYSIS

The first choice line-up for RCB in the 2019 season is as follows:

- 1) Parthiv Patel (WK)
- 2) Virat Kohli (C)
- 3) AB de Villiers
- 4) Moeen Ali
- 5) Akshdeep Nath
- 6) Marcus Stoinis
- 7) Washington Sundar
- 8) Tim Southee
- 9) Umesh Yadav
- 10) Navdeep Saini
- 11) Yuzvendra Chahal

RESERVES

Colin de Grandhomme, Shivam Dube, Shimron Hetmyer, Gurkeerat Mann, Heinrich Klaasen, Pawan Negi, Dale Steyn, Mohammed Siraj

ANALYSIS

As for Parthiv Patel, there was no one-for-one replacement in the reserves. Hence, in case they had to replace him, they would have had to bring in Heinrich Klaasen which would have caused them to drop an overseas player. The same was the case with Umesh Yadav and Moeen Ali. Marcus Stoinis could directly be replaced with Colin de Grandhomme. Akshdeep Nath had a perfect one-for-one replacement in Gurkeerat Mann. As for Washington Sundar, he could be replaced with Pawan Negi directly whereas Tim Southee could very well be replaced with Dale Steyn. Now, in the 2019 season, most top order RCB players were struggling for form in the initial stages of the tournament. This meant that they had to play an extra overseas batter to compensate for the same. Also, Umesh Yadav's inability to bowl crucial overs as effectively as he used to in the past meant that he had to be replaced with some of the more inexperienced Indian bowlers. These forced changes caused a lot of changes in the playing eleven at times. Because of the instability, they finished last on the points table.

2020 SEASON ANALYSIS

The first choice line-up for RCB in the 2020 season is as follows:

- 1) Aaron Finch
- 2) Devdutt Padikkal
- 3) Virat Kohli (C)
- 4) AB de Villiers (WK)
- 5) Washington Sundar
- 6) Shivam Dube
- 7) Chris Morris
- 8) Isuru Udana
- 9) Navdeep Saini
- 10) Mohammed Siraj
- 11) Yuzvendra Chahal

RESERVES

Adam Zampa, Umesh Yadav, Dale Steyn, Shahbaz Ahmed, Josh Philippe, Parthiv Patel, Pawan Negi, Gurkeerat Mann, Pavan Deshpande, Moeen Ali

ANALYSIS

In the 2020 season, AB de Villiers had taken up the responsibility of wicket keeping. This meant that RCB could play an extra specialist batsman or bowler. For this reason, Devdutt Padikkal can be treated as the one-for-one replacement for Parthiv Patel in that both are left handed opening batsmen. Josh Philippe could directly replace Aaron Finch as both of them were right handed opening batsmen. RCB played Washington Sundar as a bowling all rounder. This meant that players such as Shahbaz Ahmed and Pawan Negi too could directly be cast into that role. As Shivam Dube was playing as a specialist batsman, he could directly be replaced with Gurkeerat Mann. Similarly, Navdeep Saini could be replaced with Umesh Yadav. Moeen Ali was Chris Morris' one-for-one replacement in that both played the role of an overseas all rounder. Dale Steyn and Isuru Udana could be used interchangeably given that both are overseas pace bowlers. Thus, the RCB squad in 2020 had much more flexibility in terms of the options they had both with bat and ball.

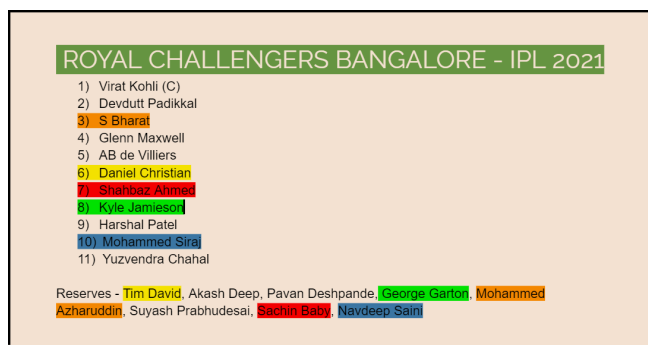


FIGURE 15: RCB in 2021



FIGURE 16: DC in 2019

2021 SEASON ANALYSIS

The first choice line-up for RCB in the 2021 season is as follows:

- 1) Virat Kohli (C)
- 2) Devdutt Padikkal
- 3) S Bharat (WK)
- 4) Glenn Maxwell
- 5) AB de Villiers
- 6) Daniel Christian
- 7) Shahbaz Ahmed
- 8) Kyle Jamieson
- 9) Harshal Patel
- 10) Mohammed Siraj
- 11) Yuzvendra Chahal

RESERVES

Tim David, Akash Deep, Pavan Deshpande, George Garton, Mohammed Azharuddin, Suyash Prabhudesai, Sachin Baby, Navdeep Saini

ANALYSIS

Srikar Bharat had a perfect one-for-one replacement in Mohammed Azharuddin as both are wicket-keeper batsmen having a similar batting style. In as much as RCB wanted to play Daniel Christian as a pure batter, they could have easily replaced him with Tim David in case they wanted to replace him. Kyle Jamieson could well be replaced with George Garton. RCB mostly played one Indian fast bowler in the 2021 season. In as much as they wanted to persist with that style of play, Navdeep Saini could directly replace Mohammed Siraj. Lastly, Shahbaz Ahmed was in the team in 2021 primarily for his batting. Hence, as it stands, Sachin Baby is a good direct replacement for him as both are handy lower middle order left handed batsmen.

DELHI CAPITALS (DC)

Shreyas Iyer was the captain of the Delhi franchise for the 2019 and the 2020 seasons. Rishabh Pant assumed captaincy from the 2021 season. In all the three seasons discussed, Ricky Ponting was the head coach of Delhi Capitals.

2019 SEASON ANALYSIS

The first choice line-up for DC in the 2019 season is as follows:

- 1) Prithvi Shaw
- 2) Shikhar Dhawan
- 3) Shreyas Iyer (C)
- 4) Rishabh Pant (WK)
- 5) Colin Ingram
- 6) Chris Morris
- 7) Axar Patel
- 8) Amit Mishra
- 9) Kagiso Rabada
- 10) Ishant Sharma
- 11) Sandeep Lamichhane

RESERVES

Rahul Tewatia, Hanuma Vihari, Nathu Singh, Sherfane Rutherford, Keemo Paul, Harshal Patel, Colin Munro, Manjot Kalra, Jalaj Saxena, Trent Boult, Ankush Bains, Bandaru Ayyappa, Avesh Khan

ANALYSIS

In the 2019 season, it was more of a speculative attempt from the Delhi management to try Prithvi Shaw at the top of the order. As such in that particular season, he could easily be replaced by Manjot Kalra as his one-for-one replacement. Similarly left handed Colin Ingram had a direct replacement in left handed Colin Munro. As Chris Morris was expected to play the role of a batting all-rounder, he too had direct one-for-one replacements in Sherfane Rutherford and Keemo Paul. Delhi, unlike Gujarat used Rahul Tewatia for his all round abilities. They used Harshal Patel too as an all-rounder which is in contrast to how RCB have used him. Hence, both these players could easily replace Axar Patel. Amit Mishra could also be directly replaced by Jalaj Saxena. Kagiso Rabada, a prolific overseas fast bowler too had a solid replacement in Trent Boult. Ishant Sharma could well be replaced with Avesh Khan. Sandeep Lamichhane did not have any direct replacement in the squad. But as such, since he was inexperienced, he could well be replaced with any Indian bowler in order to play an extra overseas batsman.

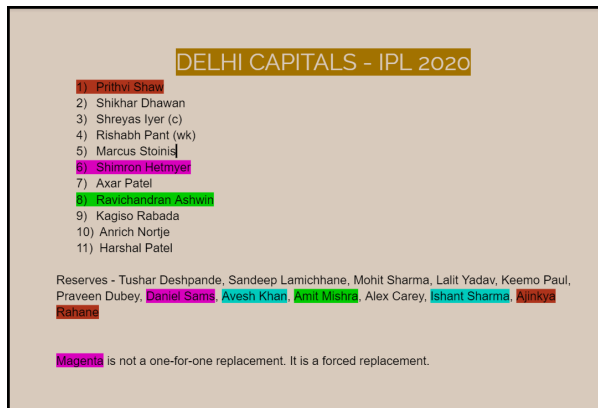


FIGURE 17: DC in 2020

2020 SEASON ANALYSIS

The first choice line-up for DC in the 2020 season is as follows:

- 1) Prithvi Shaw
- 2) Shikhar Dhawan
- 3) Shreyas Iyer (c)
- 4) Rishabh Pant (wk)
- 5) Marcus Stoinis
- 6) Shimron Hetmyer
- 7) Axar Patel
- 8) Ravichandran Ashwin
- 9) Kagiso Rabada
- 10) Anrich Nortje
- 11) Harshal Patel

RESERVES

Tushar Deshpande, Sandeep Lamichhane, Mohit Sharma, Lalit Yadav, Keemo Paul, Praveen Dubey, Daniel Sams, Avesh Khan, Amit Mishra, Alex Carey, Ishant Sharma, Ajinkya Rahane

ANALYSIS

Quite remarkably, Delhi did not have a lot of one-for-one replacements in 2020. Due to his impressive performances in the 2019 season, Prithvi Shaw had stabilized his opening position at Delhi Capitals. Ajinkya Rahane was his direct replacement for the 2020 season. Ravichandran Ashwin could be rotated with Amit Mishra on certain occasions. Shimron Hetmyer did not have any direct replacement in the reserves. Daniel Sams was the only plausible replacement solution available for the first choice playing eleven overseas players. As such Harshal Patel could directly be replaced with Tushar Deshpande, Lalit Yadav or Mohit Sharma in the playing eleven.

REMARKS

- DC vs CSK (2nd leg) - Due to a string of bad performances, Delhi decided to rest Rishabh Pant for some matches. As they did not have any direct replacement

for him, he had to be replaced with Australian wicket-keeper Alex Carey. This change forced Shimron Hetmyer out of the playing eleven due to the constraint of playing four players. Essentially, Delhi replaced Rishabh Pant with Ajinkya Rahane to compensate for the depleted batting and played a pure wicket-keeper in place of Shimron Hetmyer.

- DC vs PBKS (2nd leg) - Anrich Nortje suffered an ankle injury in this match. As he had no direct replacement in the reserves, Delhi had no option but to play Daniel Sams in his place.
- DC vs MI (Qualifier 1) - Shimron Hetmyer had to be replaced as a result of some really bad performances. Again, as he had no direct replacement, he had to be replaced by Daniel Sams. This change meant that Delhi had to play Ajinkya Rahane to compensate for the batting which led to the exclusion of an Indian pacer from the playin eleven

As such, Delhi finished 2nd in the tournament. But the examples shown above show that they struggled with their team combinations in crucial matches due to a lack of flexibility in their ranks.

2021 SEASON ANALYSIS

The first choice line-up for DC in the 2021 season is as follows:

- 1) Prithvi Shaw
- 2) Shikhar Dhawan
- 3) Marcus Stoinis
- 4) Shreyas Iyer
- 5) Rishabh Pant (C,WK)
- 6) Shimron Hetmyer
- 7) Axar Patel
- 8) Ravichandran Ashwin
- 9) Kagiso Rabada
- 10) Avesh Khan
- 11) Anrich Nortje

RESERVES

Umesh Yadav, Vishnu Vinod, Steve Smith, Ishant Sharma, Ajinkya Rahane, Ripal Patel, Amit Mishra, Lukman Meri-wala, Lalit Yadav, Kulwant Khejroliya, Ben Dwarshuis, Praveen Dubey, Tom Curran, Sam Billings.

ANALYSIS

Vishnu Vinod from the reserves is a right handed top order batsman who opens the innings generally. Hence, he is a direct replacement for Prithvi Shaw. As Marcus Stonis was roped in as an all-rounder, he could be replaced directly with Tom Curran and this is one change that Delhi made frequently in the 2021 season. As Shreyas Iyer was injured for the first leg of the tournament played in India before the second wave of the pandemic, he had a direct replacement in Ajinkya Rahane. Delhi played two out of Ravichandran Ashwin, Amit Mishra and Ishant Sharma in every match.



FIGURE 18: DC in 2021



FIGURE 19: Virat Kohli v/s Jasprit Bumrah



FIGURE 20: KL Rahul v/s Mohammed Shami

Hence, on rank turners such as Chennai, Ishant Sharma had a direct replacement in Amit Mishra. Similarly, on other tracks, Ishant Sharma could easily replace one of the two as per the requirements. In as much as Avesh Khan bowled overs both in the powerplay as well as the death, he had a direct replacement in Umesh Yadav. In the first leg, Delhi played a number of matches on turning tracks. Hence, they needed an experienced international batsman to anchor the innings in the middle overs. Whereas in UAE, the need was to have an explosive middle-order as there is not much for bowlers in those wickets. For this reason, Steve Smith played most of the matches that were played in India and was replaced on multiple occasions by Shimron Hetmyer when the matches were played in Dubai or Abu Dhabi. Thus, in 2021, Delhi had a very strong and loosely coupled squad design which helped them manage injuries and rotate players efficiently in 2021.

MATCH-UPS

Match-ups are basically analysis of how effective a batter or bowler is against a specific type of opponent in each phase of the game. Analysing match-ups have gained a lot of momentum particularly in the big data era. For the ease of understanding, we analyse these key battles by considering match-ups of three types. These are player v/s player, player v/s type and type v/s type match-ups.

PLAYER V/S PLAYER MATCH-UPS

These are perhaps the most popular match-ups in terms of the fan engagement around them. Here, teams analyse the performance of their best players against the best players of the opponent teams and devise their strategies accordingly. Some of the most popular player v/s player match-ups are listed as follows. As for the KL Rahul v/s Mohammed Shami match-up, the numbers are skewed heavily in the latter's favour. Hence, it is does not come across as a surprise that teams often bowl Shami against Rahul in the power-play as bowling in the power-play is one of Shami's greatest strengths and gives them the best chance of dismissing Rahul early in the innings. Of all the match-up categories stated, player v/s player match-ups are the most specific ones.

PLAYER V/S TYPE MATCH-UPS

These are the most difficult match-ups to analyse as one needs to be completely aware of cricketing context as well as statistics to generate valuable insights. For demonstrating the power of player v/s type match-ups, we consider the match-up of batsmen against Rashid Khan.

CASE STUDY

Rashid Khan is perhaps one of the most accomplished T20 bowlers of the current generation. He has absolutely dominated every T20 league that he has been part of. Now, teams need to figure out a way of not only surviving Rashid Khan's spell but also counter-attacking when the opportunity presents itself. Basically, they need solid evidence about the type of batsmen that have played Khan well historically. We list the statistics of some batsmen against Rashid Khan and present a way of counter-attacking him through the middle overs as follows. From the figures, it is pretty evident that Shane Watson and Ambati Rayudu have dominated Rashid Khan whereas Dhoni's numbers against the leg-spinner are pretty ordinary.

One question that naturally arises is about the choice of batsmen to come up with for matching up against Khan. We chronologically break the problem of selection as follows.

- Rashid Khan is a leg spin bowler whose stock delivery does not turn much. Hence, he relies more on his Googly (the wrong one) in order to trap right handed batsmen to get them either bowled or LBW.
- As a result, batsmen who can player the slog sweep well can counter Khan as they can only prepare for the one turning in and not worry too much about the leg spinner.
- Thus, we select Shane Watson and Ambati Rayudu who are two of the finest exponents of the slog sweep.
- We select MS Dhoni as he does not play that shot well. We use Dhoni's example to highlight the subtle difference in numbers.

In as much as we talk about leg spinners bowling more googlies than leg spinners, the discussion can also be extended to find an appropriate match-up for bowlers such as Wanindu Hasaranga and Ravi Bishnoi who have a similar bowling profile to that Rashid Khan.



HEAD-TO-HEAD Twenty20											
Shane Watson Batter vs. Rashid Khan Bowler											
Inn	Runs	Balls	0s	1s	2s	3s	4s	5s	6s	6+	Fours
12	111	77	22	38	3	1	7	0	6	-	0

FIGURE 21: Shane Watson v/s Rashid Khan

HEAD-TO-HEAD Twenty20											
Ambati Rayudu Batter vs. Rashid Khan Bowler											
Inn	Runs	Balls	0s	1s	2s	3s	4s	5s	6s	6+	Fours
7	79	65	25	29	1	0	6	0	4	-	0

FIGURE 22: Ambati Rayudu v/s Rashid Khan

HEAD-TO-HEAD Twenty20											
MS Dhoni Batter vs. Rashid Khan Bowler											
Inn	Runs	Balls	0s	1s	2s	3s	4s	5s	6s	6+	Fours
7	24	35	19	12	2	0	2	0	0	-	1

FIGURE 23: MS Dhoni v/s Rashid Khan

HEAD-TO-HEAD Twenty20											
AB de Villiers Batter vs. Krunal Pandya Bowler											
Inn	Runs	Balls	0s	1s	2s	3s	4s	5s	6s	6+	Fours
7	51	49	16	27	2	0	2	0	2	-	4

FIGURE 24: AB de Villiers v/s Krunal Pandya

HEAD-TO-HEAD Twenty20											
Prithvi Shaw Batter vs. Deepak Chahar Bowler											
Inn	Runs	Balls	0s	1s	2s	3s	4s	5s	6s	6+	Fours
9	80	70	41	12	2	0	13	0	2	-	6

FIGURE 25: Prithvi Shaw v/s Deepak Chahar

HEAD-TO-HEAD Twenty20											
Dinesh Karthik Batter vs. Yuzvendra Chahal Bowler											
Inn	Runs	Balls	0s	1s	2s	3s	4s	5s	6s	6+	Fours
11	42	46	17	22	4	0	3	0	0	-	3

FIGURE 26: Dinesh Karthik v/s Yuzvendra Chahal

TYPE V/S TYPE MATCH-UPS

Type v/s type match-ups are very generic in nature. These match-ups can also be thought of as fallback match-ups as teams use them when they typically cannot think of better reasonable options. Some examples of the most common type v/s type match-ups are as follows.

- Left Arm Orthodox v/s Right Handed Batsmen
- Swing in the Power-play v/s Opening batsmen
- Off Spinners v/s Left Handed Batsmen

The above list is not exhaustive by any means but has been kept short for the sake of brevity. AB de Villiers vs Krunal Pandya is one of the best examples of a type v/s type match-up that has developed over the years. Pandya was used against the AB because of the left arm angle that he creates when bowling from round the stumps as an extra bowling option. Another excellent example of a type v/s type match-up is that of Prithvi Shaw against Deepak Chahar as swing bowlers are a threat to most top order batsmen with the new ball especially when the batsmen are just starting to get into their groove. In general, leg spinners have troubled right handed batsmen in the middle overs. Based on their respective numbers, the match-up between Dinesh Karthik and Yuzvendra Chahal is no exception to this rule.

REMARKS

The three categories discussed for match-ups are just a way of simplifying the analysis work for franchise teams. A match-up may belong to one, two or all of these categories. The player v/s player match-up is the most specific whereas the type v/s type match-up is the least specific of all the match-up categories. Apart from the numerous strategies that match-ups help generate, they also help in answering certain pointed questions in various phases of the game. An set of example questions that one can answer using the theory of match-ups

is as follows:

- Why was AB de Villiers sent at no 6. in the match against Kings XI Punjab in the 2020 season?
- Why did Mumbai Indians play Jayant Yadav in the final of the 2020 IPL season?
- Why did Harpreet Brar open the bowling against Royal Challengers Bangalore in the 2022 season?

Plausible answers to the above set of questions could be as follows:

- AB de Villiers had struggled against leg spin bowling for quite some time leading to that match. Kings XI Punjab had two quality leg spinners in Murugun Ashwin and Ravi Bishnoi who were bowling in tandem. Hence, RCB wanted to shield AB de Villiers in a way. An example of a player v/s type as well as type v/s type match-up
- Delhi Capitals had four left handed batsmen in the top seven. Thus, the plan from Mumbai Indians was to use an off spinner against them. An example of a type v/s type match-up.
- Punjab did not have a quality swing bowler who could trouble the top order batsmen in the first six overs in the 2022 season. Hence, their plan was to use a left arm orthodox against two right handed batsmen in Virat Kohli and Faf du Plessis in order to restrict the flow of runs. An example of a type v/s type match-up.

MISCELLANEOUS

We consider the examples of Mumbai Indians (2020) and Rajasthan Royals (2022) in order to demonstrate the synergy between match-ups and the one-for-one replacement design for the bowling units of both the teams.

MUMBAI INDIANS - 2020

Mumbai Indians had Trent Boult begin their bowling innings throughout the 2020 season. Boult's left arm over the wicket bowling style has often troubled right handed batsmen and he has a high success rate getting them LBW in the power-play. On occasions where the requirement was to get the ball across the body of the right handed batsmen and eventually away from him, Mumbai Indians had the option of swapping Boult with Mitchell McClenaghan. Further, Jasprit Bumrah bowled one over in the power-play and three overs later in the innings. As far as death overs are concerned, the need is to have a bowler who can bowl wide yorkers outside the offside stump and can use the slower ones to a good effect. Jasprit Bumrah executed those deliveries at the death quite effectively. Further, in the middle overs, they could either use a combination of Krunal Pandya and Rahul Chahar if the opposition had more right handed batsmen or use Jayant Yadav with Krunal Pandya if the opposition had more left handed batsmen. Lastly, they had the option of using either James Pattinson or Nathan Coulter-Nile alongside Jasprit Bumrah in the death overs. Hence, the MI bowling unit of 2020 was indeed a very strong bowling unit both in terms of variety and flexibility.

RAJASTHAN ROYALS - 2022

Rajasthan Royals in 2022 enjoyed the same services as Mumbai Indians in 2020 due to the presence of Trent Boult as their opening bowler and their 'go to' option in the power-play. Prasidh Krishna was able to give them vital breakthroughs in the power-play as well as tight overs at the death because of his varied skill-set. Further, in case Rajasthan wanted to play an extra bowler, they could use either or Navdeep Saini or Kuldeep Sen. Both these bowlers are good hit the deck bowlers with a remarkable ability to bowl the death overs. As far as their spin bowling department is concerned, they had two bowlers with altogether different skills. Ashwin an off-spinner and Chahal - a leg spinner provided them with options to trouble both right handed batsmen as well as left handed batsmen. Finally, whenever Rajasthan wanted to play an extra batsman, they typically benched Kuldeep Sen and brought Obed McCoy in his place. Obed McCoy, because of his height could bowl slower ball bouncers at an awkward height in the death overs which made it very difficult for batsmen to pick him easily. Thus, similar to that Mumbai Indians in 2020, the Rajasthan Royals bowling unit in 2022 was very effective.

VI. RESULTS AND CONCLUSIONS

- The impact of non-cricketing attributes such as a player's age and nationality on IPL auction prices were examined in detail. The analysis provides IPL teams with information on the right set of players to buy.
- Time constant unobserved effects were first studied using the fixed effects model and the random effects model. The result from the Hausman test reveals that the fixed effects model should be used in this case. Thus,

finally, player specific information is accounted for via the use of the Least Squares Dummy Variables Model.

- The list of players with significant fixed effect is not exhaustive. With each passing auction, the list will continue to grow and provide franchise teams with much better insights.
- The Least Squares Dummy Variables Model returned an R-squared value of 0.6889 for overseas players and 0.5743 for Indian players.
- Various IPL franchise squads were analysed for the extent of their use of a common yet powerful squad design pattern, the one-for-one replacement pattern. The 'How to buy players' part of IPL auctions is addressed by the use of the above design pattern.
- Match-ups and the extent of their use by IPL franchises was examined in detail.

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