Dynamics of Cricket and
Cricket Derivatives

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Abstract

Hedging stakes in sports like cricket is the need of the hour, for it no longer restricts its claims to league owners, cricket associations, independent teams and individual players. Financial, economic and social stakes today extend to the general public and governments who happen to patronize the game and its economics in many roles, as spectators, speculators, sponsors, developers and even organizers. The national and international significance of the game is much credited to the revolutionized viewing experience seized by game organizers, stadium owners and information dissemination channels including internet, television, radio and others. Yet returns are not guaranteed for any of the stakeholders. The game just like any economic good is not free from effects of economic and business cycles especially in regions where it continues to be a Veblen good. The paper explains the economics of the game, its origins, development, mathematics and risks and develops a new financial instrument – the Cricket Derivative.

I. Financial Stakes at the Game

WORLD CUP 2015 IS likely to generate US$ 250 million for the International Cricket Council (ICC) with its host- Australia and New Zealand each generating at least US$ 10 million to US$ 20 million each from the event. Earnings in the last World cup for ICC were about US$ 320 million with a surplus of US$ 204 million. All the ticketing receipts as per the contractual arrangements are to be maintained with the host countries which are Australia and New Zealand for the World Cup in 2015. Organizers are expected to earn about 1 million ticket sales from the cricketing events. Stakes of the Cricket Associations are inbuilt with the revenue sharing

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arrangements with the ICC. After deducting costs the Australian Cricket Association as per the contract would receive 26% share of the revenue. The business model of cricket is not limited to the earnings of associations, counties, and international councils. Deals and game spillovers are prominently observed in the gross earnings of the cricketers like Shane Warne with US $ 6 million, followed by Michael Clark with US$ 5.5 million or with retired test players like Ricky Ponting with US$ 2 million earnings. Earnings portfolio no longer contained only remunerations/ wages/ salaries with small perquisites from the Cricket association but also includes personal sponsorship deals and lucrative overseas contracts in the Indian Premier league (IPL).

ICC itself has commercial partners like ESPN Star sports[1] (host broadcaster) with 310 million viewers in Asia, 24 hours a day with 17 networks covering 24 countries. Among its other commercial partners are Reliance Communication (telecommunication service provider); LG electronics (consumer electronics, home appliances and mobile communications); Pepsico (consumer product company); Emirates (Airlines connecting 100 destinations); Reebok International limited (athletic footwear, apparel, and accessories); Castrol (lubricants); Money gram (International money transfers) and Hyundai (Automotive group). Media and other sponsorship deals and partnerships are separately undertaken with host country providers for each event. The latest partners include banking giants like ANZ Grindlays, media and telecommunication giant like Telestra and airlines operator Etihad for the World Cup 2015.

With many countries like U.S., U.K. Ireland, Greece, Germany, Spain, Australia permitting wagering agreements and with the advent of high speed technology on smart phones and other devices, organizations like Betfair or others observe stakes of billions of dollars with the public investing their hard earned money in wagering contracts of speculations before and in play; exchanges and gaming platforms. Betfair itself estimates that the UK online sports betting market is worth £ 650 million per annum where sophisticated bettor account for £150 million, recreational bettors to about £440million and occasional bettors to about £60 million. Betfair itself registered revenue of £387 million in 2013[2]. Unorganised market stakes in the *Satta Bazar* with local bookies and players offering hawala transaction and use of laundered money in many Asian and middle eastern economies have estimated betting stake that approach trillions of dollars on the day of a big game[3]. It is not possible to estimate the size of the informal market or the black money market that runs the parallel economy in many of these countries. Glamour, power[4] and money make the game rich in its financial, economic and social stakes today but it has taken centuries before this game could establish itself and be well recognized. Football, as a game has gathered much mass in its economies of scale that offer sufficient margins to its stakeholders. Cricket on the other hand could not generate that viewership

for the Test matches and ODIs. The introduction of Indian Premier League (IPL) with twenty 20 cricketing and auctioning of cricketer supported by team owners who happen to be top notch politicians[5], businessmen[6], Bollywood stars and other influential or powerful groups, cricket has also emerged as sport with spectators from all over the world.

Cricket like all business models has had to invent and reinvent itself to generate the interest and money in the game. Beginning eras had to struggle to establish the sport as a national interest. The Overseas tours of teams to America and Canada in 1859 and to Australia in 1861 and 1863 helped in establishing local and national markets[7]. Leagues, counties, council and other establishments have continuously improved the game deliverables by improving the pitch, grounds, stadiums, player efficiencies, modifying rules, neutralizing umpires, increasing sponsorships, media coverage, establishing anticorruption units and government allied associations. The business of cricket for counties, leagues and association has also grown many fold over the past three decades. The accounts of ICC reveal that from US$ 6.4 million (2001) it has grown to US$ 101million (2012) which were at a higher level of US$ 203 million (2011) before the recession hit the markets. With recessionary trends observed in the world economy ICC has also suffered a fall of Revenues from ICC events from US$ 321 million (2012) to US$ 131 million (2011) with subscription and other revenues to the tune of US$ 26 million. This is not the first time that ICC has observed downward trends in 2008; ICC had suffered serious losses of about US$ 3.302 million. It was only when Cricket reinvented itself in the form of Twenty 20 that the ICC could possibly come out of its losses. The combination now offered was the glamour quotient of the Bollywood celebrities, auctions of players for forming teams, fast paced cricket structures and tapping of large market like India, Pakistan, Middle East and others.

II. Economics of the Game

A game much recognized to have monopoly powers[8] in the output market and monopsony power in the input markets has never attracted the attentions of the competition laws. One may wonder what the commodity in question is for the monopoly power is and who has it. The commodity is the GAME-CRICKET[9] itself and monopoly power is in the hands of the controlling bodies like the Associations or clubs that organize and maintain team ownerships for matches. When such associations or clubs that organizes cricket teams are plenty they move to imperfect competition. To avoid competition or retain monopoly power many clubs and associations combine together to form Sport leagues that organize matches between member clubs or team owners. BCCI[10] in India has had a monopoly power for the Indian Cricket team till the advent of the Indian Premier league in 2008. Similarly in the 18th century the two counties, All-England XI (1846) and United All-England XI monopolized the game until the rise of the County clubs and their teams.

In many countries, the association or counties have territorial rights for selecting, organizing and distributing the rights of the game which afford them the monopsony power in the selection of the input which is the cricket players. Many countries like the US also afford restriction on the association of the cricket players with the county clubs which restricts the players from oscillating from one team to another. Cost from many association or counties has thus been reduced by restricting competition. But with the advent of IPL and the auctioning structure where domestic and overseas players can participate, this restriction is largely over.

The game "Cricket" is a commodity supplied by Sport leagues, Cricket Associations, Cricket clubs known with different names like Indian Premier League, BCCI, ICC, County clubs or regional/district clubs. The hierarchy of the leagues and associations of the clubs determine the market that offers accessibility to the game. Like any other commodity, Cricket can be packaged, repackaged and distributed with brand promotions and has several stakeholders involved in the process. Suppliers of the commodity would weigh their offering as per the Law of Supply. Associations, Leagues, Clubs and others would organize matches and other events that have the potential to generate demand and hence profits out of the event/events.

The purpose of every economic unit in its organization of factors of production is to meet the profit maximization objective by minimizing the cost of inputs and maximizing the revenues. Revenue streams can be enhanced by maximizing utility of the consumers by repackaging cricket as Test matches, ODI, World Cup, U19, Twenty 20 and others. Distribution of the game over media broadcasting channels like radio, television, laptops, iphones, smart phones and now mobiles with live feeds, expert opinions and player and match insights, viewership awards are all a means for enhancing the value of cricket. Added entertainment is offered with new 3D gaming and betting deals offered with fantasy cricket. In a real match every match is unique, its toss, players and conditions of play are different and unique in their formation. The providers such as leagues, counties/ team owners, players, broadcaster and distributors and sponsors try to offer the product in the most unique, differentiated and highly satisfying manner. Like all economic commodities cricket can be Normal, Inferior or Veblen good based on the consumer's income levels and also on the time they have to engage themselves either in playing or watching the game. As income levels and time for leisure increases the consumption of good-cricket also increases. In many developing economies it is a Veblen good whereas in many developed economies it may be Normal or Inferior good. In any economy whether good observes a downward or upward sloping demand curve would depend whether the good is Inferior, Normal or Veblen good which would depend on its packaging, consumer's income levels, memberships to the game and cultural importance of the game. Globalization, liberalization and privatization has standardized the game

by neutralizing its rules, pay packages and acceptance of players and teams in the world of cricket. Growth in the emerging economies like India and others with growing income levels has further contributed to development of cricket.

Cricket in the past has been packaged / repackaged / distributed and promoted by offering differentiated product lines like Test Matches with different durations ranging from 2-3-5 days. Tests Matches organized at home and overseas tours. Test Matches with 6 or 8 overs. Test Matches were a rage till the 18th and 19th century but lost shine in the 20th with the advent of One Day International (ODIs) where cricket was played with limited overs. A repackaging strategy devised to overcome the falling attendances at the Test Matches. Initially to overcome the delays in test matches, cricketers that would speed up the matches were given bonus points. Experiments with limited overs of 50 -60-80 were also used to package the ODIs. Later 50 over matches were common. The latest product offering of the commercial cricket comes in 21st Century with the launch of the Twenty-Twenty (T20) cricket by the Indian Premier league (IPL). Besides exhibition matches, cricket festivals and tours abroad and many other variations have been introduced in offering the game to the audience. Earlier the major revenue earning sources were the bet deals among the elites which later on was incentivized with audience attendance and the gate receipt collections. Attendance to the stadiums in the past had been falling with the slow pace of test matches to which ODI offered a better attendance rate especially with Triangular series organized in Sharjah. With falling gate receipts, the organizers have now been banking on other incomes such as broadcasting rights, membership fees, sponsorships and others. In 1950s with the advent of television and radio, cricket sought much sponsorships from companies that made products especially for Men like Gillete, John Players and Benson and Hedges and others. Sponsorships were annual or periodic or continuous and dependent on the audience they reached. Stake and value for the game was on a continuous rise which made it difficult for many sponsors to continue their patronage. Market for the game was an important parameter for sponsorships. Fair play and uncertainty in the game also added to the market stakes of the game. From test matches to ODIs financial and other stakes were on a continuous rise.

Market for any cricket game is also dependent on the hierarchy of the leagues or matches. Audience or reach to the game would be dependent on several parameters like championship money, honor and prestige in winning the game, stakes of the team owners in the game. Uncertainty that would permit betting on the game, strength of the participating teams, cultural association of the teams and Impartiality of the rules, umpires and others.

Cricket leagues or Associations function like any other economic unit and can continue to earn normal profits. Profits of the leagues like any other business are the difference of the revenues and costs of the economic unit. Revenues for most economic units associated with cricket were identified

with the following (a) gate receipts; (b) Membership fees; (c) Test Match Distributions; (d) Selling Broadcasting rights (TV, Radio, Mobile, PC, Tablets); (e) Sponsorships; (f) Merchandising and (g) Licensing.

Cost would generally entail the cost of selecting, recruiting, training, remuneration and maintenance of team players; their travel and stay costs; cost of publicity, advertisements and rents for stadiums and other sport equipment; merchandise for players and staff and cost of the organizing team or board and other miscellaneous expenses including litigation on commercial contracts.

Profits would depend on the elasticity of the demand curve and ability of the economic units to enhance demand via movement along the demand curve or shift along the demand curve. Elasticity of the demand curve faced by the economic unit would be governed by the ability of the unit to curtail competitions. Closer to the monopolistic situation the more inelastic the demand curve and closer to perfect competition the more perfectly elastic the demand curve. Formation of cartels as association in oligopolistic markets has also been encountered in the cricket world. These economic units unlike any other business enterprise with government support/ enjoy monopsony power in the input markets that help them keep check on the costs of the inputs. Presently, a contestable market structure has been established with different leagues and potential teams that have been created with the IPL.

The economic units can shift the demand curve by (a) promoting quality and competition between teams; (b) Limiting the numbers of drawn games; (c) Improving striking rate of both batsman and bowlers; (d) Making better use of time allotted for matches and (e) Improving the accessibility of the game to the public.

Monopoly power by the unit can be enjoyed if it can successfully provide to curtail competition by (a) exclusion of outsider or local competitive teams (exclusivity of membership of teams participating in the competition) like Bangladesh was given the Test Match status in 2000 only and for several years the three teams of England, Australia and South Africa reigned cricket; (b) Establishment of method of Internal regulation protecting monoposony power like the counties in the US restrict membership of players in the counties by their residency status or domicile status; (c) Attempting to maximize jointly profits by organizing cartel like the IPL (an initiative that involves BCCI and many big players and associations). Cartel formations in sports are not uncommon to pursue the objectives of maximizing profits and gainful economic rents for the players. Most sports including cricket have not been favoured by the audiences for the lack of incentives available to the team players and other participant's like coaches and others. For long cricket players were not recognized as professionals and did not receive their dues however the interest in the sport and associations with corporate along with formation of cartels did lead to establishment of gainful pursuit in the game.

There are four main participant players in the game

i. *Batsmen*

Factors that affect the performance of the Batsman and outcomes of the game

— Right Hand Batsman
— Left Hand Batsman: Brooks, Bussiere, Jennions and Hunt (2003) provide that lefthanders[11] occur at unexpectedly high frequencies at top levels of many interactive sport, most successful teams had 50% left handed batsman. For the strategic advantage they derive by batting position over bowlers.
— Confidence of the Batsman
— Strike Rate (ODI and Twenty-Twenty Cricket)
— Physical Exertion
— Partnership
— Ability to predict the swing of the ball

ii. *Bowlers*

On batting pitches, the bowler and fielders assume importance for the next running teams. Capable bowlers can make a new or well preserved ball[12] deviate in flight from its initial vertical plane of projection giving a new dimension to already established game, Barton (1982). Bowling by bowlers can be classified as:

(a) *Fast Bowling: Bowlers are called Pace bowlers/ fast bowlers:*
— Fast Bowler (≥ 142kmph, ≥ 88mph)
— Fast Medium (130-141kmph, 80-87mph)
— Medium-Fast (120-129kmph, 70-79 mph)
— Medium (96-119kmph, 60-69mph)
— Slow Bowling (<96kmph, <60mph)

(b) *Spin Bowling*

iii. *All Rounders'*

iv. *Wicket Keeper/s*

Teams could actually comprise of

i. 4 Batsmen, 4 Bowlers, 2 All Rounders' and 1 Wicket Keeper
ii. 4 Batsmen, 3 Bowlers, 3 All Rounders' and 1 Wicket Keeper

III. Dynamic Setting of the Game

The dynamic settings of the game are at play with several factors affecting it while the game rules and league matches are designed to the selection of the teams participating in the game; selection of the players; selection of the host countries; stadium, audience pressure and then the game itself. Before a game begins, the historical performances of the players and specific tactics used by them previously are highlighted by the commentators besides offering their take on the form of the team and its immediate performance in the season. Every player and his offerings contribute to building a team and the match that offers a product which is

packaged by several stakeholders to be offered to its ultimate audience. Strategies are devised for an overall winning streak with the pack of matches that may enable them to determine their rival and their selection to the final matches. As mentioned above, countries, players, coaches, umpires and audiences and elimination strategies add on to the possibilities of the game. Any game played would have three possibilities of Win, Lose or Draw. Interrupted matches are no longer a possibility for their outcomes are now determined by the adaptation of Duckworth and Lewis rule[13]. Earlier when the rule was not adopted, losing teams and fans would pray for the rain to happen to save them from defeat or the aggressions of the winning team. Allsopp and Clarke (2003) divided the teams as defensive or aggressive. As for them, batting teams strive to maximize its score and bowling teams strives to restrict the score of the batting team. Countries also place their teams as either batting teams or bowling teams based on the pitches, rival teams and host country audience parameters. Rivalry and pitch estimates may offer selection of batsman, bowlers and wicket keeper with combinations to defeat the rival group. Brooks, Bussiere, Jennions and Hunt (2004) found that team's success was positively associated with the percentage of innings played by left handed batsmen peaking at 50.5%. Lefthanders do not score at faster rates than right handers but last longer before being dismissed. While the batting streaks may make runs, bowling and fielding may restrict the runs and wickets. A ballers spin or action besides his physical strength, skill and experience is found to be influenced by the weather conditions that may determine the fatigue and stamina. Hot, humid, dry or cold conditions all impact the bowlers, batsman and fielder performances given their tolerance and past play histories. Pitch conditions with changing weather and in rain affected areas besides the pressure of team performance that has won the toss all affect the outcomes of the match. Not much empirical evidence has been gathered on this aspect of cricketing besides the regular commentator/expert opinions one can gather while watching a match. Though, the outdoor dimensions of the game have a suggestive impact on the physical stamina of the batsman and bowler[14].

3.1 *Learning curves in the Game*

The learning curves are

i.   As the game proceeds Pitch deteriorates and spin bowlers have an advantage.
ii. Fieldsman learn the batsman weakness
iii. Risk taking ability of the Batsman increases with an Inning Proceeding
iv. Batsman Fatigue

v.   Home Advantage: Schwartz and Barsky (1977) define home advantage as team's better chance of winning a game if it plays that game at home, then, whatever the reason for such advantage, we would expect its magnitude to vary in accordance with the quality of both the home team and its visiting opponent. They identify the sources of home advantage from (a) Local players greater intimacy with the home arena and playing arena; (b) elements of fatigue and asserts that the home team is in better

physical condition than the visiting team; (c) moral support of the local spectators. Support of public can enhance and dissuade teams from winning and a home advantage and public participant has a strong impact on the same (Allport 1920; Cottrell 1972; Paulus and Cornelium 1974; Travis 1925; Zajonc 1966; Edward 1979). Schwartz and Barsky (1977), Andrew (1984), Greer (1983) Zeller and Jurkovac (1988) found strong advantage in some games like hockey, basketball and football where the crowd would determine the quality of competition. They also investigated the same using quantitative factors like crowd intensity, actual crowd size and behavior. Most of these finding were in support of the "social reinforcement" theory where audience behavior interacts with task performance distinguishing between their passionate interest in the game and mere presence.

However, some researchers like Dowie (1982), Pollard (1986) found negative/ no impact on home teams of the home audiences. Further home audience pressure and aggressions were found to dissuade the teams from performing. Liefer (1995) denied the home advantage to teams with the advent of national television networks, for sport leagues were no longer interested in cultivating interest in home teams but in fans worldover for the league. Much can be observed as negative evidence to Brazil against Germany in the Football World Cup 2014. Crowd density and stadium capacity have been used in several researches as a determining factor for home advantage.

vi.   Toss and Weather Predictions
vii. Form of the Batsman[15]
viii. Umpires[16] and their Decisions[17]
ix.   Audience Pressure[18]
x.   Restriction on the Bowling and Fielding in specific matches[19]

The Factors considered by betting industry for performances included

i.   Career batting Average
ii.   Time of the day Innings
iii. Inning Order
iv.   Home Country
v.   Quality of Opposition
vi.   Number of Games played
vii. Team
viii. Past Performance
ix.   Ranking of the Teams

The Rating Teams and Analyzing Outcomes

Elo (1978) system can be easily used to rate cricket players as was done then to rate chess players. Clarke on Elo concept developed exponential smoothing process to develop team ratings and ground advantage. Among the early works of ratings of sport teams is the work of Stefani (1977) who developed a least squares system for American football and basketball at college by averaging opponent's rating with Margin of Victory (MOV). The work was furthered by James and Stein (1981) with and without an

adjustment for regression to the mean. Law of averages have also been found to operative in the rating systems. Harville (1980) use the probabilistic approach and Clark (1993) used the exponentially smoothened approach.

3.2 *Stakeholders of the Game*

Every person who draws an interest in the game and is affected by its outcome becomes its stakeholder. This includes the sport leagues association, cricket counties, players, coaches, umpires, stadium owners, sponsors, media, cricket following journalists or bookies or the audience at large. Spillover participants who gain at the event include the pandits and Maulvi's at the Yagna in World Cup 2003 match or the advertisers, campaigners or other contract holders of the events are also the stakeholders of the game. However for economic relevance the stakes are highest for the organisers of the sports league or the team owners who purse profit maximizing objective. For our study we concentrate on the broad groups of stakeholders viz sport leagues, team owners, team players, network owners (broadcasters, distributors, bookies, journalist and others), Sponsors (corporate, individuals, government), government and society. Studies in the past reflect how the stakes of each stakeholder have contributed to advancement of the game and its pursuits.

The organization of the match can be done by any of the below mentioned authorities

3.2.1 *Independent Teams*

A team that does not belong to any specific league but organizes matches on its own with other teams like college or other informal set up team sports.

3.2.2 *Barnstromers*

Noll(2003) defines Branstromers as a team that does not have regular home field and that travel country playing exhibition. Usually teams are organized in championships for they have higher demand than exhibition games. Sport leagues hence become a more relevant concept for understanding the economics of the Sport.

3.2.3 *Sports Leagues*

Noll (2003) defines a leagues as a group of teams that schedules games and develops other policies and rules for the purpose of determining a champion. The structure of the sport league defines the various stakeholders. Noll provides that the league structures depend on format (method of scheduling matches to determine championship); hierarchy (the relationships between leagues of lesser and greater quality; multiplicity (number of leagues at the same level of hierarchy); membership (conditions under which a team enters and exits a league); governance (the methods for deciding and enforcing league rules and policies). Playing rules, Controlling aspects are also some other decision that the Sport leagues undertake. According to Noll the choice of the organizational form like any business entity would decide

i.   Demand for a sport
ii. Cost of Scheduling games

iii. Extent of competition among teams for fans
iv. Players
v. Coaches and
vi. Stadiums

Major, Premier or first division leagues have almost been always monopolies. The leagues can be divided into American[20] versus European[21] league based on the organizational structure.

Formats there can be two types of schedules a round robin and elimination tournament. Round Robin the schedule of games for the championships involve each team playing a predetermined number of games other league members. The championship is determined by aggregating the results of all matches. In the elimination tournaments teams are dropped from the schedule after losing a certain number of games –one or two or more depending on the rules. Leagues can allow multiple memberships to the team or completely exclusive memberships to the team depending on their expansion and contraction mode. Indian Premier league (IPL) that launched twenty-twenty cricket introduced more players into the teams through the auction mode. Further premier and championship leagues can guide the code of conduct of players and teams in the matches. Sport leagues can also exercise territorial rights where no teams can stage matches even broadcast games within another team's home area without first obtaining permission. According to Noll (2003) attendances also permit the existence of major league teams that can coexist in the same city. Where, attendance or love for the sport is high, multiple leagues can exist.

Cave and Crandall (2001) identified major professional sport leagues for baseball, football, basketball and hockey which have been in existence for decades and which have lucrative broadcasting contracts. A combination of competitive and co-operative arrangement distinguishes members of a sports league from its members as an industrial cartel.

3.2.4 *Team Players*
Mandle (1972) provides that Mc Intyre was paid £5 a weak by the Philadelphia Club in 1869 and given a benefit match. In 1860s more lucrative rewards were available to team who went overseas. Till the 19th century professional cricketer faced most of hardships. It was only a few handful or the fortunate minority that commanded lucrative fees, coaching positions, 'perks', presentations and overseas trips. The image of a cricketer slowly improved. According to Mande (1972), Ranjitsinghji was among many who paid tribute to the new professionals who were better paid and better behaved and so did the cricket become the gentleman's game.

3.2.5 *Network*
World Cup 2015 is likely to have one billion eyeballs plugged to the game. Cricket as per the statistics is the most watched sport after soccer world cup and summer Olympics. The domestic rights for the event would be shared by Fox Sports Australia and Nine Entertainment company. Leifer (1995) national televisions made national publics possible. They happen to

mobilize expectation driven national publics where broadcasting factors are the best indicators for success. Schofield (1982) Noll (2003) found that quest for championships generate fan interests which are freely promoted by the media. Broadcasting rights are given by sport teams and leagues which can be collective or exclusive in nature. Cave and Crandall (2001) found that prior to 1984 the National Collegiate Athletics Association (NCAA) negotiated a single national contract for televising football games of major US universities. Dissatisfied, two universities that attempted to break away from this arrangement and negotiated their own contracts were sued by NCAA lost the suit. There was sharp increase in the number of games being telecasted but the value of the contracts declined. Liefer also found that Major League Baseball and National Basketball Associations were deriving more revenue from network broadcasts and similarly revenue contribution in hockey was also high.

Vertical Integration of the broadcaster and the sport league owners lessening of competition in the market for sports broadcast rights. It was believed that it would provide broadcasters with a toe-hold advantage or a better information advantage. Hence the commission in the US looking after this recommended that the integration should not be permitted (Monopoly and Mergers Commission,1999).

Cave and Crandall (2001), found that there existed difference in the manner rights of the domestic leagues in five European countries was sold. For in United Kingdom a limited number of gamers were sold for live broadcast to a single broadcaster and no individual rights were sold, whereas in France, Spain there no rights were sold exclusively. In Italy a single broadcaster was prohibited from holding more than 70% of live matches. In Germany, leagues were given the right to exclusivity.

Liefer (1995) found that networks also induce *"Matthew effect[22]"* inducing performance inequalities as winning teams in the leagues often receive more television and print support. He also notes that the lack of close races at the top can serve as an obstacle to cultivating national publics.

3.2.6 *Sponsors*
Sponsorships were not a serious business revenue generating source till the sixties. Schofield (1952) in his paper on the development of the game provides for the initial sponsorship received in the game from Gillete, John Player (1969) and Bensen and Hedges (1972) for one day competitions, from Prudential Insurance (1972) for one day internationals, Cornhill Insurance (1977) for test matches, Schweppes (1979) for county championships, Holt products (1979) for county matches against touring teams and commercial union (1980) for junior representative cricket. Sponsorships did not restrict themselves to high end tournaments but extended to others for Schofield provides that test trials (1976) were sponsored by Pheonix Assurance. Individual clubs also sought revenue

from local sponsorship and advertisements such as ground hoardings/player merchandise, team travel kits and others. Several official sponsors continue to provide additional revenue to the organisers. Contentions against sponsorships range from commercialization of the game as it was believed that sponsorships direct cricket towards extraneous ends and overshadows cricketing concerns.   .

3.2.7 *Government*

Wisden (1923), Schofield (1952) found the role of the government as a mere tax authority that levied entertainment taxes on the clubs which was vehemently protested by the clubs.

Noll (2003) found that sport leagues structures were not completely independent but were constrained by government policies such as antitrust, labour laws and non-governmental governing bodies in each sport. Regulations of the land and economic participation of the government and other semi government bodies has an important influence over the game and its participants. Governments can forbid some matches for political or other reasons. They may promote some matches for friendly purposes or for the promotion of the sports. In many developing countries, this sport and other similar sports have been subsidized for low incomes or lack of viewership incomes. Many times in the National interest of member countries of the European Union (EU) or specific sporting events like Olympic Games, Soccer World Cup, finals of soccer, rugby and tennis competitions, the governments regulate the sale of broadcasting rights or any additional rights to the event.

Cave and Crandall (2001) found that besides the broadcasting rights there are also additional rights for sale of sporting events of National Interest member countries of the European Union (EU) or such events like Olympic Games, Soccer World Cups, Finals of soccer, rugby and tennis competitions which are regulated. They found that in under the EU system or the United Kingdom, the governments were considerate to the universal coverage on fair and reasonable terms. In EU, it is provided that holders of such events must first of all offer them to free to air broadcasters and then any additional rights may be sold.

3.2.8 *Society*

Dimeo and Kay (2004) portrays the interest and interdependence of the society in the sports when they say that society elites want to be associated with it, ordinary fans feel passionately about, play players of all backgrounds can become national heroes and there is strong financial support through the media and commercial sponsorship. Liefer(1995) mentions that both local and national publics are creations of leagues. A sport by itself attaches teams to cities and then to leagues to network televisions.

3.3 *Financing Models in Sports*

All types of financing models have become popular in sports with globalisation. Traditional models of financing sports in most economies is through local or national subsidies, event ticket receipts, donations,

membership contributions and sponsorship as identified above. Revenue from broadcasting right till 1980s was limited. Presently, the heavy weight of financing come from media oriented rights and investments from wealthy individuals, companies and others. Training centers have futher added a revenue stream to the sports industry in form of academies. Capital sourcing from capital markets is also opted by may associations, joint stock companies or public enterprises, trusts and others. The parallel economy of illegal betting also supports the industry along with networks of highly influential people trying to park black money in these activities. The betting industry has further seen many advancements due to globalisation which has further added parallel economics to the game.

IV. Cricket Game Mathematics

Mathematics by its very nature has the potential to logically decipher what a common man considers common sense. Making it easier to analyse and assess everyday situations like the game cricket itself. Cricket is a sport in which statistics feature heavily[23]. Averages feature heavily in media coverage of professional cricket. The winning criteria for the game is logical criterion for victory which is how many runs scored for the given assumption that every run is as good as any other run and so the runs can be summed. The rule of averages determine the performances of the best bowler, best batsman and other. Converting expected scores to probabilities is simplified by assuming scores are geometric. Elderton (1927) used batsmen scores to illustrate exponential distribution, Wood (1945) used geometric distribution of scores to investigate consistency. Elderton and Wood (1945) found that mathematical endeavors exited with the work of Wisden Cricketer Almanac which worked the mathematics of the players, teams and league matches. It provided records for batting averages[24] and the frequency distributions of the scores of individual batsmen. Frequency distribution[25] were found to be approximately geometric progressions[26]. Kimber and Hanford (1993) found that if a set of scores say $x_1, x_2, \ldots x_n$ for a batsman together with indicators $d_1, d_2, d_3 \ldots d_n$ where d_i=0 if the batsman was left out with a score of x_i, they predicted the probability mass function (PMF) as$_1$ x=0,1,2.... Where $0 < \theta < 1$ where the distribution holds for non-negative integers for which it holds. This was for individual players and their performance. While testing

the fit of geometric distribution with $F(x) = \sum_{y=x}^{\infty} p(y)$ denote the survivor function of the underlying scores distribution. Log likelihood of a set of

scores is given by $L = \sum_{i=1}^{n} \{d_i \log h(x_i) + \log F(x_i)\}$ where h=ho, $F(x) = (1-\theta)^x$,

L is maximized $\theta / (1-\theta) = B$. They found that the memoryless geometric distribution was a poor fit for the set of individual scores but the tail of the run scores for a batsman is atleast roughly geometric in form especially the upper tail. They found that in the classical extreme value results of high

scoring values of the batsman would want an assumption for a continuous distribution. Skewness of the distributions indicates that the low centiles may not be very informative. Among the score they also found no presence of autocorrelation furthering no evidence to certain myths of cricketing lores[27].

Elderton and Wood (1945) also found that there was no correlation between the scores of the opening batsman on the same side. Where they found absence of any skewed distribution in the batsman's score of the two sides, they were convinced that total scores of a side in an innings was nearer to binomial than to the geometrical progression. The purpose of defining the distribution is to determine the patterns that may be detected through tabulation but for the Bernoulli trials randomness and its nature to the game is essential where there is an equal likely chance for an event to occur. Colwell and Gillett (1982) found that speculation in cricket vis-vis football was more difficult as the results of the game were much depended on the toss of the coin or the weather. They found that results of tournaments may be sought by distributions of numbers of runs in each sequences where the term in a sequence either be W for Win and L for Loss. Then the sequence with n terms of W's and L's for the tournament of a team could be totaled as

$n_1 + n_2 = n$ where the expected value of the X that is the number of runs

can be obtained as $E(X) = \dfrac{2n_1 n_2}{n} + 1$ and $Var(X) = \dfrac{2n_1 n_2 (2n_1 n_2 - n)}{n^2 (n-1)}$ for larger

N they assumed that X is normally distributed. Where they rounded up the integer values for lower confidence intervals and rounded down for the upper confidence interval.

Clark (1988) used dynamic programming in determining optimal scoring strategies. Johnston, Clark and Noble (1993) furthered it for assessing comparative player performances particularly between batting and bowling. Brooks, Faff and Sokulsy(2002) used an ordinal response model to predict the match outcomes given the batting and bowling strengths of the team.

Clark (1998) in his model of dynamic programming of the one day cricket optimal scoring rates found that for each ball ignoring no balls, run outs and overthrows, a batsman can either lose his wicket without scoring 0 to 6 runs. Let p_d be the probability of dismissal and p_x be the probability of scoring x runs, x=0-6 where

$$p_d + \sum_{0 \le x \le 6} p_x = 1$$

The probability for runs would depend on the skill and batting styles of the batsman, state of the ball, the bowler, the run rate.

Clark (1998) provided that r=run rate/ball is the expected number of runs scored off each ball which can be given by

$$r = \sum_{0 \leq x \leq 6} x.p(x)$$

To increase the run rate a batsman will attempt to alter the distribution of the number of runs per ball where he would like to increase the run rate from 4 to 6 runs in each bowl. Hence run rate was described as R = 6r.

Clark (1999) also gave that at any point $f_n(i)$ be the maximum expected score under an optimal policy in the remaining n balls with i wickets in hand and hence the f(i) function would be given as:

$$f_n(i) \qquad = Max_R\{pd. f_{n-1}(i-1) + \Sigma_{0 \leq x \leq 6} px(x + f_{n-1}(i)\}$$

$$= Max_R\{pd. f_{n-1}(n-1) + \frac{R}{6} + (1-p_d). f_{n-1}(i)\}$$

On dismissal probabilities the Clark (1998) provides for the p_d being a function of the run rate R. These probabilities might be estimated after a match by analyzing the data or before a match by expert opinion. Warren Bretteny (2010) proposed the use of integer optimization for the selection of a fantasy league cricket team based on performance measures (Annexure II) of the batting, bowling, all rounder and wicket keepers as players. He also identified several operation research methodology besides the Duckworth and Lewis method used to solve several expectation at cricket.

V. Factors Affecting the Economic Aspects of the Game
5.1 *Match Outcomes*
Match outcomes probabilities can be modelled using multinomial regressions with a win, draw and loss responses. Covariates it may depend on score or lead, overs remaining or used, run rate, a home advantage factor, surrogates for the state of the pitch and pre-match strengths of teams. Schofield (1982) provided that greater the competitive equality between teams and hence the greater the uncertainty of outcome on the field, greater is spectator interest. Quirk and Fort (1992) found that large city teams dominated competition for the leagues to take advantage of the largest local markets. Liefer (1995) provides that most major league competition is not intrinsically zero sum for the Matthew effect observed by national public supports. Bailey (2005) used the MOV[28] concept to determine the outcomes of the Australian Football league (AFL) and ODI. Bailey used Normal distribution approximations for MOV calculated for AFL and ODIs as against Bailey and Clark (2004) approximation of log- Normal distribution to estimate the ODI outcomes with fielding restrictions and time constrains. For AFL football he used predictors like (a) Home Advantage[29]; (b) Travel Fatigue[30]; (c) Ground familarisation[31]; (d) Measure of performance[32]; (e) Bookmaker prices [33]. The multivariate model for AFL used variables of home advantage, Quality (representing team performance), interstate travel (0,1 (<2hrs),2 (>2 hrs)),

form and familiarization. Bailey for ODI used predictors like (a) Home advantage[34]; (b) Class Structure[35]; (c) distance travelled[36]; (d) Familiarization in host country[37]; (d) Familiarization at the venue[38]; (e) experience[39]; (f) experience against the opposition[40]; (g) measures of performance[41] and (h) Specific measures of performance[42]

5.2 *Opposition*

In 1992 Test and Country Cricket Board (TCCB) determined dual opponents for leagues should be entirely random[43]. Wright (1992) provides for the change in the rules for the counties to conduct matches that appeared to fair but was not much justified with the arch rivalries and the attendances they drew and further by the draw of matches that fixed dual opponents for the championships.

5.3 *Individual Player Performances*
5.3.1 *Team performances*

Team Strength measured using a win percentage for each team in each year calculated as number of matches played in the previous ten years to the number of matches played in previous ten years (Scarf and Akthar).

5.3.2 *Pitches*

Test pitches typically deteriorate with the progress of the match and captains hesitate to make decisions.

5.3.3 *Attendances*

Attendance depends on the significance of the contest with respect to the championships as survey by Cairns (1990), Dobsons and Goddard (2001) and Borland and Macdonald (2003). Attendances since 2003 in the cricket have been falling in Test cricket and hence the emergence of Twenty-Twenty cricket for a quick and fast paced game.

According to Noll (2003) uncertainty of the match does not decide the attendance but who is playing the leagues. If a top ranking player is playing the match there is likely to more attendance than when there are two weak teams playing the match even though outcome is more uncertain there. However it is believed that betting statistics would indicate more gambling perspectives in the latter than the former. Noll provides attendances depend on the strategic location of match venue which if in half an hour distance draws more audience. However the main driver for the audiences is the quality of the team and competition it offers at the match. Arch rivalries and other factors add to the audience interest. Match and season revenues can provide information on the same. To mobilise national public, winning became an imperative and drawn matches were not so suitable as a choice for match outcomes (Latell & Marcus,1988; Rader, 1984; Liefer, 1995). Liefer also found that crowd densities were highest where the delicate balance among teams competitiveness was observed between high performing teams in the sport leagues. He also confirmed that attendance potential exceeded stadium capacity for game between winning teams outside of baseball.

5.4 *Risk and Uncertainty of the Game*
5.4.1 *Balanced versus Unbalanced League Schedules*
   In balanced schedule, all teams play all others an equal number of matches. Unbalanced schedule, each team plays some teams more than others.

5.4.2 *Exclusivity versus Multiplicity*
   Where teams can belong exclusively to one league some multiple memberships are permitted.

5.4.3 *Expulsion of Team*
   All leagues can expel a team if it does not follow the code of conduct devised by the league which includes attending matches, maintenance of players in the team or even indulging in unethical practices so defined by the Leagues like doping or match mixing.

5.4.4 *No. of Teams in a Championship*
   Noll (2003) provides that adding team creates an external cost. Adding a team reduces the probability that each team will win or be in participant member to the championship.

5.4.5 *Closed versus Open Leagues*
   Financially weak markets may support monopolized output and inputs to support the sport. Such markets support closed leagues. However, where the markets are not financially weak or are offered support by the government there open leagues are more popular. Each addition in the open league reduces the probability of the win.

5.4.6 *Rain Interrupted Games/ Game Series*
   Duckworth and Lewis (1998) identified that in case the match was interrupted by rain the most common method used in the past for deciding the result of a game shortened after its start is to award victory to the team with highest average run rate. They further reviewed Average Run Rate (ARR)[44], Most Productive overs (MPO)[45], Discounted most productive overs(DMPO)[46], Parabola (PARAB)[47], World Cup 1996 (WC96)[48] and Clark Curves[49] method for offering resulting solutions to interrupted matches where they clearly identified that these methods did not take into account the stage of the inning at which the overs are lost or the number of wickets have fallen.

   Duckworth and Lewis(1998)[50] developed a model that recognized that batting side has resources at its disposal from which to make its total score. It has overs to face and wicket in hand. Given five assumptions[52] the method was based on two factor relationship between proportion of the total runs which may be scored and the two resources overs to be faced and wickets in hand.

   Average Total Score Z(u) which is obtained in u overs described by the exponential equation is given by

$$Z(u) = Zo\{1-\exp(-bu)\}$$

where, Zo is the asymptotic average total score in unlimited overs, b exponential decay constant.

When w that is wickets are to revise the scores besides the overs as a resource the relations would have the asymptote to be lower and the decay constant will be higher and both will be functions of w. The revised relations is of the form

$$Z(u,w) = Zo(w)[1-\exp\{-b(w)u\}]$$

where, $Zo(w)$ is the asymptotic average total score from the last 10-w wickets in unlimited overs and $b(w)$ is the exponential decay constant.

For N over inning u = N and w = 0 the expected runs are $Z(N,0) = Zo[1-\exp\{-bN\}]$ and the ratio $P(u,w)=Z(u,w)/Z(N,0)$ gives the average proportion of the runs still to be scored in an innings with u overs to be bowled and w wickets down.

Duckworth and Lewis (2004) further found that their method appeal though simple and easy to apply still favoured the team batting second. Teams in knowledge of rain interruption can bat more aggressively as their wickets have to last for fewer overs than the first team. Further captains who won the toss of the coin generally chose to bat second with rain forecasts and generally win.

Duckworth and Lewis (2004) also found that toss and batting and bowling preferences had little influence on the winning capabilities of the team in either interrupted[52]. For interrupted matches, De Silva, Pond and Swartz (2001)[53] found that the toss had no effect on win percentage which was on even split. Identifying toss and batting and balling preferences as irrelevant for winning performances.

5.4.7 *Injury to Main players*

Injuries of the opening Batmans or star players whether bowlers or batsman can affect the team performance. The match results would then not be the same and such circumstances must also be viewed with the alternatives available for determining the team performance.

5.4.8 *Forms of the Team players*

A very good player may not be in form or upto the expected average performances he has exihibited. Such circumstances would put a lower the expectations from the player which need to weighted in a team and its performance for a match or competition.

5.4.9 *Match Fixing*

Results tampered due to corruption or fraud or malpractices lower the unpredictability of the matches played. It has been found that the underworld has been influencing match results based on bets received by them. They happen to corrupt the team players to achieve the desired results in a match or a competition that favour their offering of the bets in many informal set up. Usually formal set up betting avenues tend to discount the information on the match results like that of the stock markets where more efficiencies are found with stock performances reflecting all information. Here if

information is available before the competition or match, corrective actions can be taken. Though if the matches are rigged or fixed it is fraud with the very spirit of the game and sentiment of all those associated with the game.

5.4.10 *Regulatory Issues*

International and National bodies define the competitive spirit of the game. Playing conditions defined for each league, competition or match has a bearing on overall sport and its expectation. Regulatory issued range from selection of a team players; doping; Salaries of players; participation of a players in a competition; playing conditions given to players; selection of a coach; penalties for offences committed during a match; umpire selection; criminalisation of match fixing and others play an important role in the understanding and development of a sport in a country. These issue define the boundaries of the sportman spirit and sport and need to be flexible, competitive and creative to determine and create an environment that is both encouraging, transparent and trustworthy. We discuss these issues in the last section of the paper.

5.4.11 *Social Issues*

Every sport in the world originates from the society that values valour, fair competition, skill and knowledge of the player. Popularity of the sports indicate the inclination of the society towards different skills. Every sport similar from its orgins to evolution has a historical background which the society protects, progresses, develops and nurtures. Tests of human ability in the framework of world records/ national/state/local records creates appreciation from the players and the sports bring cohesiveness and pride in the human ability and the society. Sports from long have been used to build between enemy states. Unfortunately sometimes these social setup and cultural issue can cause disturbances in match performances where the audience turns hostile or the international or national environment is not conducive for a particular team or competition to be hosted. Such issues then affect team players and matches and the overall competition. India versus Pakistan matches for ODI were initially held at Sharjah rather than hosting them in India or Pakistan for the fear of audience exuberance.

5.4.12 *Weather Complications*

When one goes through the playing condition of any competition and as it specifies the ground layouts, advertisement placements and pitch covering arrangement, ball changing avenues, one can understand that every possible effort is made to keep the spirit of the competition fair. However days which may hot, cool, dry or humid are not in the hands of the organiser though they can choose the days for the competition. Similarly sunny or rainy or normal condition cannot be created in outdoor games and they affect performances. The win of a toss and determining who plays first in which weather would influence the

target to chased by the second team. Similarly the toss advantage and weather advantages need to be considered while determining the match results.

VI. Why Hedge? — Need for Cricket Derivatives

Health (1998) defines financial derivatives as an instrument linked to a specific financial instrument or indicator or commodity and through which specific financial risks can be traded in financial markets in their own right. Derivative derives its value from the price of an underlying item such as asset or index. The value of the instrument can only be anticipated or estimated. For the development of a derivative product it is necessary to determine the prevailing market price for an underlying item. Cricket Derivatives in the form of futures, forward, options would need an underlying asset which is the economic commodity Cricket. Cricket however with matches or events is a deliverable and tradeable commodity. A match or the league event is the deliverable. Commodity is priced for different investors differently which ranges from general public viewing the match (either by purchasing tickets, watching it on television or by betting) to sponsors and other stakeholders. Forward contracts which are customized to the needs of the sponsors, broadcasters and others have been in existences for a very long time. Depending on audience reach of a match or league, contracts have been undertaken by corporates, NGO and other sponsors from time to time. Future contracts can be created in a similar manner for Test Cricket, ODIs and Twenty Twenty matches. Auction practices or Tender system has much been prevalent for the discovery of the price. The contract contain a future date, a future price and a deliverable which is associated with the commodity Cricket packaged as Test cricket, ODIs and Twenty-Twenty Matches. The probability of winning, losing or a draw of a match is also traded in the form of bet on several betting counters where betting is legalized and informally where betting is illegal (called Satta Bazar in India). Derivatives as options can be created on the match deliverables of a win, loss or a draw where an option writer (government, Company, NBFC, ICC, BCCI, others) can sell/buy a right to opinion on match results in Match (single) or Match series or a League Championship which is tradable over the counter or exchange. The buyer can then buy/sell a right to opinion on match results in a Match (single) or Match series or League Championship. The volatility of the performance of the teams and the present probability estimates can derive the value of such an option. Such options tradable would enable governments to formalize the trade of cricket performances, limiting the role of the underworld and enable government to generate revenue and protect participation and development of this sport. Here the asset cricket would be deliverable on the event date of the match or the dates of the series of matches or the finale of the league. Opinions would be categorized as Winning Position, Losing Positions or Draw Conditions. Buyer of winning positions would trade with sellers of losing/draw position
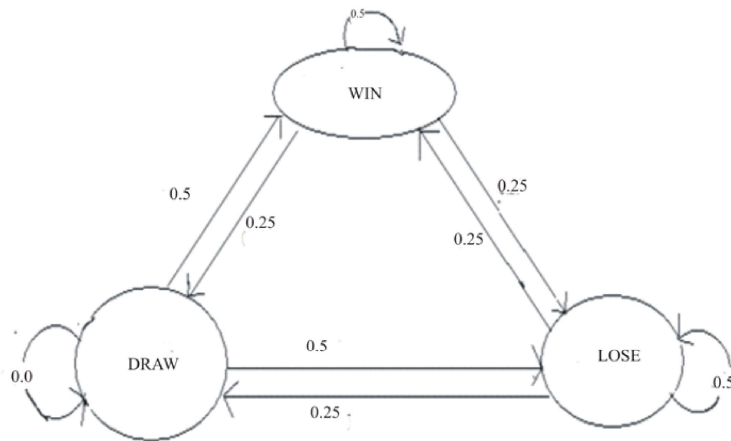
and buyer of losing/draw position would trade with sellers of winning position. Premiums on the options could be determined by the supply and demand of a position and skewness of the market opinions to Winning, Losing or a Draw position. In play options could also be made available on Team players which would again be dependent on the performance volatility of the team member and the probability of a performance outcome. Performance of a team in a match, match series or league would be judged on the several parameters mentioned above. Performance of a Team player would be based on the performance indicator mentioned in Annexure B.

VII. Valuing a Cricket Derivative

Classical probability theory and much of the statistics considers a sequence of chance experiments that have independent trial processes, the possible outcomes for each experiment are the same and occur with the same probability. However in Cricket this is not true specially in league matches. The knowledge of the previous match outcome influences the predictions of future matches. When we observe the matches as a sequence of chance experiments, all of the past outcomes could influence the prediction of next match. Such processes and their outcomes that form a chain are described through the process called Markov Chain given by A A Markov in 1907.

Markov Chain is represented by a set of states $S = \{s_1, s_2, s_3, \ldots s_n\}$ where there are s_i different states, which in this case would be the different matches played by a team with different opponents at different stages of a tournament or league and then be represented as $S = \{m_1, m_2, m_3, \ldots m_n\}$. The process starts with the first match in the series or tournament or league and moves successively from one state of the first match to another state of the next match giving points to the team that plays the match based on the results of the match (win/lose/draw). If a team has match result established as m_1 or s_1 state or generic form m_i state then it move to state m_2 or s_2 or generic state mj. Each move is then called a step from i to j and change in the state can be denoted by probability (p_{ij}). This probability does not depend upon which state the chain was before the current state. There exist a Markov property in each match for its independence. However they have serial dependence just like a chain. Hence every match played by the team is independent of its previous match result but linked with the previous match as a process. The probability p_{ij} are then called transition probabilities. If the previous match results continue to be present in the next match then the probability can be defined as p_{ii}. An initial probability distribution defined on S specifies the starting state of the team playing the match. This can be represented in the square array as follows

$$
\begin{array}{cccc}
 & \text{Win (W)} & \text{Draw (D)} & \text{Loss (L)} \\
P = \begin{array}{c} W \\ D \\ L \end{array} & \left[\begin{array}{ccc} 0.50 & 0.25 & 0.25 \\ 0.50 & 0.00 & 0.50 \\ 0.25 & 0.25 & 0.50 \end{array}\right. & &
\end{array}
$$

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A team playing matches in a tournament is not always blessed with one outcome but with several possibilities. It is possible to play two matches and win both or draw both or lose both. It is possible to win the first one and draw the second or lose the second. To draw the first and win/draw or lose the second or to lose the first and win/draw or lose the second. The first row in the this transition matrix represents the probabilities for various results following a win and second row results following a draw and the third row following a loss. The same transition matrix in a generalised format would appear as follows

$$\begin{matrix} & \text{Win (W)} & \text{Draw (D)} & \text{Loss (L)} \\ P = \begin{matrix} W \\ D \\ L \end{matrix} & \begin{bmatrix} P_{11} & P_{12} & P_{13} \\ P_{21} & P_{22} & P_{23} \\ P_{31} & P_{32} & P_{33} \end{bmatrix} \end{matrix}$$

represented as p_{ii} and p_{ij} formats. A similar attempt of using Markov Chain for estimating cricket outcomes between the same two teams England and Australia with results outcomes as win/losses/draws were considered by Bendall and Eggar (2001). They considered any sequence of length N of letters chosen from the set {E, A, D} where E represents England wins, A represents Austrailia wins and D represents a draw. Let n (E), n (A), n (D) denote the number of letters "E", "A", "D" respectively in the sequence. Let n (E, A) denote the number of occasions in

the sequence that the letter "E" is followed immediately by the letter "A". They defined n (E, E), n (E, D), n (A, A), ..., n (D, D) similarly. For example, for the sequence EADEEEAA they found that they have N = 8, n (E) = 4, n (A) = 3, n (D) = 1, n(E,A) = 2, n(A,D) = 1, n(D,E) = 1, n(E,E) = 2, n(A,A) = 1,n(E, D) = 0, n(A, E) = 0, n(D, A) = 0, n(D, D) = 0. In [1] this information (for the sequence of test results, where E = England win, A = Australian win, D = draw) was recorded in a 3 x 3 matrix

$$\begin{bmatrix} n(E,E) & n(E,A) & n(E,D) \\ n(A,E) & n(A,A) & n(A,D) \\ n(D,E) & n(D,A) & n(D,D) \end{bmatrix}$$

and the matrix P was formed

$$P = \begin{bmatrix} p(E,E) & p(E,A) & p(E,D) \\ p(A,E) & p(A,A) & p(A,D) \\ p(D,E) & p(D,A) & p(D,D) \end{bmatrix}$$

by dividing each element of the first matrix by the sum of the elements in its row, e.g. p (D, A) = n (D, A) / (n (D, E) + n (D,A) + n (D,D)). They further found that p (D, A) gives the best estimate obtainable from the data for the conditional probability that an element of the sequence is an 'A', given that the previous element is a 'D'. Define p (E) = n (E) N, p (A) = n (A) N, p(D) = n(D)/N.

In a simpler language the win/losses /draws for games played between two similar teams is identified to determined the probability using the events approach. In our case we have one team play two different matches with two different teams. Thus the probability of England Play with Australia and South Africa. The first match as England versus Australia and the second as England versus South Africa. The two matches are independent though but in a series the results of the first match is likely to impact the outcome of the second match and a chain /series of these matches then defines the winner of a series or tournament. Here for the two matches we would calculate the total matches played between England versus Australia and England versus South Africa given as N total observations of which we can calculate N. Here the total win/losses / Draws of the England versus Australia can be determined and between England versus South Africa can be determined. The transition matrix must follow the following feature

i.   It is square, since all possible states must be used both as row and as columns;
ii.   Since entries represent probabilities they must lie between 0 and 1;
iii. The sum of the entries in any row must be 1

The power of the transition matrix cannot be used to define the different states as the only one team is constant and the opposing team would change. The initial distribution of the states of a team ability to perform can be determined by simply dividing the Total Matches won/lost/draw with a particular team over the Total matches played between two specific teams which can be normalised to the total matches played by either teams. This initial distribution would give rise to probability vectors. A probability vector is a matrix with only one row, having non negative entries with the sum of entries equal to 1. The transition matrix P given above would then be multiplied with the probability vector (í) to determine the distribution of the state which would be given as í P. Let us assume that team England has the following í which is given as

$$V = \begin{matrix} W & D & L \\ \overbrace{[0.65 \quad 0.07 \quad 0.28]} \end{matrix}$$

With the probability vector and transition matrix for first state (P_1) the probability that the chain/process is in state s_i can be given by

$$v^n = vP_n$$

where, P_n would be calculated as the $P_1.P_2.P_3......P_n$. A vector matrix can be developed for each transition state of the next match. The probability vector matrix when multiplied with the transition matrix would give normalised probabilities because of the event probabilities draw over a long period and large number of matches. Transition probabilities for each match between two teams can be determined using   Bendall and Egar (2001) and means of identifying outcomes with W,L and D sequences of the total matches played by the two teams and their distributions using Colwell and Gillett (1982) method.
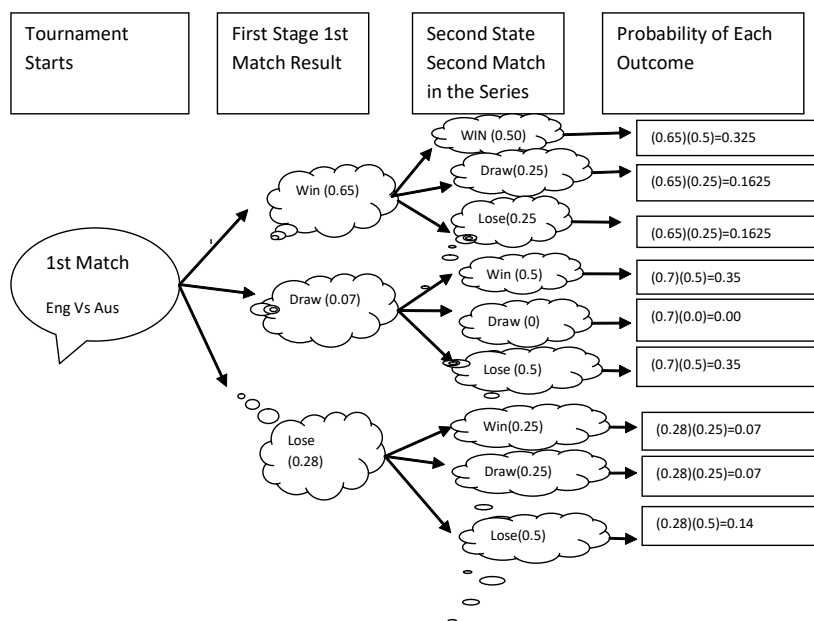
The figures in brackets represent probability of the match result.

The probability that the team would win both the matches would be given by

$$P_{win-win} = 0.325+0.35+0.07=0.745$$

Draw possibilities are often converted into win or loss condition based on some performance index like in case of the ICC Cricket World Cup it may be the run rate which leaves the match results to binomial

possibilities of a WIN or LOSS that can be identified with a binomial distribution with p and q as probabilities of favourable and unfavourable events.

If there are *r* absorbing states (Ab) (entry (win) or exit (loss), so there are two absorbing states) and t transient states (Tr) (Draw is the only transient state, so there one transient state), the transition matrix will have the following canonical form

$$P = \begin{array}{c} \\ Tr \\ Ab \end{array} \begin{array}{c} Tr \quad Ab \\ \begin{bmatrix} Q & R \\ O & l \end{bmatrix} \end{array}$$

where,

Q is a t by t matrix
R is a non zero matrix of t by r =P_n
I is a r by r identity matrix

So from a transient state the process would move to an absorbing state.

Just like R matrix would the absorption states after *n* times Q would represent the transient state would be established after *n* matches are played. As n approaches infinity the Q matrix would also approach 0.

The match results that decides the team's participation or exit to or from the next level would define the absorption and transient states of the league much to Markov Drunkard walk example the first step would be the exit and fourth its entry to the next level. The N number of time the transient state would take to become an absorbing state is also definable through the fundamental matrix however in most leagues it is a fixed number of matches which determining an absorbing state, for example ICC Cricket World Cup 2015, a team has to play and be among the top four in its pool match series in case there seven teams then there are 21 matches that will determine the winner.[54]

Given the probabilities and the match outcome of Win identified with twice the payoffs and Loss identified as zero payoffs a option can be created with runs rate or number of runs as the strike rate[55] on which the buyer can choose to exercise the option or not to exercise the option of betting on the team for its win or loss or its participation to the next level. A binomial tree approach can be used to determine the value of the option. Both call and put options can be created and trade can take place between the buyers of winning possibilities of a team or losing possibilities of a team.

The value of a win or loss can be calculated for a team player or a team based on computing the average of the indicators of team players performance or a team's performance using cricket performance indicators which can be z in number as mentioned above. We take the average of the n number of cricket performance indicators. We then calculate the dimension index as is the actual value of the dimension, is the minimum value of the dimension, is the

maximum value of the dimension. The value of the cricket performance at the team players level or team level can be measured by the cricket index given as

The cricket indicator so devised for a team players performance or a team performance is measured by normalized inverse of Euclidean distance from point d_i from an ideal point I which is equal to 1. The numerator of the CI is the Euclidean distance from an ideal point, normalizing it by square root of the number of observations and subtracting it by 1 giving an inverse of normalized distance. The index value will give the initial start value of the team player or team from where the valuation would begin. Then instead of A_i we take Me_i =Median value of z parameters to calculated the CI which would be the upper value of the performance for a team player or team. Valuation of the team player performance can then be evaluated using a Binomial Tree Approach. The cricket indicator is normalized to lie between 0 and 1 where 0 would indicate a loss and 1 a win.

Cricket Derivatives can be created to the making or accepting a prediction on the competition or other event or process or on a team player's performance or team performance with the likelihood of anything occurring or not occurring or whether anything is true or not. There can be fixed amount options where a buyer takes a stake to receive a fixed amount calculated by the odds available for which he pays a premium. Options can be provided by the exchange (cricket/sport derivatives). Different option can be created as

i. *Straight Options*
— Win, if your team finishes first in the competition,
— Place,if your team reaches finals
— Show if your team reaches Semifinals/Quaterfinals

ii. *Exotic Options*
— Exacta if you choose the correct order of the teams finishing the finals
— Superfecta if you choose the correct order of the teams finishing the Semifinals
— Quaterfecta if you choose the correct order of the teams finishing the Quaterfinals
— Daily Doubles if you choose the winners of two consecutive matches in a competitions before the matches
— Pick 3 if you choose the winner of three consecutive matches in a competition before the matches
— Pick 4 if you choose the winner of four consecutive matches in a competition before the matches
— Head to Head where you choose two teams out of the several teams competing in a competition and place a bet on winning of one team. Irrespective of how other teams play, your option would be dependent on the relative performance of the chosen teams
— Combinations: (a) *Across the Board:* When same team or team player performance is chosen for all three straight options; (b) *Box :* When two or more exotic options are chosen for more than one team or team player performance; (c) *Exotic Straight Combination*: A combination of exotic

and straight combination on teams and team players; (d) *Pool:* Different performance indicators are choosen to define the team or team player performance in a match or a series of matches; (e) *Probable Payoffs*: Exotic Option payoffs on all competing teams or team players of a specific team; (f) *Wheel*: Exotic Wager of one team with all other teams in pool matches or quarter finals or semifinals or finals;(g) *Will Pays*: Actual payoffs of exotic multiple options shown before the competition begins for all possible winning team combinations.

iii.   *Options on Teams, Batmans, Bowlers and All rounders can also be created with the ICC Rankings available from different websites*

— www.cricbuzz.com/cricket-stats/icc-rankings for test, ODI and T20
— www.icc-cricket.com/player-rankings/overview
— www.relianceiccrankings.com
— www.espncricinfo.com/rankings/content/page/211270.html
— www.bbc.com/sport/cricket/28970884
— www.cricwaves.com/cricket/ratings/playerratings.html
— sports.ndtv.com/cricket/rankings
— sports.mapsofindia.com/cricket/icc-top-ten-t20-batsmen.html and others

Just like stock index options are traded, the ranking indexes available may be used define the new ranks after each competition. A match performance of a team can also be determined using logit or probit models of developing win/loss outcomes given the profiles of teams on the ICC website. Similarly a players performance as a batsman, bowler, all rounder can also be determined using regression estimate. We are presently not calculating the same and would follow it in our future papers.

iv.   *Pool Options:* Options created with corpus using a special purpose vehicle that has member investing in a predicition. In case of a favourable prediction, the fixed amount (minus commission) would be divided among the members.

v.   *Spread Options:* Option created with spreads of different payoffs of straight and exotic options

VIII. Social and Stakeholder Welfare with Cricket Derivatives

The sports market accounts for about 2% of the World GDP[56]. The market in Sports are an integral part of any economy. It is estimated that the market was worth Euro 800 billion to Euro 900 billions in 2011 excluding the parallel market of illegal sport bets. It is estimated that sport wagering agreements alone are worth trillions of Euro/US dollars. When we add the illegal market with most conservative estimate, it indicates that volume of the sector can rise from 20%-50% to the highest estimate of 100%. Before the match fixing scandals were unearthed the industry thrived on the thrill of demonstrating valor, integrity, fair competition and unpredictability that has attracted billions of people to the world of sports. Global sporting events, their revenue streams of television events and sports betting had increased exponentially from 1921 to present age. Scandals have caused much fanfare to fall leading to a rise in speculation oriented

activities which has received much boost by the legalized online betting platforms in many countries like U.K., Australia and others. A negative side of globalization has been added to the game whereby massive amounts of money is laundered through this sector, much questioning the integrity of stakeholders of this segment, shaking public and private confidence in this industry.

Match fixing and money laundering are a serious threat to the sports world and economies worldwide. UNODC describes match fixing as an arrangement an arrangement or irregular alteration of the course or result of a sporting competition or any of its particular events (e.g. matches, races etc.) in order to remove all or part of the uncertainty normally associated with competition. In a study on criminalization approach to combat match fixing out of 19 jurisdictions (namely Argentina, Australia, Brazil, Canada, China, including Hong Kong (Special Administrative Region of the People's Republic of China), Japan, Malaysia, New Zealand, Nigeria, Qatar, Republic of Korea, Russian Federation, South Africa, Thailand, Trinidad and Tobago, Ukraine, United Arab Emirates and the United States of America) studied with civil and common law systems only 5 jurisdictions have specific or ad hoc criminal offences for match fixing. Bribery[57] and fraud provisions are mostly applicable in most jurisdictions as the objective of match fixing is not very clear.

In the above mentioned 19 jurisdiction, the ambit of gambling was found to be very different. Gambling is prohibited in some countries and in some it is allowed. Countries where it is legal[58] to gamble, a framework for illegal gambling[59] and irregular gambling[60] is also available. Such countries attract not only domestic speculators but international speculators not specifically associated to any sport. There is specific recognistion of gambling and match fixing offence in many countries with specific acts like in Australia -Interactive Gambling Act 2001; Hong Kong (Special Administrative Region of the People's Republic of China)-Gambling Ordinance 1997; Malaysia-Betting Act 1953; New Zealand-Gambling Act 2004; Qatar-Gambling (Article 275 qPC); Republic of Korea-Gambling, habitual gambling (Article 246 kCA), National Sports Promotion Act (NSPA) 2007; Russian Federation -Bribery of Participants and Organizers of Professional Sports and Entertainment Profit-making Competitions Provision; South Africa-National Sport and Recreation Act 110 of 1998; Ukraine-Gambling Business (Article 203); UAE-Gambling (Article 414 uaePC), USA-Bribery in sporting contests (18 USC Section 224); European Union-9 states have specific provisions to match fixing;

Poor governance and standards continue to plague the world of sports. Criminalisation of the sports world has made many economies vulnerable. Governance issues demand policy frameworks that guide and direct wealth transfers to clubs either by ownerships, sponsorships or illegal betting means; also requires comprehensive framework for supportive payment to athletes, umpires; creating sufficient facilities for education among athletes for sport integrity; requires making Board/trusts/clubs publicly

accountable especially the one that acquire national importance like BCCI with pubic disclosure of the financial and administrative structures of Boards. Governments need to create watchdog for market regulations whichever regulation model they follow (prohibition (US), Monopoly (Israel) and Licences (Norway). It is found that information and regulatory asymmetries have crippled multilateral and multinational investigations in matter of illegal betting and corruption. Whistleblower protection is also must to improve the governance of the sports industry. The acts[62] of doping; recreational drug use; violence on/off the field; racism and discrimination; illegal sports gambling; match-fixing and competition manipulation; vilification, hetero sexism; abuse of children and young persons; sexual harassment, assault and violence; Off-field bad behaviour, especially related to gender and sexuality; Human trafficking ; Coaching malpractices; Player school/academy and transfer abuses; Sport management malpractices; Procurement transparency and accountability issues; Institutional fraud; Inappropriate sponsorship and funding; Corruption via organised crime should be severely punished with proper regulatory frameworks in place. Presently, repressive measures and potential sanctions limit the illegal trade.

This confidence in the game and sports worldwide can be restored with cricket derivatives valuing a match, team and a team player upon their performances. The instrument would then hedge anyone investment of time, confidence and money in sports. Instead of speculating on the outcomes and losing money to informal and illegal channels, fans worldwide would have an avenue to earn or invest their money on their planned prediction. Several Million dollars of public and the government tax revenues that the governments have been loosing can be recoverd. Role of the underworld fear and participation in speculative activities can be reduced. More transparency and accountability can be associated with the matches, teams and team players by scientifically determining the odd of winning and losing. Speculators can be converted into investors. With Derivatives there would be reduction in this parallel economy as it would now become a part of organised planned investment avenue with interest aligned to scientifically understood event performances.

IX. Limitation of the study and instrument

The study is aimed at protecting the public that losses several trillion dollors in illegal activities soiling the spirit of the sport. Derivatives would be used to introduce more planned, understandable odds of wins/losses of the most popular sport in India. Filter by regulatory bodies in determining an exchange that offers such a product by itself or through brokers or direct seller and using clearing houses to mitigate the risk need to be explored. The study ventures into an instrument that is likely to contribute to the confidence in sport community and its performance after the informal market is kicked out of this business because of government or organized sector patronage. The study so far has not explore the covenants of the instrument, its standardization and trade terms. It has only expressed the possibility of such instruments being introduced to protect speculator or gamblers who lose heftily in the hand of the underworld.

X. Scope for Further Research

We have tried to explore several aspects of the game, its scientifically determined outcomes and instruments called Cricket Derivative that can be created for the welfare of people. Research on logit and probit models for determination of the outcomes of matches, competition and team players has not been explored. Development of rankings that can be used as Cricket index derivatives has also not been explored. Further, the development of payoffs of the instruments has not been also explored. Specific instrument for organisations like ICC, BCCI, Yorkshire Country club that deal with sporting events alone have not been formulated as yet. Value at risk measures can be used to further develop specific instruments for them. We intend to develop our work in near future by elaborating on some of these issues.

Notes

1. Star Group paid BCCI Rs. 3851 crore to telecast cricket matches on Indian soil from 2012 to 2018. A fee of Rs. 32 crore per match between 2012 and 2014 and Rs. 40 crore per match between 2014 and 2018.
2. Betfair Annual report 2013
3. In 2012 A TV sting caught players taking bribes to spot fix games and alleging how under hand money is a norm in IPL.
4. Most cricket association are headed by Ministers at the state or center in India besides the association of several big businessmen. In 2012, Union Power Minister Jyotiaditya Scindia was the president of Madhya Pradesh Cricket Association, Rajeev Shukla, Minister of State or parliamentary affairs was chief of Uttar Pradesh Cricket Association. BCCI's president's has made headline over the long fights of Dalmiya and Bindra, Dalmiya and A.C. Muthaih (2001), Srinivasin and Lalit Modi(2010). In 2010, Lalit Modi was ousted as IPL chairman facing 15 charges of irregularities in the initial bids of Rajasthan Royals and Kings XI Punjab broadcasting deal and bid rigging of the two franchises.
5. In the year 2010 there was a big time controversy surrounding the new Kochi consortium that lead to the resignation of Shashi Tharoor, the team mentor.
6. In year 2007 the conflict of interest issue came up when India Cements Srinivasan's company bought the Chennai IPL franchise. Srinivasan was then BCCI treasurer and the conflicting interests were resolved by making amendments to the BCCI constitution which made it possible for BCCI stakeholders to have interest in the T20 competitions.
7. W.F. Mandle, 1972, The Professional cricketer in England in the Nineteenth Century, Labour History, No. 23, pp.1-16
8. See Shofield J.A. 1982, The Development of First class cricket in England: An Economic Analysis, The Journal of Industrial economics, Vol. XXX, No. 4, pp. 337-360 for more.
9. Mandel (1972) notes the history of cricket as obscure. He provides that the sport by the eighteenth century was flourishing in south England. Aristocrats such as Dules of Dorset, Newcastle, Hamilton and Richmond and the Earls of Winchilsea and Sandwich and Lords Tankerville and Beauclerk gathered teams together, nominally called 'Kent' or 'Sussez or 'Surrey' to play games for stakes and satisfaction.
10. Formed in December 1928 as a private club consortium registered under the Tamil Nadu Societies Registration Act, 1975. The control of the board in 1931 was oscillating between Maharaja of Patiala, Viceroy Lord Willingdon and the Maharajkumar of Vizianagaram. As per the newspaper report dated May 2013, BCC I has total assets worth Rs. 3,308 crores and annual surplus of Rs. 385 crores in 2010-11. Till 2006, BCCI functioned from house of the president and later obtained its offices in Wankhede Stadium. BCCI consists of sub committees of finance, marketing, IPL governing council and the tours and fixtures committees that decide match venues. The board consist of 27 state associations. Each state association

headed by voting member draws money out of BCCI profit pool. Annual distributions of about Rs. 25 and Rs. 30 crore for each association are obtained through predetermined formulas on IPL grants and TV subsidies. BCCI is presently not under the Right to Information (RTI) purview under the Sports Bill, so not many details can be sought by the general public for the same.

11. Lefthanders may derive an advantage in sports like cricket, tennis, fencing, boxing as most sportsmen have right hand positions. A partnership of left hand batsman with right hand batsmen is difficult to bowl.

12. Barton also provides for the index ā of the power law curves of best fit in Table 2 that gets smaller as the seam angle gets larger. He also found that the ball may be impaired in case there are any irregularities in a ball's surface like scuff marks, printing, brand marks, ridges associated with the secondary seam and uneven curvature. A ball can be balled as a good length ball, pull shot, bouncer and a Yorker.

13. See Preston Ian and Jonathan Thomas, 2002, Rain rules for limited overs cricket and probabilities of victory, Journal of Royal statistical society, series D (The Statistician), Vol. 51, No. 2, pp. 189-202 and Duckworth F C and AJ Lewis, 2004, A successful operational research intervention in one-day cricket, Vol. 55, pp. 749-759.

14. Barton (1982) referred to nature and magnitude of certain transverse aerodynamic forces on cricket balls in flight. He noted that the cricket balls swing well if the ball has a prominent seam inclined at a slight angle to the direction of the projection. Though the experiment conducted by him denied the fact that the cricket ball swings more on humid days.

15. Form = (Short Term EDMA)/(Long Term EDMA)*100 (see Shah and Shah (2014)). Exponential moving average of the runs scored, Short term considers five matches and longterm considers eleven matches. The minimum over rate to be achieved in the matches is 14.28 per hour.

16. 2012 A sting operation umpires caught Pakistani Nadeem Ghauri and Anees Siddiqui, Sri Lanka's Gamini Dissanayake, Maurice Winston, Sagara Gallage along with Nadir Shah of Bangladesh agreeing to take money to spot fix.

17. With countries like England, Australia and South Africa reigning cricket, the game has suffered from unfair advantage to these and other countries. Many countries that non neutral umpires and games rules are used as a strategy to combat competitive streak of many Asian and other players. Third umpire verdicts with better and advanced technology have cancelled any speculations on the decisions for now, yet penalties continue to be questionable. Further issue or corruption in the governing bodies with selection, administrative and other matters continue gray the area of cricket. Doping, betting and criminal offences of physical harm have further tainted the game.

18. See Home advantage

19. Scientiae Magister provides that rules of the game restrict bowling or fielding actions. For example in Twenty 20 cricket each bowler can bowl a maximum of one fifth of the allocated overs and for matches not interrupted by rain this is a maximum of 4. Fielding restriction may exist for first 6 overs and after power play. Also the rules of the game restrict the number of fielders at any given point of time that may be allowed on the leg side.

20. Leagues with fixed membership and territorial exclusivity

21. League based on promotion and relegation system

22. Past successes are often used by public, analysts and others to form performance expectations. Winning teams often receive higher fan following and losing teams are often abandoned. High(low) performance expectations help a team continue winning (losing) and hence induce performance inequalities.

23. Kimber and Hanford(1993)

24. Batting Averages (Wisden's Cricketer Almanac) was given by Total runs scored by the number of "completed" innings (i.e. the total number of inning played less those when the batsmen was "not out".

25. Earliest work of Frequency distribution found in Primer of Statistics (W.P. and E.M. Elderton), pp. 42-44 on the assumption the individual scores made in 1905, 1906 and 1907 by four cricketers.

26. If geometric progression holds for batman it would mean with n runs made he is likely to increase the score to n+1.

27. Cricketing lores in Kimber and Hanford(1993) indicates that (a) a batsman is vulnerable

when going first in to bat; (b) some batsmen are accused of being careless when well set and some scores are claimed to unlucky or difficult such as 87, 111 and the 'nervous nineties'; (c) after scoring many runs batsman tires and becomes error prone.

28. MOV can be readily quantified by converting remaining resources into runs which more easily possible in ODIs as against test matches.
29. HA measured by average winning margin of the nominal home side in the AFL in five year periods.
30. Measured by introduction of a binomial variable to identify interstate travel using a cut off of 1500 Km (approx.. two hour travel). Teams travelling more than two were found to be disadvantage by an additional goal.
31. Based on the number of matches played at different venues , home versus away. Familiarity was gained with 100 matches at a given venue. MOV was proportional to the difference in experience between two teams.
32. Moving or exponential average of past performances.
33. Collected from Centrebet on Friday morning prior to the commencement of each round of matches
34. ODI recognized with either triangular or round robin format. Differentiated between leading and developing cricketing nations.
35. Distingushes MOV for developing and established nations.
36. Found negligent effect of travel fatigue on the players for the game is played in series
37. Viewed as how often teams have played with a given country or how often teams have played at a given ground within each country. Found that greater the difference in familiarity between two teams the greater MOV.
38. Clear advantage was found for having played at a venue more times. Measured in terms of MOV gains with more than 10 matches played at a venue.
39. Measured by the number of previous matches played
40. Found at the individual level and not at the team level relevant
41. At two level current and overall quality measured using moving and exponential smoothening averages
42. Past average and exponential smoothing average to determine the form and quality
43. Wright(1992) provides that English Country cricket championship structure was questioned in 1992 where each county as per the structure played the same dual opponent every year. It was believed by most that the structure of the league was discriminatory giving an advantage to Worcestershire (Structure of the leagues such that 22 matches in competition, 26 of three day duration and six of four days such that each county played ten other counties once only in three day match but the other six twice. Pair that played twice were dual opponents.) The introduction of Durham a weak team in 1992 was then opposed for giving further unfair advantage to already
44. Winning Team is decided by the higher average number of runs per over that each team has had the opportunity to receive.
45. The target is determined for the overs the team batting second (Team 2) are to receive by totaling the same number of the highest scoring overs of Team 1. The method favours Team 1.
46. Total of most productive overs is discounted by 0.5%for each over lost. Still favours Team 1
47. Rego (South African) calculated Table of norms y for overs of an innings x using the parabola $y=7.46x-0.059x^2$ to the model. Point of Inflexion is at 63 runs. Diminishing returns measured as total runs scored and total number of over available.
48. As per PARAB method each norm is converted into a percentage.
49. Defines six stoppages of three for each innings. Stoppages occurring before innings commences, during the innings or to terminate the innings. Different rules for each interruption.
50. In case of interrupted matches, if due to suspension of play after start of the match, the number of overs in the inning of either team have to be revised to a lesser number than originally allotted (minimum 20 overs) then the revised target score should be set for the number of overs which the team batting second will face and the target will be calculated using this method. In case o prematurely terminated matches the match will be decided by the comparison with D/L Par Score determined at the time of suspension by the same method.

51. Assumptions: (a) The match must be equally fair to both sides that is relative positions of two teams should be exactly the same after the interruption as they were before it; (b) It must give sensible results to all conceivable situations; (c) Should be independent of Team 1s scoring pattern as indeed is the target in an uninterrupted game; (d) Should be easy to apply, requiring more than a table of numbers and pocket calculators; (e) Should be easily understood by all involved in the game, players, officials, spectators and reporters.

52. They took a case history from 1997 to 2003 with 375 matches that were concluding following one or more stoppages. Of these Team 1 win percentage was 52.8% (not statistically significant different from an even split.

53. With 797 uninterrupted ODIs conducted between 1991-2000, team 1 win percentage of 51.9%.

54. Competition Format (reproduced from the ICC World Cup 2015-Playing Conditions) for ICC Cricket World Cup 2015 was with the contest by 14 teams which were divided into two pools namely Pool A and Pool B Pool A consisted of England, Australia, Sri Lanka, Bangladesh, New Zealand, Afghanistan and Scotland. Pool B consisted of South Africa, India, Pakistan, West Indies, Zimbabwe, Ireland, United Arab Emirates. The first round of the completion was a pool stage round with each team playing with other team in their pool. Thereby every team with their pool countries would play six matches overall and for each pool there would be 21 matches. Pool Matches will be given points on the following basis:

Win   2
Tie, No Result or Abandoned 1
Loss   0

The top four teams from each pool shall then qualify for Quarter Finals. In case two *teams tie on the points basis then the team with higher2 net run rate* in the pool matches will be placed in the higher position. After the pool stage the top four (4) teams in each pool will play quarter-finals as follows

Quarter Final 1   A1 vs B4
Quarter Final 2   A2 vs B3
Quarter Final 3   A3 vs B2
Quarter Final 4   A4 vs B1

The winners of the quarter finals shall play semi finals in the following order

Semi Final 1 Winner QF 1 vs Winner QF 3
Semi Final 2 Winner QF 2 vs Winner QF 4

The winners of semifinals shall play the finals.

55. The strike rate can also be determined on any of the performance indicators given in Annexure II

56. Illicit Trade, OECD publication

57. Six Corruption criminal offences in match fixing are Active and passive bribery in the public sector; Active and passive trading in influence; and Active and passive bribery in the private sector.

58. It means all types of betting that are allowed on a specific territory or jurisdiction (e.g. by licence given by a regulator or recognition of licences given by the regulator of a third country).

59. all types of betting that are not allowed on a specific territory or jurisdiction.

60. mean all types of betting based on match-fixing

61. Sports Integrity: The Real Problem, ppt by International Centre for Sport Security, The Centre of Excellence in Sport Safety, Security and Integrity

62. Prepared using the terminology and definition given for Cricket at Britannica *Encyclopedia* (http://www.britannica.com/EBchecked/topic/142911/cricket/299671/21st-century-developments#toc30493) and official website of ICC , BCCI and Online resources of JSTOR.

63. BCCI's secret society: Power, patronage and intrigue. The inside story of how Indian cricket is controlled By Kunal Pradhan and G.S. Vivek May 31, 2013 at India todayin

64. Sourced from Brettenny Warren, Integer Optimisation for the selection of a Fantasy League Cricket Team, Magister Scientiae dissertation, Faculty of Science, Nelson Mandela Metropolitan University

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Annexure I
Cricket Terminologies[62]

Bails: Two horizontal pieces placed on the across the top of each wicket. Two pieces of wood called bails, each 4.37 inches (11.1 cm) long, lie in grooves on the tops of the stumps. The bails do not extend beyond the stumps and do not project more than half an inch above them.

Ball: The ball, which has a core of cork built up with string, was traditionally encased in polished red leather, although white is now frequently used, especially for night games. The halves of the ball are sewn together with a raised seam (the seam being like the equator on a globe, not like the curved seam of a baseball or tennis ball).

Bat: The blade of the paddle-shaped bat is made of willow and must not be broader than 4.25 inches (10.8 cm). The length of the bat, including the handle, must not exceed 38 inches (96.5 cm).

Board for Control of Cricket in India (BCCI)[64]**:** BCCI was formed in December 1928 as a private club consortium registered under the Tamil Nadu Societies Registration Act, 1975.

Boundary Line: Lines in the ground that define the playing area

Bowling Crease: A line drawn through the base of the stumps and extending 4.33 feet (1.32 metres) on either side of the centre stump.

County Cricket: Cricket organized by specific administered areas having territorial rights for organizing and broadcasting cricket. Initially started matches between amatuers and professionals and then between different counties.

Cricket Council: A governing body of the sport which in England consists of Test and County Cricket Board (TCCB), the National Cricket Association (NCA), and the MCC. In India we have the BCCI.

Cricket Ground/ Field: An oval field where cricket is played. t Lord's in London (5.5 acres [2.2 hectares] and the even larger Melbourne Cricket Ground, to village greens and small meadows.

Cricket: A game played with a bat and ball involving two competing sides (teams) of 11 players in each team. One player is additional in each team to support any injury or accident that may preclude the any one of the 11 players from playing. Read Rules of the game at ICC website (http://icc-live.s3.amazonaws.com/cms/media/about_docs/518a6f5d5f88e-Third%20Umpire%20-%20Decision%20Review%20System.pdf)

Decision Review System: Rules governing decisions in matches involving third empire. Available at ICC web site : http://www.icc-cricket.com/about/38/rules-and-regulations)

Duckworth Lewis Method: A professional method used by ICC for determining the revised target for a match that was suspended after it has started such that the number of overs available to be faced by either side is reduced from that determined when match started.

England and Wales Cricket Board (ECB): TCCB, the NCA, and the Cricket Council were all subsumed in 1997 into ECB.

Innings: Each turn of batting or balling in a match for a team.

International Cricket Council (ICC): Founded in 1909 as Imperial Cricket Conference by representative from England, Australia and South Africa and took its present name ICC in 1989. is the global governing body for international cricket, encompassing men's, women's and youth participation and competition. Full Members are 10 Members, Associate Members are 37 Members and Affiliate Members are 59.

International Cricket Council's key rules and regulations: Rules and regulation for playing cricket for Men Matches; Women Matches; Approved/disapproved cricket and domestic crickets; ICC classification of cricket. Available at ICC web site : http://www.icc-cricket.com/about/38/rules-and-regulations)

Leg before Wicket (LBW): LBW law, which had been introduced in the 1774 laws to prohibit a batsman from using his body to prevent the ball from hitting his wicket.

Marylebone Cricket Club (MCC): One of the oldest and longest reigning cricket clubs of Londons in the second half of the 18th Century that gave the first revised code of laws to play cricket. Ended most controls in 1969 but still has some responsibility for cricket laws.

One Day Internationals (ODIs): A style of one day cricket usually consisting of 50 overs per side

Over: A bowlers delivery of six balls to a wicket.

Pitch: A rectangular area in the middle of the oval cricket field/ground that is 22 yards (20.12 metres) by 10 feet (3.04 metres) wide.

Players, Player Support Personnel and Officials Information at ICC: Rules for players conduct, umpires conduct, anticorruption, anti-doping, anti-racism, Illegal bowling actions, pitch monitoring process, clothing and equipment regulation and eligibility rules for players available at ICC website.

Popping Crease: A line parallel with the bowling crease and 4 feet in front of it. When a batsman is running between wickets, the crease represents the area in which he is "safe" (in baseball parlance) and only a cricketer's bat need be in the crease; thus a batsman will often place just the tip of the bat over the line of the crease and then begin to run for the opposite wicket.

Return Crease: A line at each end of and at right angles to the bowling crease, extending behind the wicket. Marks the area within which the bowlers rear foot must be grounded in delivering the ball.

Test Matches: A style of cricket that may last usually for 3-5 days with unlimited overs given to each side.

Twenty20 (T20): A style of one-day cricket consisting of 20 overs per side

University Cricket: Cricket played at the college level. Players are less skilled and trained to enter counties.

Wicket: Two set of three sticks called stumps each of each 28 inches (71.1 cm) high and of equal thickness (about 1.25 inches in diameter), stuck into the ground and so spaced that the ball cannot pass between them. They are placed at the two end of the pitch.

Annexure II
List of Performance Indicators[64]

Batting Average

$$Aver^t_{BAT} = \frac{Total\ number\ of\ Runs\ Scored}{Total\ Number\ of\ Times\ Dismissed}$$

Batting Strike Rate

$$= SR^t_{BAT} = \frac{Total\ number\ of\ Runs\ Scored}{Total\ Number\ of\ Ball\ Faced} \times 100$$

Bowling Average

$$AVE^t_{BWL} = \frac{Total\ number\ of\ Runs\ Conceded}{Total\ Number\ of\ WicketTaken}$$

Bowling Economy Rate

$$ECON^t_{BWL} = \frac{Total\ number\ of\ Runs\ Conceded}{Total\ Number\ of\ Balls\ Bowled} \times 6$$

Bowling Strike Rate

$$SR^T_{BWL} = \frac{Total\ number\ of\ Balls\ Bowled}{Total\ Number\ of\ Wickets\ Taken}$$

Combined Bowling Rate

$$CBR = \frac{3r}{w + \frac{1}{6b} + rw/b}$$

Lemmer's Batting Performance

$$BP = AVE^{exp}_{BAT} \times C_{st} \times SR^{tr}_{st}$$

Barr and Kantor Batting

$$BK = (SR^t_{BAT})^\alpha (AVE^t_{BAT})^{1-\alpha}$$

Gerber and Sharp Batting Index

$$BT^{GS}_i = \left(\frac{Batting\ average\ of\ Batsman\ i}{Sum\ of\ Batting\ averages\ of\ all\ batsmen} \right) \times \#\ of\ specialist\ batsman$$

Gerber and Sharp Bowling Index

$$BT^{GS}_i = \left(\frac{vi}{sum\ of\ all\ vi} \right) \times Number\ of\ specialist\ bowler$$

Gerber and Sharpe Fielding Index

$$FLDi^{GS} = \left(\frac{Dismissal\ Rate\ of\ fielder\ i}{Sum\ of\ dismissal\ rates\ of\ all\ fielders} \right) \times Number\ of\ specialist\ fielder$$

Gerber and Sharpe All Rounder Index

$$ALR_i^{GS} = \left(\frac{Sum\ of\ revelant\ player\ index\ values}{Sum\ of\ that\ category\ index\ values} \right) \times Number\ players\ in\ all\ round\ cat$$

Gerber and Sharpe Wicket Keeper Index

$$WKR_i^{GS} = \left(\frac{Dismissal\ Rate\ of\ keeper\ i}{Sum\ of\ dismissal\ rate\ of\ all\ keeper} \right) \times Number\ players\ in\ all\ Specialist\ keeper$$

Maiden Rate

$$MDN = \frac{o}{m} = \frac{1/6b}{m}$$

Barr and Kantor Bowling Measure

$$BAT_{BWL} = (ECO_{BWL}^{t})^{\beta} (AVG_{BWL}^{t})^{1-\beta}$$

Mean Batting Score

$$\overline{BT} = \frac{Total\ number\ of\ Runs\ Scored}{Total\ Number\ of\ Matches\ Played}$$

Adjusted Barr and Kantor Batting Measure

$$BK_{BWL} = (SR_{BAT}^{t})^{\alpha} \overline{BT}^{1-\alpha}$$

Batting Liner Combination (Gerber and Sharp)

$$BAT_i = a_1 BT_i^{GS} + a_2 BL_i^{GS} + a_3 FLD_i^{GS}$$

Bowling Liner Combination (Gerber and Sharp)

$$BWL_i = b_1 BT_i^{GS} + b_2 BL_i^{GS} + b_3 FLD_i^{GS}$$

Wicket Keeper Linear Combination (Gerber and Sharp)

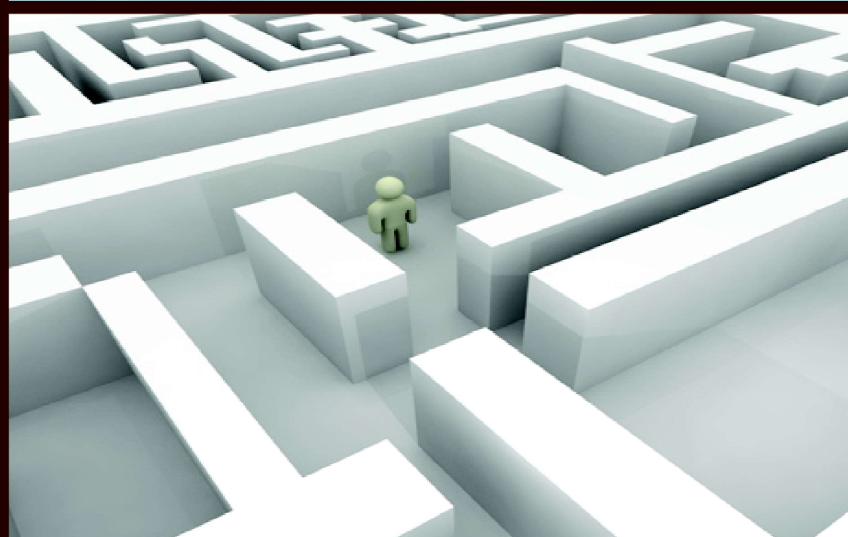$$WKR_i = c_1 BT_i^{GS} + c_2 BL_i^{GS} + c_3 FLD_i^{GS}$$

All Rounder Linear Comination (Gerber and Sharp)

$$ALR_i = d_1 BT_i^{GS} + d_2 BL_i^{GS} + d_3 FLD_i^{GS}$$

Restrictions on Fielding

i.   First 6 overs, No more than 2 fielders outside the 30 yard circle
ii.   After the power play no more than 5 fielders outside the 30 yard circle
iii. Any Time, Maximum of 5 fielders on the leg side

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