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A RANDOM EFFECT MODEL FOR THE EVOLUTION OF INTERNATIONAL CRICKET TEST MATCHES EVIDENCED FROM 1870 TO 2016

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SUMMARY

This article has proposed a random effects model to understand the trend of International Test Cricket results. The data is extracted for all the test matches played between 1870 and 2016 for countries that play test matches for at least four decades. The random effects model is applied for to study the countrywise and decadewise performance of a country at home and away matches. Analysis shows a very clear bias in the outcome towards home country winning across decades as well as for individual countries. The trend is discussed with implications of the evolution of the game itself so as to retain the tradition of cricket and to enhance the overall performance of a player.

Keywords: *Random Effect Model, Test Cricket, Home Advantage.*

1. INTRODUCTION

Cricket is a field game that has originated in England and sources differ in the officially documented first game dated anytime from thirteenth to seventeenth century. For a historical perspective of the game, Terry (2000) can be consulted for the reconstruction of the game from seventeenth century. Twentieth century has witnessed cricket as one of the highly passionate games. According to International Cricket Council (ICC), a global governing body of the game, 105 countries are members of the council in three different membership categories. There are many areas of active research about cricket. An excellent overview of the research areas can be seen in Albert, Glickman, Swartz, Koning (2017). In other sports like NBA and NHL home advantage has been studied in Swartz and Arce (2014).

Also, the game of cricket has adapted considerable changes in its formats and many dynamics of the game such as bowling and fielding restrictions and rule based score revisions. These significant interventions are directly helping to shape the game so as to draw an extensive attraction not only among traditionally playing countries but also in many countries.

The scientific advances help not only to work on dynamics of the game, but it also helps to store, retrieve and analyze the data pertaining to the game of cricket.

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Even a single shot of batsmen draws attention in studying the impact of the game (Abbasi and Khan, 2004). Recent articles such as Wickramasinghe (2014) and references thereon provide a comprehensive list of studies on cricket data analysis. This ranges from player centric analyses with the format of the game (Saikia, Bhattacharjee, Bhattacharjee, Lemmer, 2015) to leadership in the game of cricket (Smith, Young, Figgins, Arthur, 2016).

Hughes and Bartlett (2002) have identified factors contributing to the success or improved performance in the game of cricket; time at wicket is observed as one of the factors that would steer most of other factors. Sharma (2013) has revealed similar findings as far the batting capabilities of individual players that have direct influence of team performance.

Petersen, Pyne, Dawson, Portus, Kellett (2010) have compared three formats of cricket in analyzing work load of the players and have observed that test cricket requires a greater overall physical load. Such findings are favoring test format in exhibiting skills of an individual player in terms of physical, mental and emotional aspects. These attributes are necessary for a player in international level. Further, this would enhance the metrics for performance measures and / or records for the players and teams as well.

This study has made an attempt in analyzing country wise cricket data from the first ever test played in 1870s to 2016. Data has been collected from Cricinfo website (www.espncricinfo.com), one of the reliable sources in the web. A series of articles such as Mukherjee (2012, 2014, 2016) exploit the extensive details available in this web repository to study different objectives pertain to cricket data analyses. Retrospective surveys are involved in such exercise in many earlier research situations; Aggleton, kentridge, Neave (1993) have studied the longevity differences between left and right handed batsmen. Recent studies (Stevenson and Brewer, 2016) have dealt with player-centric analyses and short format of cricket.

The objective of present study is oriented towards team performance in test cricket but not based on records or scores of an individual player. In particular the focus is on the odds of winning or draw in a home compared to foreign (away from home) grounds over the entire period of test cricket (1870 to 2016). Advantages of home conditions have received research attention in many sports (Jamieson, 2010) but not so explicit in the game of cricket, especially in the test cricket.

This has been motivated by the statistics on recent results of test cricket; out of 53 tests played between the approved countries during Jan 2015 to Apr 2016, 43 matches have resulted with win in which only 9 are favoring the visitors of the test match. This indicates present day test format are no longer towards a draw or tie after five days of play. On the other hand, analyzing the odds for a win in home vs away could be interesting. This would help to understand whether test cricket are evenly positioned in earlier decades and countries act differently on the venues at home or away.

Such a focus is equally important for drawn matches also; in most instances results of a series or a tour are presented with win / lose games. But such practice of ignoring drawn matches may be a loss of information about a dominating factor of a series. For example, a 5-test series in 1983-84 has resulted with 2-0 (winner is the home team Australia); 1-0 in a 4-test series in 2006 (winner is India in West Indies); and a 1-0 in a 3-test series in 1961-62 (winner is England in Pakistan). Though a common belief favors home advantage for a victory, the tradition of cricket (or any sports) carries the spirit of the game not only in terms of results but the elegance and serenity of the game. Variations in the results of test matches (Win as well as Draw) have provided a scope for detailed statistical analysis with these data of dichotomous nature.

Results have largely revealed the distinct attitude on home vs. away in playing test cricket compared to pre and post 1980 and 1990s. This change is visible among all test playing countries with one or more countries (India and Sri Lanka) favor more on home matches in recent decades. Analysis includes a measure of variability between the countries and decade wise performances. This also indicates the shift in the effect of test match and its results. The paper is organized as follows: details of the data set have been presented in Section 2. Essential ideas for the underlying statistical model are briefed in Section 3 together with analysis of the data. Section 4 provides the concluding remark and scope for future studies.

2. DATA

The focus of the paper is well supported by the freely available and from a user friendly web portal http://stats.espncricinfo.com/ci/engine/stats/index.html; filters in the repository enable collecting the data with accuracy and in a reasonable time frame. It is possible to collect the test match results (wins, draws, and losses) in home, away, and neutral grounds (UAE was a neutral venue for Pakistan in late 2000s and early 2010s but subsequently considered as home venue for Pakistan). Nevertheless, this study has considered the matches played in these venues as home for Pakistan.

Also, the decades are selected based on the year in which ICC has approved a country to play international test matches. Accordingly, Australia and England play from 1870s; South Africa from 1880s with no matches in 1980s; from 1920s for West Indies followed by India and New Zealand in subsequent decade; Pakistan has from 1950s and after two decades Sri Lanka starts their account in test matches. Two more nations (Zimbabwe and Bangladesh) are currently approved test playing nations but not included in the analysis because they have been playing test matches less than four decades. This criterion is mainly related to the planned random effects model for dichotomized data that are further stratified by a variable. Original format of collecting the data is illustrated in Table 1 for Sri Lanka. Similar data is available for other countries and due to the paucity of space they are restrained from presentation.

The required format for the proposed analysis is a two-fold contingency table that classifies two dichotomous variables (Table 2). In this case, two levels of X_1 are home and away venues with regard to a country and that of X_2 are yes and no. Each cell count is the number of matches that accounts for the respective combination of X_1 and X_2. The stratifying variables are eight nations or fourteen decades; the first decade is dropped from the latter because only two countries (Australia and England) are involved in that period. Two data sets for each stratification are available related to Win and Draw matches.

TABLE 1. - *Number of matches that Sri Lanka has won, lost and drawn in two types of venues Home (H) and Away (A)*

Decade	WinH	LossH	WinA	LossA	DrawH	DrawA
1980-1989	2	5	0	11	5	6
1990-1999	9	6	5	15	15	16
2000-2009	31	11	13	20	11	10
2010-2016	14	9	4	12	10	5

TABLE 2. - *Data format for Win / Draw counts of a country or decade*

X_1/X_2	Yes	No
Home	n_{11}	n_{12}
Away	n_{21}	n_{22}

2.1 *Random Effects Model*

Random Effects Model (REM) is a statistical method to combine the results of individual studies so as to improve the precision of the estimates of study effect and assess whether study effects are similar enough to be combined. It can be shown that simple average of study effects may not be a proper method to summarize the results. It is important to understand the sources of variability, within-study and between study when making inferences about the population. Such models are of considerable scientific interest in multi-site or multi-strata studies and closely resemble the statistical principles of meta-analysis.

Extensive studies are available in detailing the conceptual, statistical, computational and interpretative aspects of REM and/or meta-analysis. Though medical, epidemiological and health related studies dominate this field, many other faculties exploit the advantages of REM in terms of prospective, retrospective or cross sectional studies. Card (2012) provides a better overview of methods involved in meta-analysis for social science with binary or metric data.

In REM, if Y_i is an effect size estimate of a corresponding true effect size θ_i with the within-study variance σ_i^2, then the underlying random effects model is

$$Y_i \sim N(\theta_i, \sigma_i^2) \tag{1}$$

$$\theta_i \sim N(\mu, \tau^2) \tag{2}$$

where μ is the average effect size in the population and τ^2 is the amount of heterogeneity in the effect sizes (between-study variance) respectively. In the present case Y_i is the odds ratio (OR); that is if p_{ij} refers the joint distribution of X_1 and X_2 then within home matches, the odds that winning in home is $\frac{p_{11}}{p_{12}}$ and that for away it is $\frac{p_{21}}{p_{22}}$ and the odds ratio is $(\frac{p_{11}}{p_{12}})$ / $(\frac{p_{21}}{p_{22}}) = \frac{p_{11}*p_{22}}{p_{12}*p_{12}}$. This measure is estimated based on the identified strata, countries and decades. Based on the symbols for counts in Table 2, estimate of p_{ij} is $n_{ij}/\sum n_{ij}$.

Agresti (2013) and Card (2012) can be referred for more details on odds ratio and its advantages so as to appreciate it as a desired summary measure in REM with binary data. One of the notable merits is its invariable nature across case control, follow-up, and cross-sectional studies and thus it can be used to directly compare findings of different study designs. Also, it could be observed that information regarding τ^2 and other similar measures of variability might be of considerable scientific interest Higgins and Thompson (2002).

The statistical inference aims to provide following summaries to understand the association between the variables in the individual and overall levels together with the amount of heterogeneity.

i) Point estimate and confidence interval for the true θ_i.
ii) Point and interval estimates of μ to understand the presence or absence of an overall effect and its statistical significance.
iii) Estimates of variability measures indicating the variation between strata.

For the details of statistical inference on REM and the choice between the competing procedures can be referred from a long list of studies; Engels, Schmid, Terrin, Olkin, Lau (2000); Hagger (2006); Viechtbauer (2007); Bowden, Tierney, Copas, Burdett (2011); Riley, Higgins, Deeks (2011); Davis, Mengersen, Bennett, Mazerolle (2014); Langan, Higgins, Simmonds (2016) are few but highly informative studies on the above three *i*) to *iii*) inferential requirements. This study is confined to classical statistical procedures and not involving Bayesian approaches or any other methods.

2.2 *Data Analysis*

The entire exercise has been carried out using the computational tool R (R Core Team, 2016) especially with metafor package in R (Viechtbauer, 2010). Numerical and graphical summaries are quite straightforward with the tool; however, presence of zeros in at least one of four cells of two-fold table requires careful handling in the analysis. Different recommendations are provided in the literature (earlier list of studies); this work adopts the default and widely following method of adding 0.5 to all cells of the table that has at least one zero. Conventionally, $(1-\alpha)\%$ CIs can be used to test the null hypothesis at $\alpha\%$ level of significance . In this analysis, interest is to test $\mu = 1$ against $\mu \neq 1$ (or $\theta_i = 1$ Vs. $\theta_i \neq 1$) based on whether the interval covers 1 or not. Point and confidence interval estimates (CI) for overall odds ratio (μ) for win or draw in home and away venues are presented in Table 3.

From Table 3, it can be observed that country wise odds ratio for winning in home or away venues is more than one; this indicates the advantages of home grounds across the countries stratified by the decades. India tops this list followed by Sri Lanka and Australia; New Zealand, England and South Africa share a near position whereas Pakistan has higher odds than West Indies which has the least combined odds ratio ($\mu = 1.498$). Also,except for West Indies all these estimates are statistically significant at $\alpha = 5\%$. Corresponding confidence intervals reveal similar standings ($\mu > 1$ except for West Indies) with length of CI is maximum for India followed by Sri Lanka and CIs for other countries have comparatively equal width with least value corresponds to England (0.99).

Table 3. - *Combined odds ratio for country wise analysis; LL and UL are lower and upper limits of 95% confidence interval*

Country	**Win**			**Draw**		
	Estimate	**LL**	**UL**	**Estimate**	**LL**	**UL**
Australia	2.596	1.910	3.528	0.452	0.257	0.793
England	1.708	1.283	2.273	1.203	0.710	2.037
India	3.278	1.460	7.360	3.278	1.460	7.360
West Indies	1.498	0.932	2.405	1.676	1.123	2.501
New Zealand	1.934	1.169	3.200	1.304	0.866	1.962
South Africa	1.911	1.223	2.986	0.631	0.401	0.994
Pakistan	1.624	1.027	2.566	1.692	0.856	3.345
Srilanka	3.180	1.741	5.810	1.137	0.650	1.989

Also, analysis with draw matches in home and away venues (Table 3) has revealed that $\mu < 1$ for Australia and South Africa which is statistically significant too. Among other countries, India leads the table ($\mu = 3.278$) followed by West Indies ($\mu = 1.676$) and both values are statistically significant; remaining countries have $\mu > 1$ but the estimates are not significant at $\alpha = 5\%$. These observations can be noticed with CIs also; Australia and South Africa have narrower intervals compared to others whereas India has the widest interval. This brings a contrasting pattern of odds for draw in home and away venues; matches of Australia and South Africa tend to have more draws in away venues but home venues have resulted with more drawn matches in India.

Individual measure such as country specific odds ratio (θ_i) together with 95% confidence interval is presented in forest plot (Lewis and Clarke, 2001) for easier visual interpretations and understanding the variability; Figures 1 and 2 are the forest plot for country wise estimates for odds ratio of winning a test match; Figure 3 presents that for drawn matches.

Figure 1 shows the home advantage for winning a test match in the recent decades in all the four countries for India, West Indies, Pakistan,and Sri Lanka. Except during 1960-69, decade-wise individual estimate θ_i is more than one for India, in all decades for Sri Lanka, all but two decades for Pakistan and recent four decades for West Indies. All θ_i for West Indies are not significant; Pakistan and Sri Lanka have significant θ_i in one decade each. However, India has statistically significant estimate $(\theta_i = 7.88)$ in the recent decade and a markedly higher and significant estimate $(\theta_i = 49.69)$ in 1990-1999.

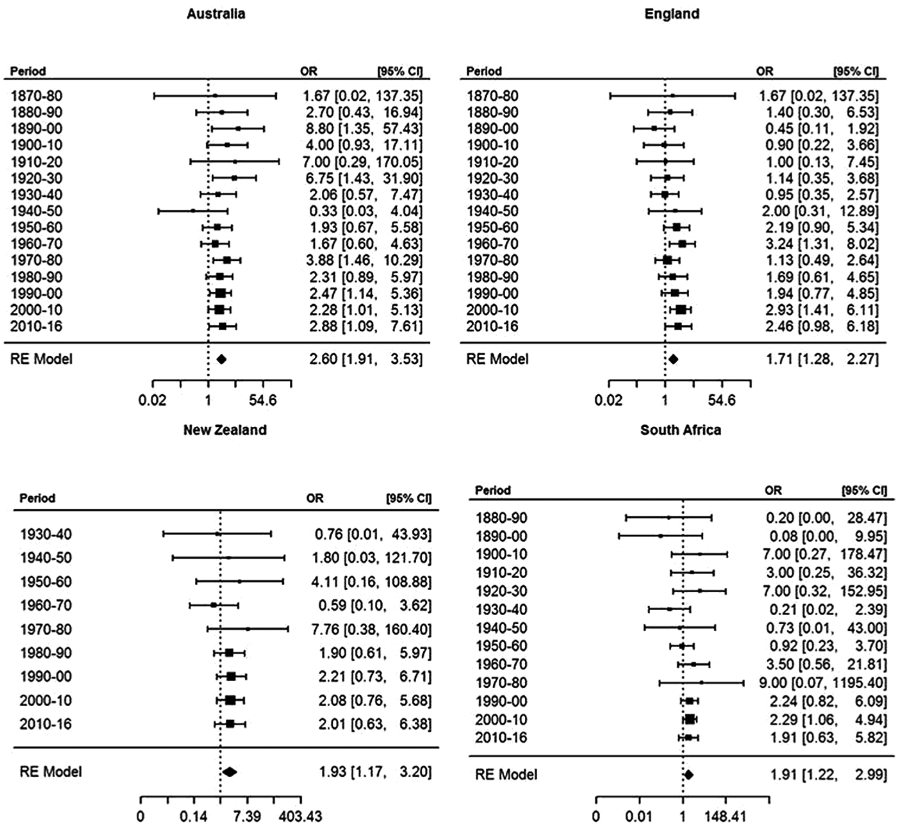

FIGURE 1. - *Forrest plot of the point and interval estimates of individual odds ratio for winning a match in home or away venues corresponding to India, West Indies, Pakistan and Sri Lanka*

Similar effect can be observed for other four countries also (Figure 2). The last four decades have witnessed home advantage for a win in test match and a shift from the earlier decades are evident. Among these four, three estimates (θ_i) are statistically significant for Australia; one θ_i for England and South Africa and no θ_i for New Zealand are statistically significant. However, with individual estimate θ_i is less than one for 5 out of 13 decades, South Africa leads this list when compared to all eight countries; this indicates it favors win in away venues though a marked variation could be seen in one decade (1970-79).

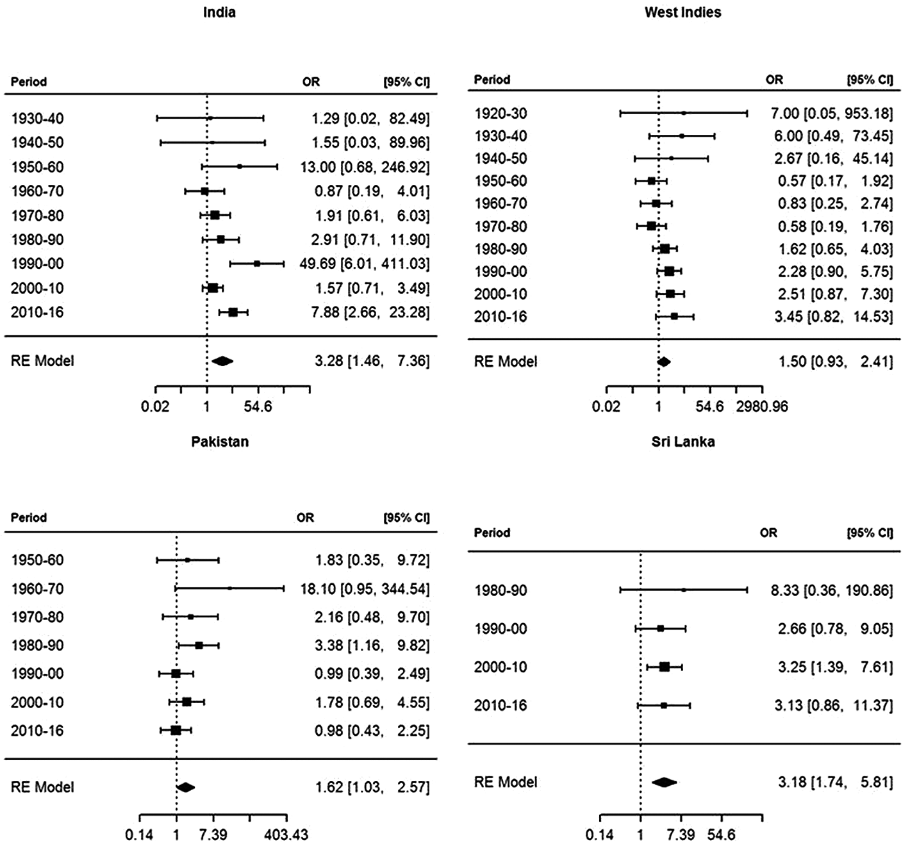

FIGURE 2. - *Forrest plot of the point and interval estimates of individual odds ratio for winning a match in home or away venues corresponding to Australia, England, New Zealand and South Africa*

Further, forest plot helps to understand the variability between the studies and (Higgins and Thompson, 2002) provides the necessary interpretation of three metrics (τ^2, I^2, H^2) for measuring such heterogeneity. India has the largest $\tau^2 = 0.72$ with 95% $CI(0.00, 5.13)$, $I^2 = 55.62$ with 95% $CI(0.00, 85.96)$ and $H^2 = 2.25$ with 95% $CI(1.00, 9.96)$. West Indies and Pakistan have higher estimates but less than that of India with regard to variability; For West Indies, $\tau^2 = 0.12$ with 95% $CI(0.00, 1.53)$, $I^2 = 22.39$ with 95% $CI(0.00, 77.82)$ and $H^2 = 1.29$ with 95% $CI(1.00, 4.51)$; For Pakistan, $\tau^2 = 0.04$ with 95% $CI(0.00, 3.31)$, $I^2 = 10.57$ with 95% $CI(0.00, 90.48)$ and $H^2 = 1.12$ with 95% $CI(1.00, 10.54)$; Other countries do not have any alarming estimates of variability that can be observed through pictorial judgment (Figures 1 and 2); hence their numerical summaries are not presented.

In the case of individual estimates (θ_i) of drawn matches (Figure 3), 13 out of 15 (9 are significant) estimates are less than one for Australia but a visible shift towards home venues in 2000-16 is seen; for a more consistent South Africa, it is 9 out of 13 and none of them are significant. In these two cases, this indicates odds for draw matches are higher in away venues. Among the countries, Sri Lanka has all but one $\theta_i > 1$ but none of them are significant; Pakistan also has similar pattern in that except during 1960-70 all $\theta_i > 1$ with only one decade (2000-16) has significant $\theta_i > 1$.

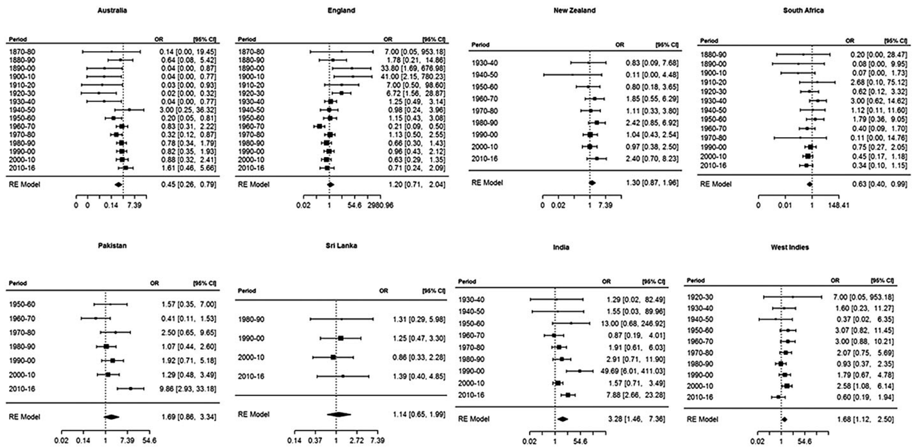

FIGURE 3. - *Forrest plot of the point and interval estimates of individual odds ratio for drawn matches in home or away venues corresponding to all the eight countries*

England has an reversal effect from $\theta_i > 1$ in recent decades and only three estimates are significant $\theta_i > 1$ whereas such reversal effect can be noticed for New Zealand but no estimates are significant. On the other hand, India and West Indies share a similar pattern towards home venues $(\theta_i > 1)$; specifically, with all (10) non-significant estimates, seven are greater than one for West Indies. India has $\theta_i > 1$ in 8 out of 9 cases in which two of them are significant with larger θ_i (49.69 in 1990-99 and 7.88 in 2010-16).

In terms of measures of heterogenity India, New Zealand, South Africa, and Sri Lanka have very least values that indicate less variablity between the decades. Other countries have notable estimates; in decreasing order West Indies, England, Pakistan, and Australia have τ^2 ranging from 0.718 to 0.481;pattern for I^2 and H^2 is same (England, West Indies, Pakistan, and Australia) with respective values range from 64.26 to 48 and from 2.80 to 1.92. Estimates of Australia and England are significant and that of West Indies and Pakistan are not statistically significant at $\alpha = 5\%$.

Further, Table 4 provides decade wise analysis of odds ratio for win or draw in home and away venues stratified by test playing countries. In the case of win, $\mu > 1$

uniformly in all 14 decades whereas significant μ can be observed only in recent four decades (1980-2016); interestingly, estimates are increasing in this period $(2.19 \leq \mu \leq 2.48)$. All countries in each decade have shown a similarity with few exception; New Zealand in 1950-59, 1990-99 and 2010-16; Sri Lanka and India in 2000-16. Measures of heterogeneity are also higher in 1900-09, 1920-29, 1960-79 and 2010-16. $(0.12 \leq \tau^2 \leq 3.28, 20.01 \leq I^2 \leq 72.49, 1.25 \leq H^2 \leq 3.64)$

TABLE 4. - *Combined odds ratio for country wise analysis; LL and UL are lower and upper limits of 95% confidence interval*

Period	Win			Draw		
	Estimate	LL	UL	Estimate	LL	UL
2010-16	2.477	1.556	3.942	1.167	0.553	2.463
2000-09	2.3	1.702	3.108	0.994	0.680	1.453
1990-99	2.197	1.539	3.136	0.959	0.650	1.417
1980-89	2.188	1.43	3.347	0.966	0.680	1.372
1970-79	1.728	0.914	3.268	1.103	0.626	1.945
1960-69	1.72	0.962	3.076	1.005	0.363	2.778
1950-59	1.58	0.945	2.644	1.010	0.542	1.881
1940-49	1.282	0.404	4.064	1.165	0.468	2.896
1930-39	1.219	0.608	2.442	1.223	0.626	2.385
1920-29	3.08	0.842	11.266	0.792	0.052	12.030
1910-19	2.066	0.507	8.415	0.926	0.035	24.201
1900-09	2.219	0.635	7.755	0.497	0.006	39.591
1890-99	1.069	0.086	13.231	0.554	0.007	44.984
1880-89	1.631	0.517	5.14	0.930	0.220	3.922

However, decade wise estimates based on draw matches do not reveal any pattern; μ ranges from 0.497 (1900-09) to 1.167 (2010-16) and all estimates are statistically not significant. Also, the measure of heterogeneity indicate appreciable variations in most of the decades except 1980-89, 1930-49, and 1880-89. In particular, recent four decades (1980-2016) have marked variation between the countries. Three measures of heterogeneity is consolidated as $0.085 \leq \tau^2 \leq 34.41, 28.38 \leq I^2 \leq 84.05, 1.40 \leq H^2 \leq 6.27$

3. CONCLUSIONS

This paper has made an attempt to study the way test cricket has evolved over decades in its perception. Earlier decades have witnessed more on the tradition of games irrespective of the home or away matches which are visible in Australia, England, South Africa and West Indies match results. Where as subsequent decades indicate a marked shift favoring home matches. For example, India except in 1950s and 1970s has higher odds for home wins in all other period of its matches.

Research studies such as (Koning, 2011) have identified few factors for home team advantages. This includes crowd support, travel fatigue, and rules or condition that favor the home team. Besides the crowd support, the playing conditions of cricket may not be comparable to other sports like football, basketball, or rugby. In particular, ground conditions, balls used to play, and weather conditions have visible and significant impact on the game. Comparatively, weather could alter the conditions of pitch or playing condition within five days in which a test match being played.

Past five decades witness at least three different brands of balls between test playing nations. Scuffed cricket balls mostly favor spin and brands usually differ in this regard. Countries usually choose balls of a brand that may favor the home grounds. Hence, visiting countries have to adapt many conditions in the test format of cricket. There is a tradition in earlier decades to conduct tour matches in host country so as to familiarize the conditions of the host nation. But this is almost ignored in recent times except few long series like The Ashes. Interventions of technology is not only used in maintenance of pitch and ground but also helps in fitness program of a player. This largely enhances the endurance of the home players to perform better in country specific weather conditions.

Though the work has not made any contribution in eliciting reasons for these changes, it provides a direction to understand the changing dynamics of the game. Further research may be in the direction of influencing factors for such variability and working towards modeling the strategies and outcome of test match. Research towards understanding the factors such as number of matches in a year, countries chosen for touring, players' preparedness for home or away strategies and definitely the attitude of the sponsors and audience of the game.

The question from the study is the further evolution of the game in present and future decades. Changes are inevitable as observed by Ernst W. Mayr. Evolution, thus, is merely contingent on certain processes articulated by Darwin: variation and selection. No longer is a fixed object transformed, as in transformational evolution, but an entirely new start is, so to speak, made in every generation. However, strategies to effect changes in the game conditions should maintain the tradition of test cricket that help any individual player to demonstrate skills and gauge the performance. This might enhance an overall performance of a player who can fit for other formats of cricket too.

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