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Odds Modelling and Testing Inefficiency of Sports Bookmakers Rmodel

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Abstract

In this paper I am applied a diagonal inflated biviriate poisson as well as a simple staking model whereby evaluate the efficiency of odds price of Asian Handicap and Goal Line offered by 40 sports bookmakers. Finally I get a breakdown profit & lose table. While I used Kelly model next to this research which generated a profit every year.

Keywords: keywords, Bivariate poisson, Multivariate discrete model, Betting strategy, Soccer, English Premier League, Expected return, Maximum likelihood, Statistical forecast, Bookmakers, R, Excel.

1. Introduction

The odds modelling in Europe and United States are very popular since decades. However statistical odds modelling and algorithmic staking has not yet popular in Far East Asia.

By refer to *Dixon & Coles 1996*[1], *Karlis & Ntzoufras 2005*[2] and also *Dixon & Pope 2004*[3] I tried to collect soccer data from year 2006 to 2011. The purpose of the research is testing the inefficiency of soccer odds offered by 29 bookmakers as well as making profit from bookmakers.

The paper *Dixon & Coles 1996* inspired by the *Maher 1982*[4] to identify the offence and defence index of every single team where *Karlis & Ntzoufras 2005* enahanced to be more complicated model. *Moya 2012*[5] taken 40000 customers' data from bwin to analayse and

[1]Refer to reference paper 02
[2]Refer to reference paper 08
[3]Refer to reference paper 05
[4]Refer to reference paper 01
[5]Refer to reference paper 10

profit and lose and applied diversified staking strategies to make profit from bookmakers. *Goddard 2004*[6] model an ordered probit regression and placed stkes on English soccer leagues from 1998 to 2002 and finally yeild `1998/99` = 0.116, `1999/00` = 0.008, `2000/01` = -0.008, `2001/02` = 0.160.

Well, *Dixon & Robinson 1997*[7] has built a rebirth model on 90 minutes In-Play soccer gaming. *Crowder, Dixon, Anthony & Robinson 2001*[8] applied MCMC[9] model for soccer result prediction and do a comparison with previous *Dixon & Coles 1996* model where concludes that previous model forecast more precisely.

Similar with *Dixon & Coles 1996*, *Karlis & Ntzuofras 1998*[10] has encountered an issue which is a number of nil-nil tied games. while *Dixon & Coles 1996* applied an inflation on low scores games while *Karlis & Ntzoufras 2005* built an extra distribution parameter to settle it.

The latest research paper wrote by Dixon is that *Dixon & Pope 2004* which have reviewed the previous model and testing the efficiency on correct score of 3 major firms in UK. *Karlis & Ntzuofras 2007* make a summary of evolution on his research which is apply Skellam's distribution on bivariate poisson model to resolve the obstacle of draw games.

Section 2 discribe a statiscal model applicable to soccer odds modelling. Section 3 talk about the dataset while section 4 model focus on staking model. Section 5 present the result and last section conclude.

2. Modelling

2.1. Basic Model

As mentioned in *Karlis & Ntzuofras 2005*, bivariate Poisson models are appropriate for modeling paired count data exhibiting correlation. Paired count data arise in a wide context including:

- marketing (number of purchases of different products)
- epidemiology (incidents of different diseases in a series of districts)
- accident analysis (number of accidents in a site before and after infrastructure changes)
- medical research (the number of seizures before and after treatment)
- sports (the number of goals scored by each one of the two opponent teams in soccer)
- econometrics (number of voluntary and involuntary job changes)

Where I just to name a few among the use.

Bivariate Poisson regression models

[6] Refer to reference paper 09
[7] Refer to reference paper 03
[8] Refer to reference paper 04
[9] Markov Chain Monte Carlo model
[10] Refer to reference paper 06

$$(X_i, Y_i) \sim BP(\lambda_{1i}, \lambda_{2i}, \lambda_{3i})$$

where $BP(\lambda_1, \lambda_2, \lambda_3)$ is the bivariate Poisson distribution with parameters $\lambda_i,\ i = 1, 2, 3$ and probability function

$$P(X = x, Y = y) = e^{-(\lambda_1+\lambda_2+\lambda_3)} \frac{\lambda_1^x}{x!} \frac{\lambda_2^y}{y!} \sum_{k=0}^{min(x,y)} \binom{x}{k} \binom{y}{k} k! \left(\frac{\lambda_3}{\lambda_1 \lambda_2}\right)^k. \quad (1)$$

- Marginals: $X \sim Poisson(\lambda_1 + \lambda_3)$ and $Y \sim Poisson(\lambda_2 + \lambda_3)$
- Means and Variance: $E(X) = V(X) = \lambda_1 + \lambda_3$, $E(Y) = V(X) = \lambda_2 + \lambda_3$
- Covariance: $Cov(X, Y) = \lambda_3 > 0$
- Can be derived using latent variables $W_i \sim Poisson(\lambda_i)$, for $i = 1, 2, 3$ with $X = W_1 + W_3$ and with $Y = W_2 + W_3$.

Figure 1: Bivariate Poisson regression models

From above formula, bivariate poisson basically measure the correlationship between X and Y compare to double poisson models. However, as I mentioned which is *Dixon & Coles 1996* modified a little on the score 0-0, 1-0, 1-1 and vice versa.

- Covariates can be linked directly on the means of the latent variables as in Karlis and Ntzoufras (2003) or directly on the marginal means.
- A Simple Model (Karlis and Ntzoufras, 2003)
  - Response variables (X, Y) are the home and away goals in each game.
  - Consider the structure of Lee (1997) for λ_1 and λ_2

$$\log(\lambda_{1i}) = \mu + H + A_{HT_i} + D_{AT_i} \quad (2)$$
$$\log(\lambda_{2i}) = \mu + A_{AT_i} + D_{HT_i} \quad (3)$$

    μ: constant; H: home effect; A_k, D_k attacking and defensive parameters of team k; HT_i, AT_i home and away team in i game.
  - Constant covariance λ_3

Figure 2: Double Poisson regression models

A Double poisson model can be easily applied by generalized linear model. The covariates is a constant parameter across all soccer matches or teams as we know from figure 2.

Diagonal Inflated Bivariate Poisson regression models

Due to the bivariate is not accurate enough and applicable to predict the real life soccer result. *Karlis & Ntzuofras 2005* introduced a more complicated model which able to inflated the probabilities of the occurrance on draw games.

Under this approach a diagonal inflated model is specified by

$$P_D(x,y) = \begin{cases} (1-p)BP(x,y \mid \lambda_1,\lambda_2,\lambda_3), & x \neq y \\ (1-p)BP(x,y \mid \lambda_1,\lambda_2,\lambda_3) + pD(x,\boldsymbol{\theta}), & x = y, \end{cases} \quad (4)$$

where $D(x,\boldsymbol{\theta})$ is discrete distribution with parameter vector $\boldsymbol{\theta}$. Such models can be fitted using the EM algorithm.

Important: diagonal inflation improves in several aspects: better draw prediction, overdipsersed marginals, introduce correlation

Figure 3: Diagonal Inflated Bivariate Poisson regression models

The author then introduced Skellam's distribution which measure the correlation between X and Y on draw games, he term it as Zero-Inflated Poisson Model.

Skellam's Distribution for Football Scores

- Response variable: $Z = X - Y$ the goal difference in each game.
- Same structure for parameters λ_1 and λ_2 as in Bivariate Poisson:

$$\log(\lambda_{1i}) = \mu + H + A_{HT_i} + D_{AT_i} \quad (6)$$
$$\log(\lambda_{2i}) = \mu + A_{AT_i} + D_{HT_i} \quad (7)$$

  μ: constant; H: home effect; A_k, D_k attacking and defensive parameters of team k; HT_i, AT_i home and away team in i game.
- Use the zero inflated variation of Skellam's distribution to model the excess of draws. Hence we define the zero inflated Poisson Difference (ZPD) distribution as

$$f_{ZPD}(0 \mid p,\lambda_1,\lambda_2) = p + (1-p)f_{PD}(0 \mid \lambda_1,\lambda_2) \quad \text{and}$$
$$f_{ZPD}(z \mid p,\lambda_1,\lambda_2) = (1-p)f_{PD}(z \mid \lambda_1,\lambda_2), \quad (8)$$

  for $z \in \mathcal{Z} \setminus \{0\}$; where $p \in (0,1)$ and $f_{PD}(z \mid \lambda_1,\lambda_2)$ is given by (5).

Figure 4: Skellam's Distribution for Football Scores

Well, when we talk about the parameter to measure the correlationship. How can we know what models might fit into it? *Karlis & Ntzuofras 2005* has compare few models which are :

- Discrete distribution (with an adjustable paramters)
- Poisson distribution
- Geometric distribution

They built 12 statistical models to compare and get the best fit model. For more details

kindly refer to the paper.

2.2. Model Enhancement

There has a popular quote in sportsbook betting industry which is term as `FORM`. There is a flutuation of the ability and aggresiveness on sports competition as time goes by. Lets review the *Dixon & Coles 1996* model and fit the decay parameter into our basic model.

Choice of Weighting Function ϕ

There are various possible choices for the weighting function ϕ in equation One possibility would be

$$\phi(t) = \begin{cases} 1 & t \leqslant t_0, \\ 0 & t > t_0, \end{cases}$$

in which case, at time t, all results within the last t_0 time units would be given equal weight in the inference. Instead, we work with the model

$$\phi(t) = \exp(-\xi t),$$

in which all previous results, downweighted exponentially according to a parameter $\xi > 0$, are included in the inference at time t. The static model arises as the special case $\xi = 0$, whereas taking increasingly large values of ξ gives relatively more weight to the most recent results.

Optimizing the choice of ξ is problematic, since equation defines a sequence of non-independent 'likelihoods', whereas we require ξ such that the overall predictive capability of the model is maximized. In fact, in subsequent sections, we restrict attention to the prediction of match outcomes rather than match scores. Therefore it is pragmatic to choose ξ to optimize the prediction of outcomes. First note that the probability of a home win in match k is estimated as

$$p_k^{\mathrm{H}} = \sum_{l,m \in B_{\mathrm{H}}} \Pr(X_k = l,\ Y_k = m)$$

where $B_{\mathrm{H}} = \{(l,\ m):\ l > m\}$, and the score probabilities are determined from the maximization of model (4.5) at $t(k)$, the time of match k. Similar expressions hold for p_k^{A} and p_k^{D}, the probabilities of an away win and a draw respectively. Now define

$$S(\xi) = \sum_{k=1}^{N} (\delta_k^{\mathrm{H}} \log p_k^{\mathrm{H}} + \delta_k^{\mathrm{A}} \log p_k^{\mathrm{A}} + \delta_k^{\mathrm{D}} \log p_k^{\mathrm{D}})$$

where, for example, $\delta_k^{\mathrm{H}} = 1$ if match k is a home win and $\delta_k^{\mathrm{H}} = 0$ otherwise, and p_k^{H}, p_k^{A} and p_k^{D} are the maximum likelihood estimates from model , with weighting parameter set at ξ. Considering only the outcomes, and not the scores, equation is the analogue of a predictive profile log-likelihood. A plot of $S(\xi)$ against ξ, with time units taken to be half-weeks, is given in Fig. 1. The function is maximized at $\xi = 0.0065$, and all subsequent results are given with respect to this choice of ξ, though in fact the results are robust across a range of ξ-values.

Figure 5: decay rates

After simulation, I get a decay rate which is almost `0.0065` and similar with *Dixon & Coles 1996*. However, due to I consider the soccer matches has come out result once the whistle is blew. Therefore I've tried to build another model which is similar with Weibull model to make the decay rate flexible compare to constantly annum. few models, which are:

- Count in the soccer result once a soccer match is finished to get a dynamic decay rates to refresh next prediction odds price.
- Follow *Dixon & Coles 1996* which taken a constant decay rates for a soccer session.
- Count in the soccer result once a week to get a weekly dynamic decay rates to predict next week soccer matches.

I got a vector of decay rates around `0.0045` with the standard deviation not more than 1~10%. which is similar with the model at MatchOdds.org.

3. Data

3.1. Soccer Sports Dataset

1) test the efficieny of 29 bookmakers' Asian Handicap prices.
2) comparison between EM model, observations/outcome, and also pure probabilities of products offered by 29 bookmakers.
3) 29 bookmakers exclude below 11 companies:

i) bwin
ii) Interwetten
iii) William Hill
iv) SSP International
v) Betfair
vi) Intralot
vii) SNAI
viii) SingaporePools
ix) Stan James
x) Unibet
xi) Coral

3.2. Odds Price Dataset

In order to test the efifciency of my model. I took quite long time period[11] to gather data from below websites. You are feel free to browse over the dataset via 200611 EngAllOdds[12]

Data source :

[11] After I completed the odds modelling part. took time more than 10 hours per day and around half year time manually copy and paste the odds price (soccer matches data, all events in all English 9 leagues + cups as well as all Japanese leagues and tournaments for both prematch as well as the rebirth modelling, and also testing staking model's purpose)

[12] The spreadsheet file locate inside the dataset of **Odds Modelling and Testing Inefficiency of Sports-Bookmakers** *2008-2010 by ®yo Eng Lian Hu* to see the odds price of every single soccer match.

1. the soccer matches and also Asian Handicap odds prices of 29 bookmakers getting from 3 websites below:

   - http://www.500wan.com
   - http://www.bet007.com
   - http://www.nowgoal.com

2. English soccer leagues from 2006/07 to 2010/11 collected as my sample data, which are include:

- 1) English Premier League
- 2) English League Championship
- 3) English Division 1
- 4) English Division 2
- 5) English FA Cup
- 6) English League Cup
- 7) English League Trophy
- 8) English FA Trophy / English Challenge Cup

3. Season 2006/07 and 2007/08 used for EM model, however odds price of only seasons 2008/09 and 2009/10 gathered and use for testing efficieny.

- there are 4389 soccer matches used as sample in our research.
- unfortunately, odds prices of around 10 to 20 soccer matches inside research works have no data source.
- open prices and closed prices collected but only open prices get into research works.

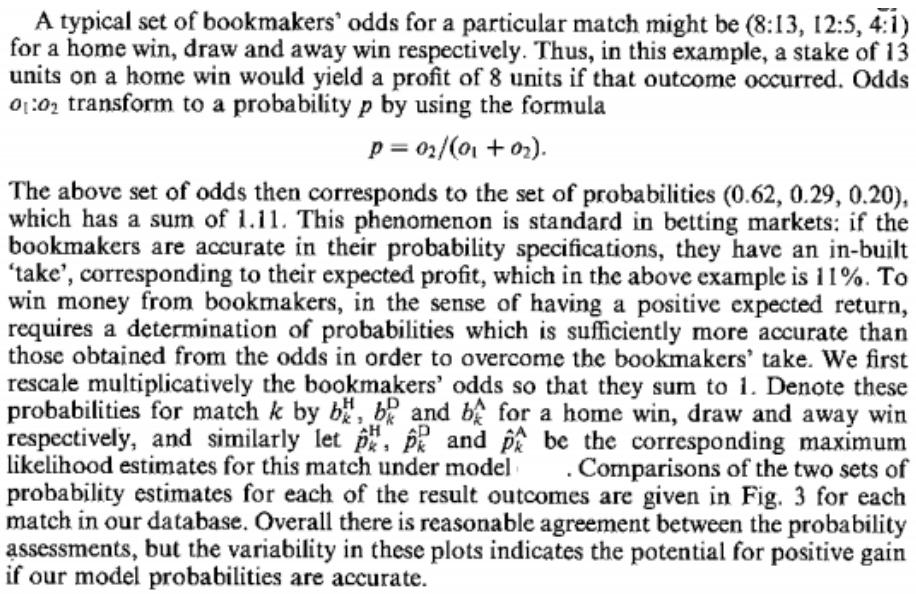
3.3. Convertion to Odds Price

Odds Price based on Pure Probabilities

From above description we know the bookmakers has charges a certain spread margin / overounds / vigorish.

Odds Price based with Vigorish

Therefore we need to convert to a net probabilities without vigorish to compare with our time series diagonal inflation bivariate poisson regression model.



A typical set of bookmakers' odds for a particular match might be (8:13, 12:5, 4:1) for a home win, draw and away win respectively. Thus, in this example, a stake of 13 units on a home win would yield a profit of 8 units if that outcome occurred. Odds $o_1:o_2$ transform to a probability p by using the formula

$$p = o_2/(o_1 + o_2).$$

The above set of odds then corresponds to the set of probabilities (0.62, 0.29, 0.20), which has a sum of 1.11. This phenomenon is standard in betting markets: if the bookmakers are accurate in their probability specifications, they have an in-built 'take', corresponding to their expected profit, which in the above example is 11%. To win money from bookmakers, in the sense of having a positive expected return, requires a determination of probabilities which is sufficiently more accurate than those obtained from the odds in order to overcome the bookmakers' take. We first rescale multiplicatively the bookmakers' odds so that they sum to 1. Denote these probabilities for match k by b_k^{H}, b_k^{D} and b_k^{A} for a home win, draw and away win respectively, and similarly let $\hat{p}_k^{\mathrm{H}}$, $\hat{p}_k^{\mathrm{D}}$ and $\hat{p}_k^{\mathrm{A}}$ be the corresponding maximum likelihood estimates for this match under model . Comparisons of the two sets of probability estimates for each of the result outcomes are given in Fig. 3 for each match in our database. Overall there is reasonable agreement between the probability assessments, but the variability in these plots indicates the potential for positive gain if our model probabilities are accurate.

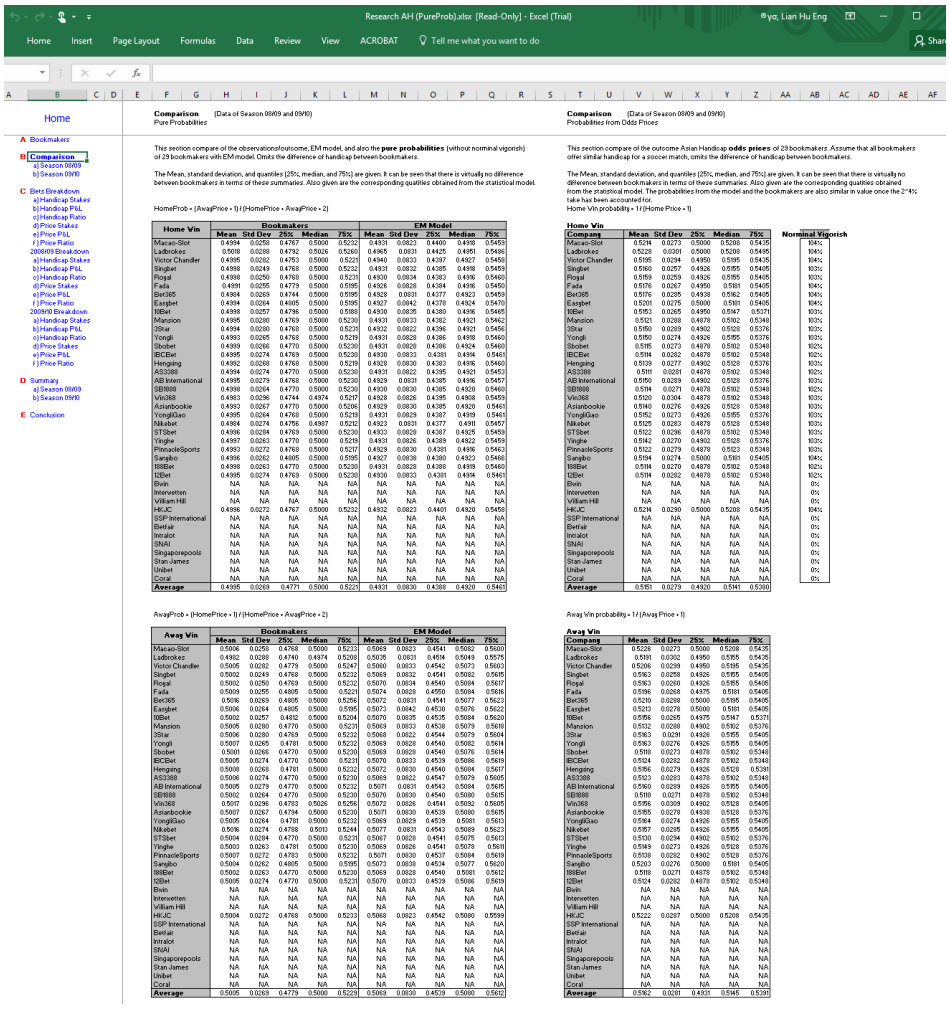
Figure 6: odds price with vigorish

Remarks : you are feel free to browse over dataset of **Odds Modelling and Testing Inefficiency of Sports-Bookmakers** *2008-2010 by ®yo Eng Lian Hu* to observe the EM odds, odds price offered by bookmakers without vigorish as well as with vigorish for every single soccer match. Total soccer matches in this research project has 4389 across 8 leagues + tournaments in England.

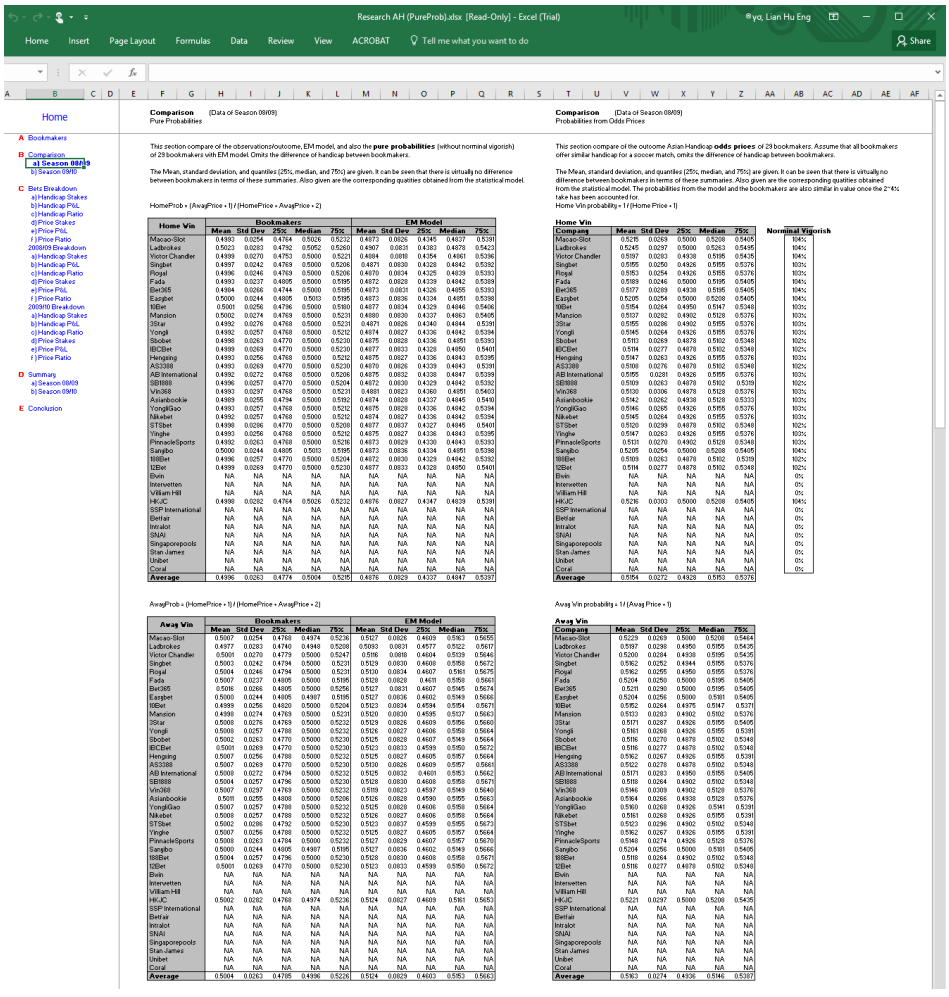
4. Betting Strategies

4.1. Comparison of Efficiency of the Models

By refer to *Dixon & Pope 2004*, before we start build our staking model, we try to summarize the statistical prices offered by 40 sports bookmakers on both Asian Handicap and Goal Line.



Above figure shows a comparison the mean, standard deviation, quantile 25%, median, quantile 75% of Asian Handicap odds price without vigorish of total soccer matches in season 2008/09 and 2009/10.



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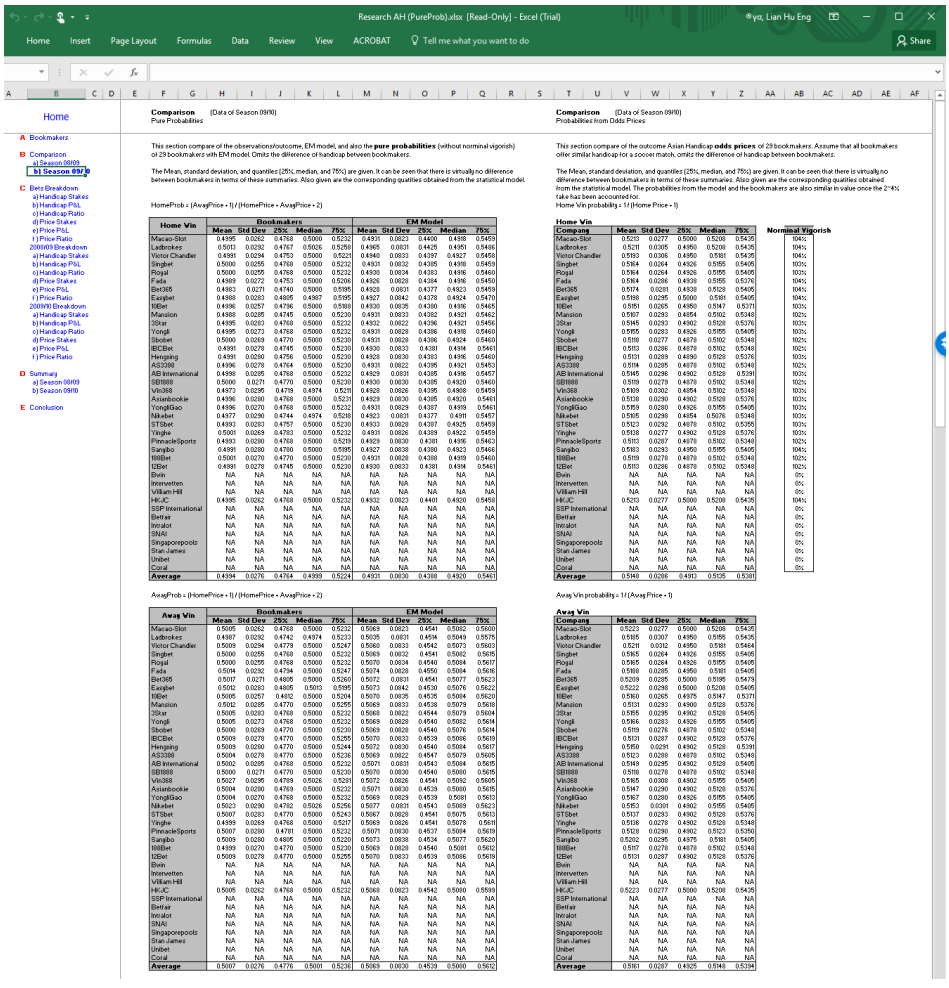

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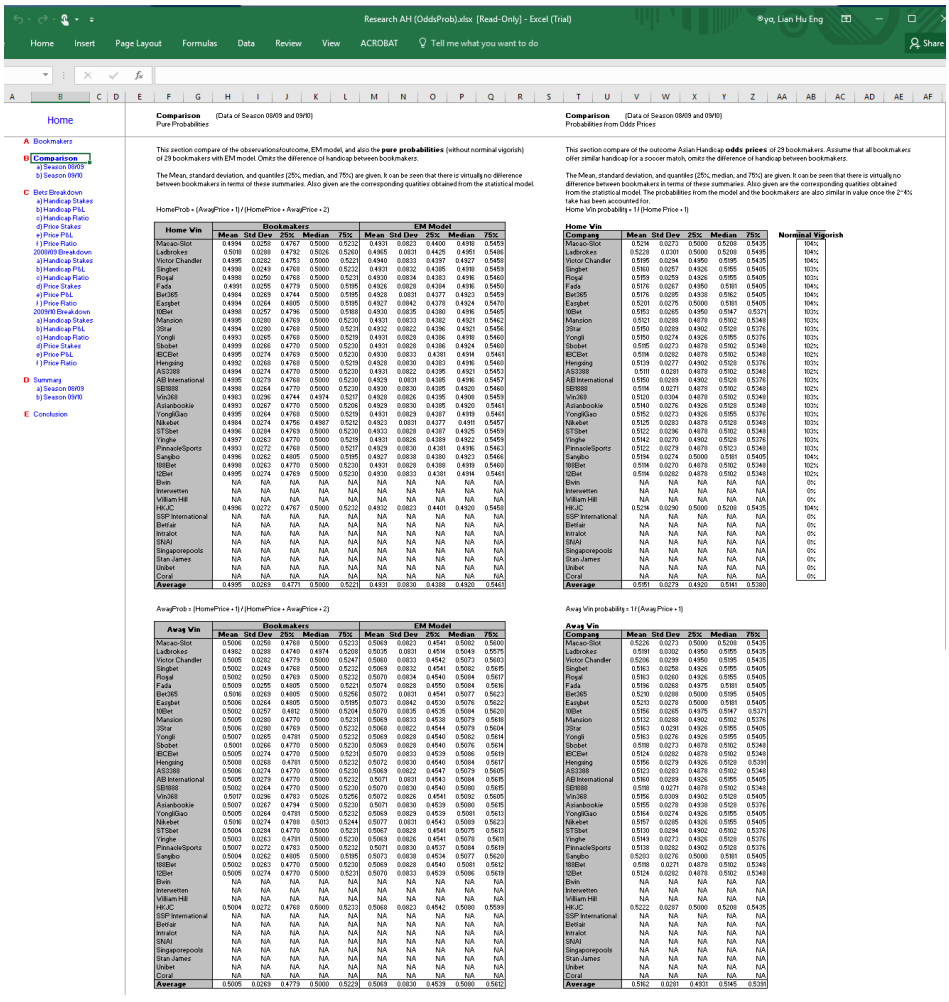
Research AH (OddsProb)



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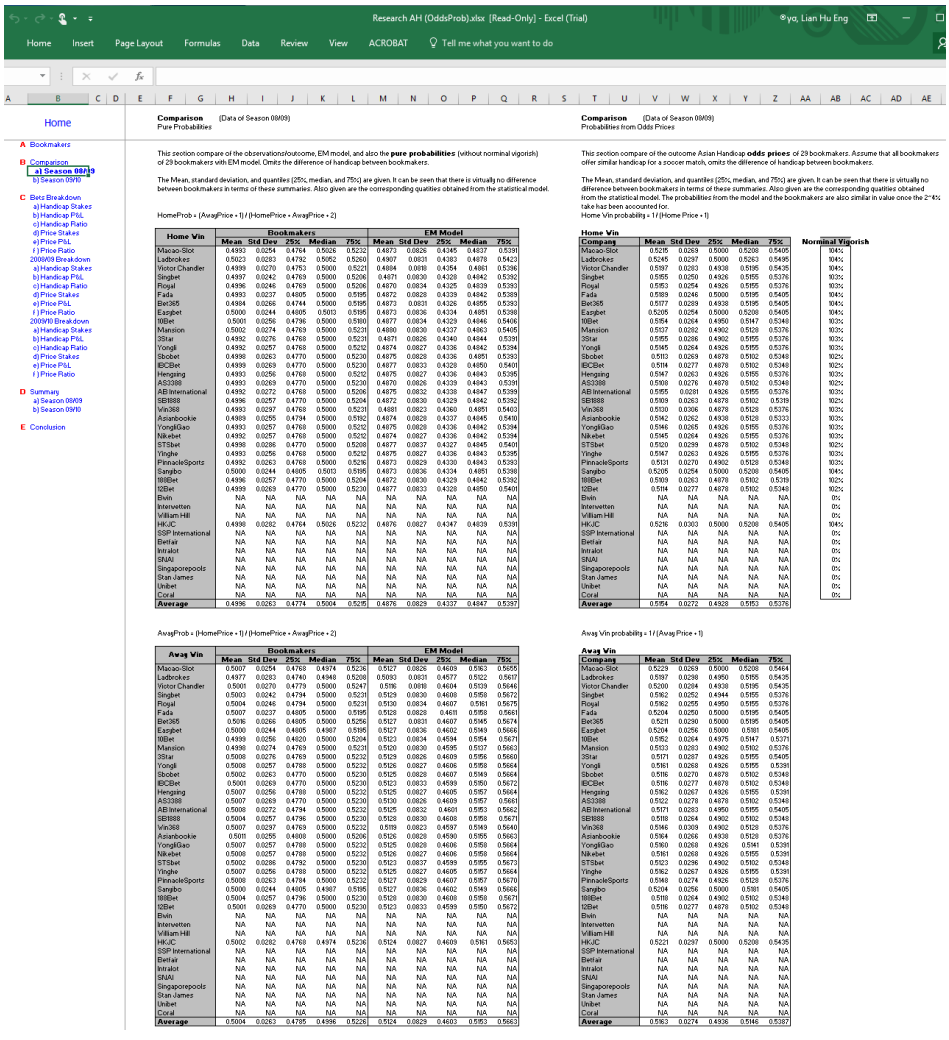

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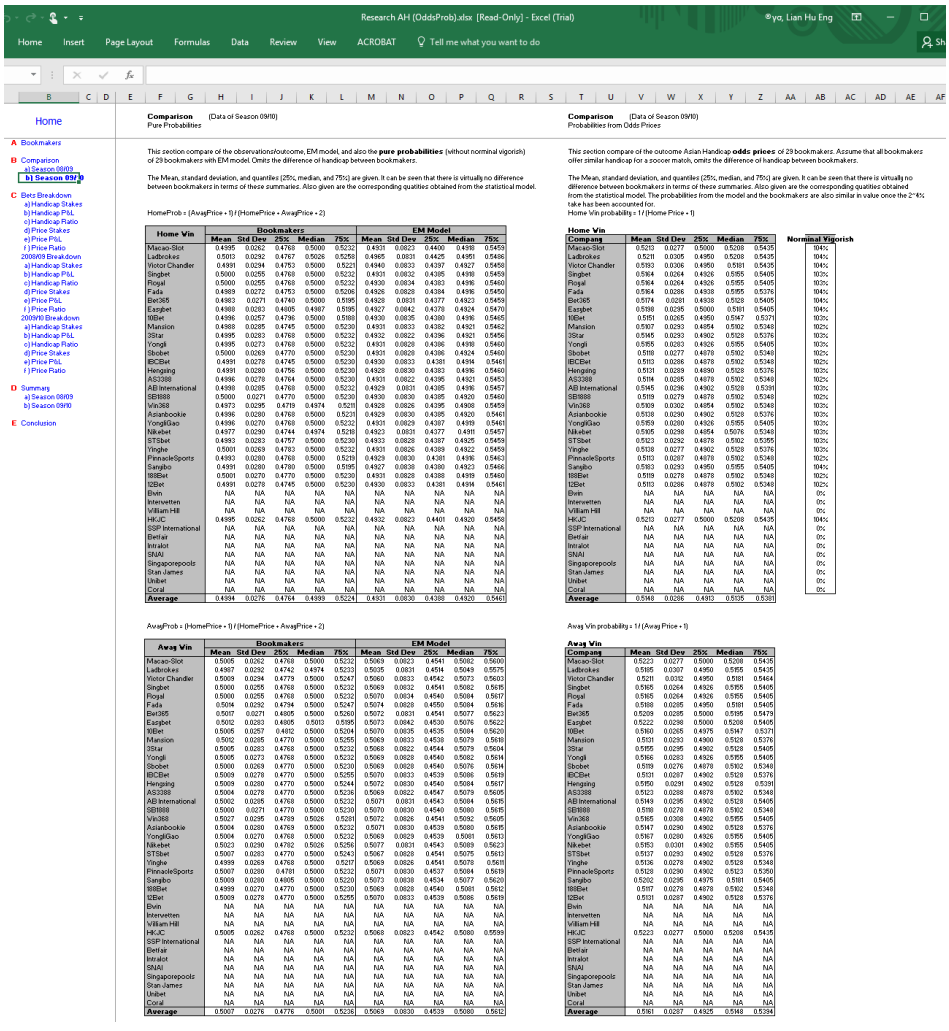

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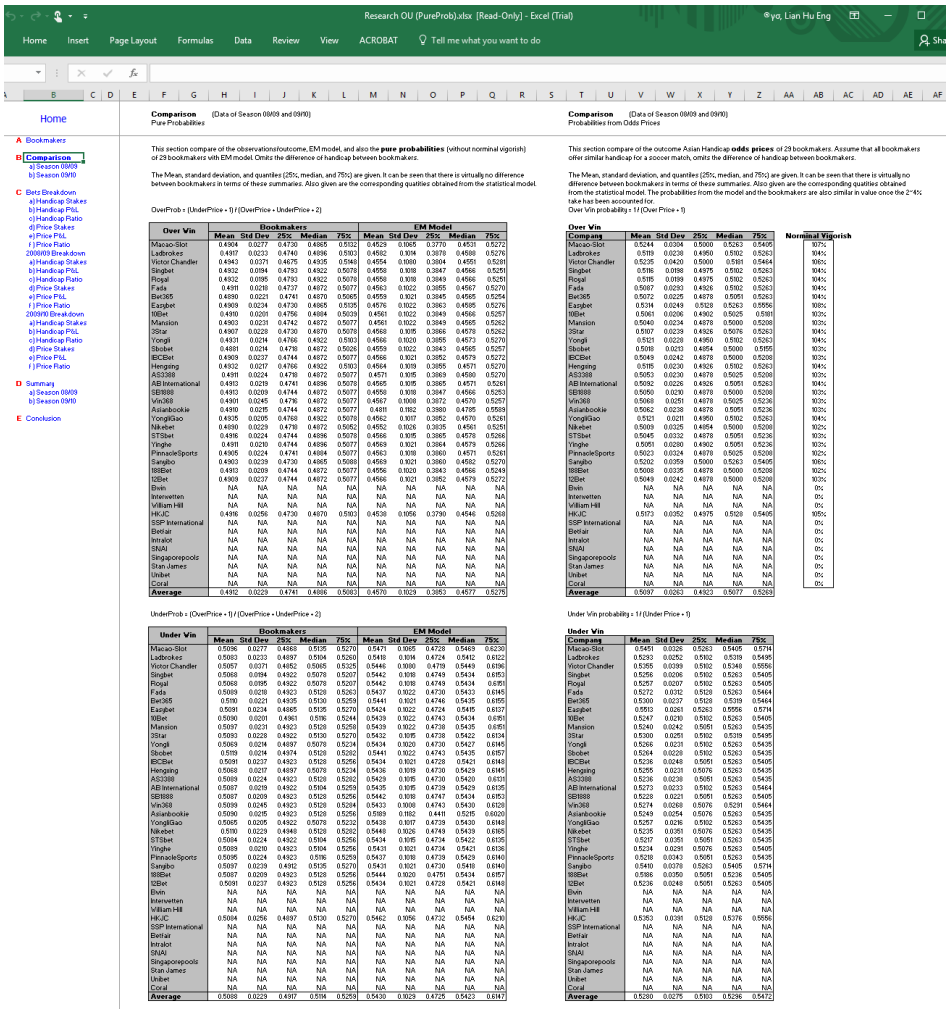
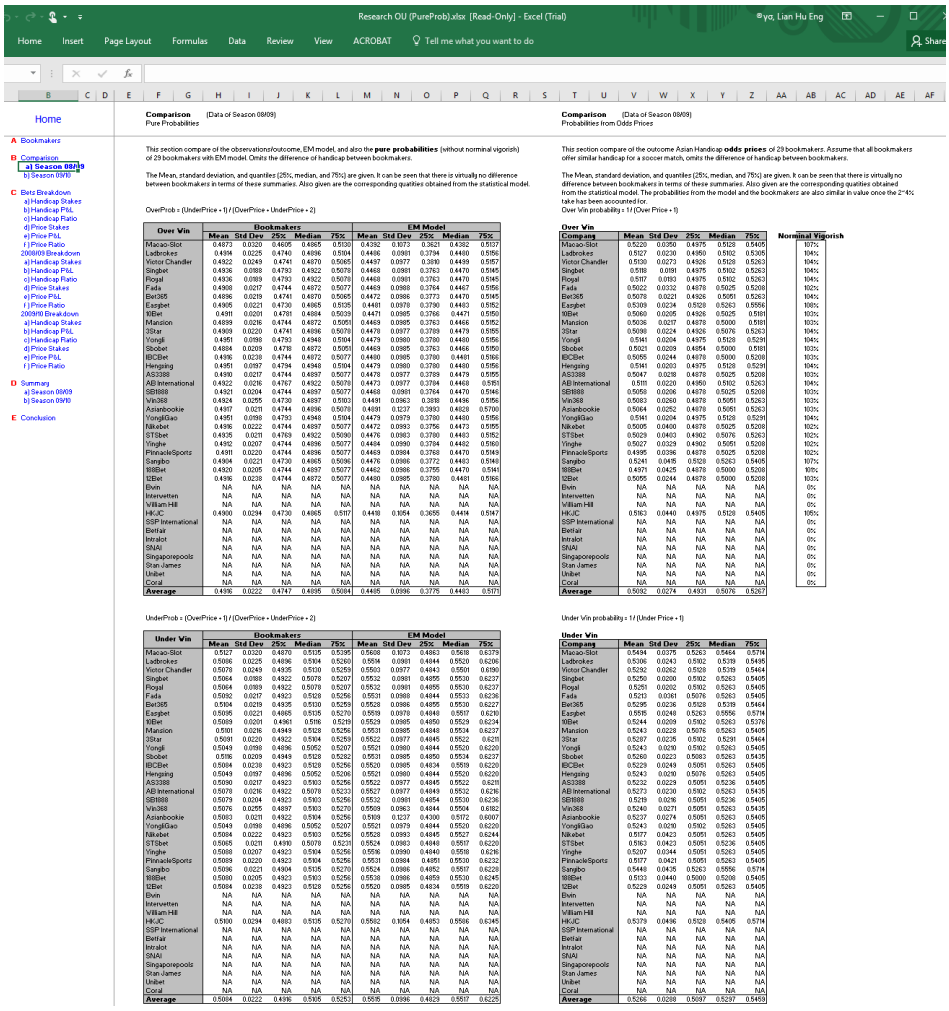


Above figure shows a comparison the mean, standard deviation, quantile 25%, median, quantile 75% of Goal Line odds price without vigorish of total soccer matches in season 2008/09 and 2009/10.



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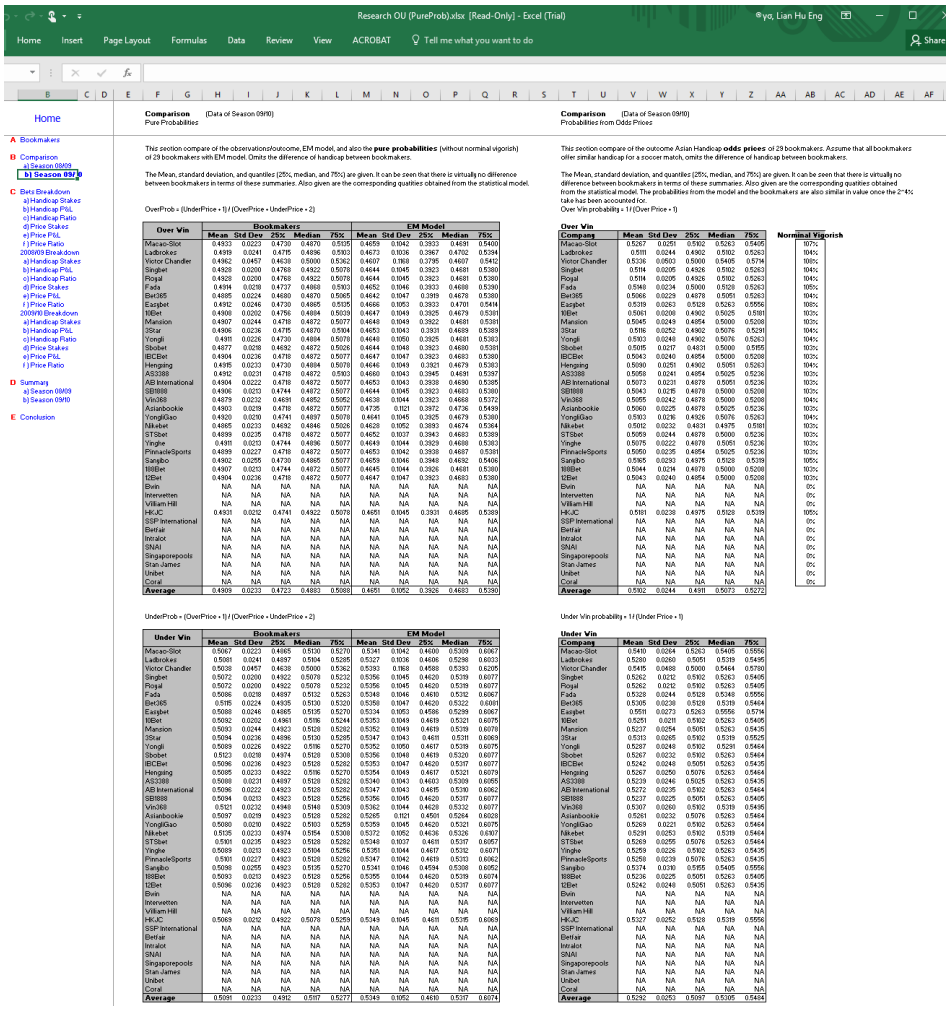

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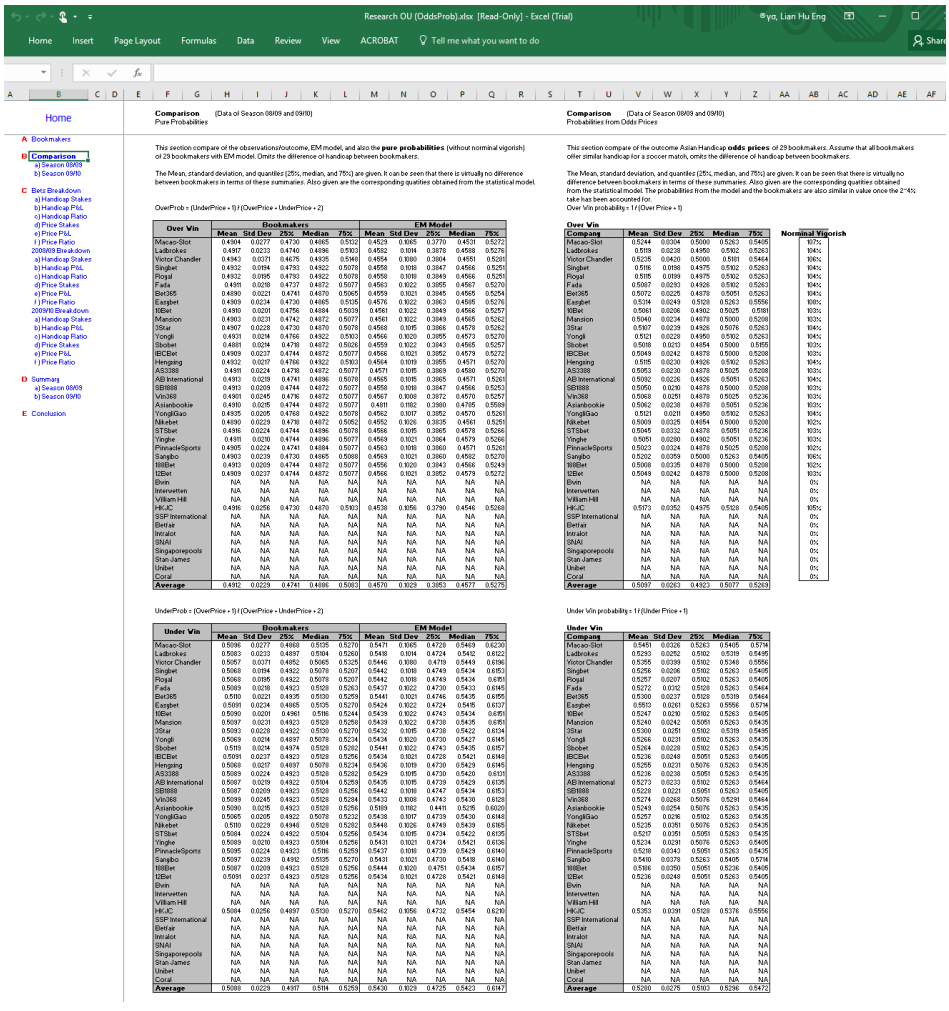

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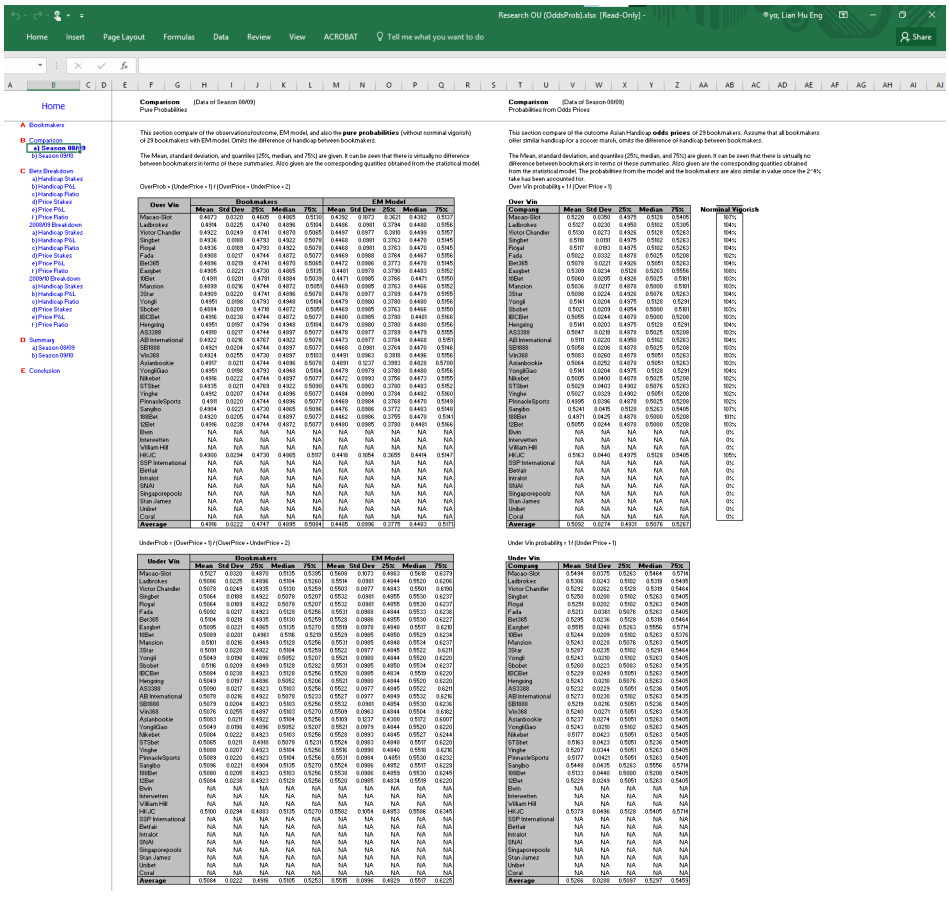

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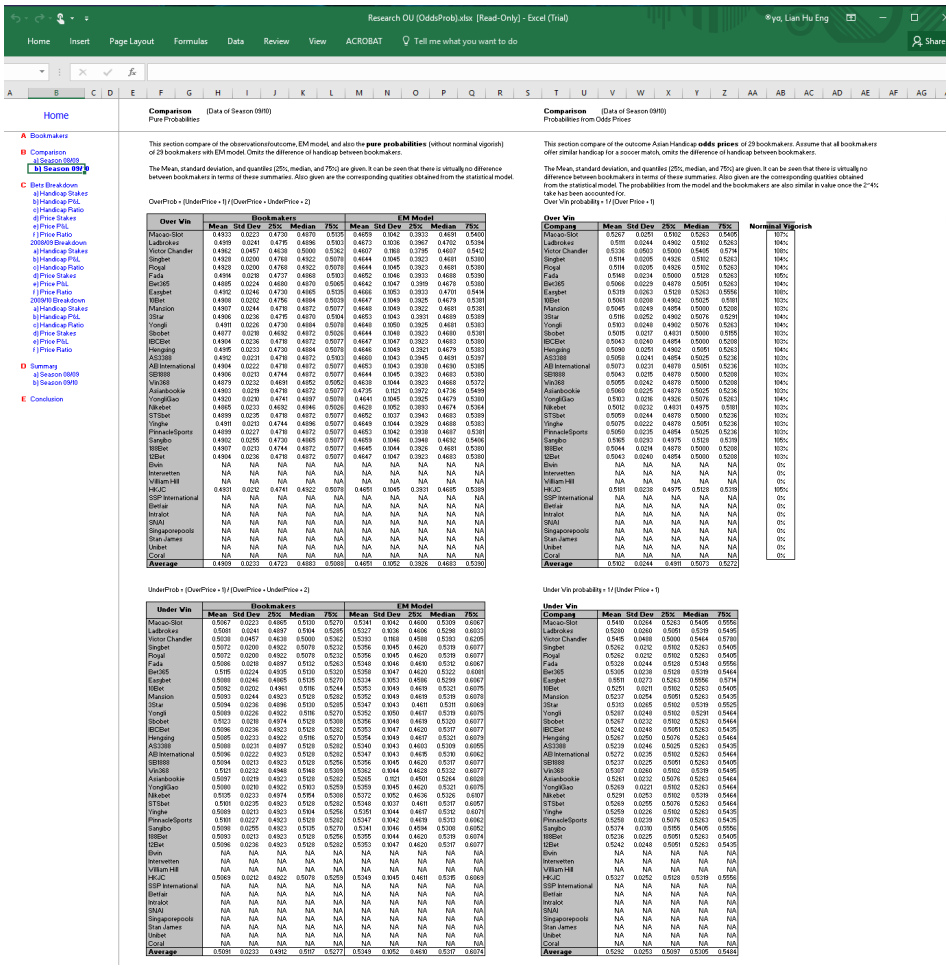

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4.2. Staking Model

As I mentioned in section Model Enhancement on the decay rates. In order to test the efficiency and the return of investment, I've taken both models in *algorithmic simulations*[13]. For the staking model, I just simply using the most simple staking model which from *Dixon & Coles 1996*.

Only $1 One dollar placed on every level of edge from 1.00 until 4.00. Kindly refer to below sample table.

Below table is another sample breakdown table which showing the handicap breakdown and odds price breakdown in:-

- stake amount

[13] I tried to fit the constant decay rates, weekly dynamical decay rates and dynamical decat rates just right after finish a soccer match. It is my previous research saved in Rmodel.RData files prior to start this spreadsheet. Therefore this spreadsheet only taken the compleleted and converted odds price for staking and testing efficiency purpose.

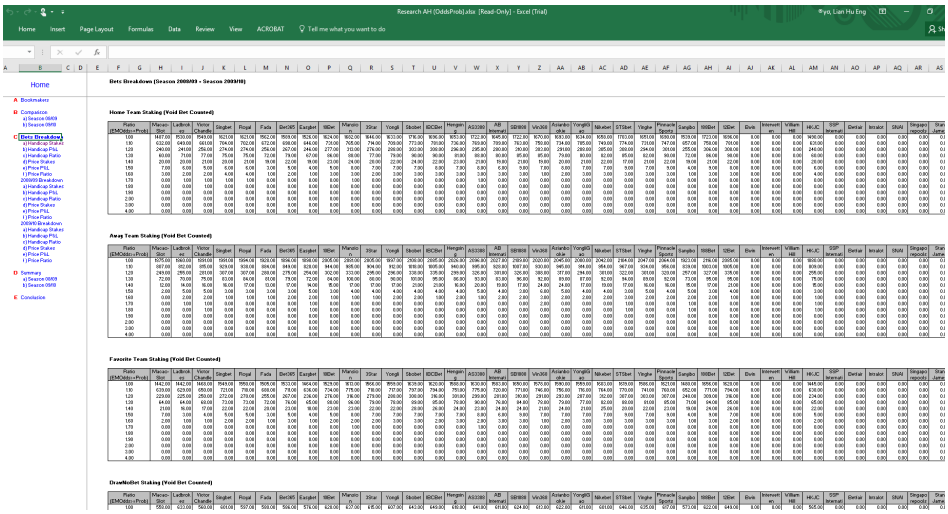

Figure 7: A sample of edge value and staking breakdown table

- staking ratio
- profit & lose
- profit and lose ratio

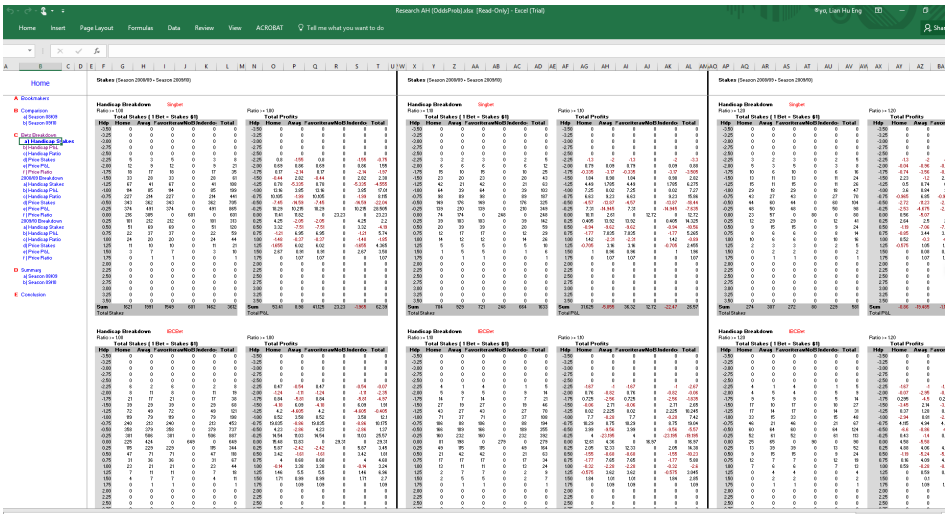

Figure 8: A sample of staking breakdown table

4.3. Preview of Returns.

Below tables breakdown the stakes and return on every single edge point that overcame the overrounds.

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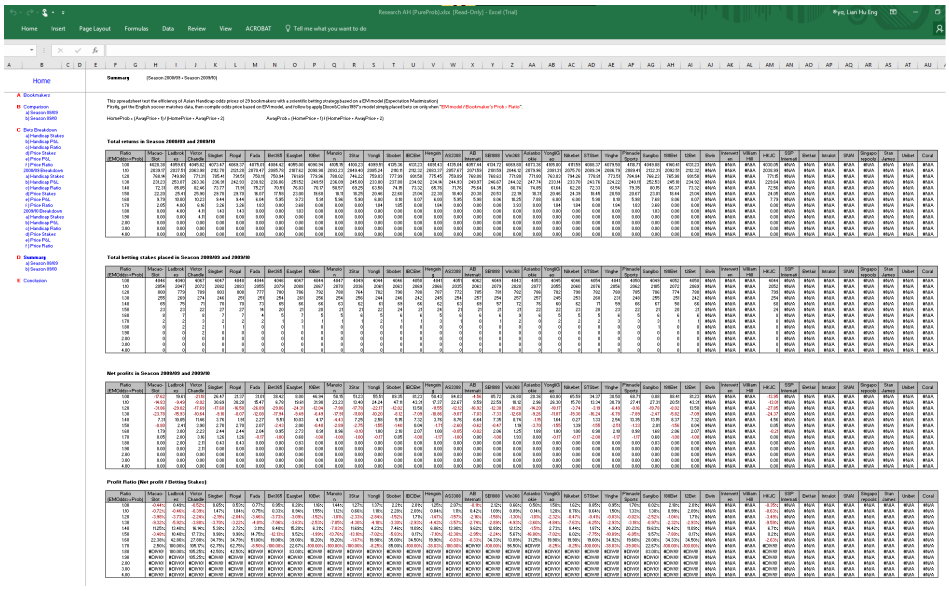

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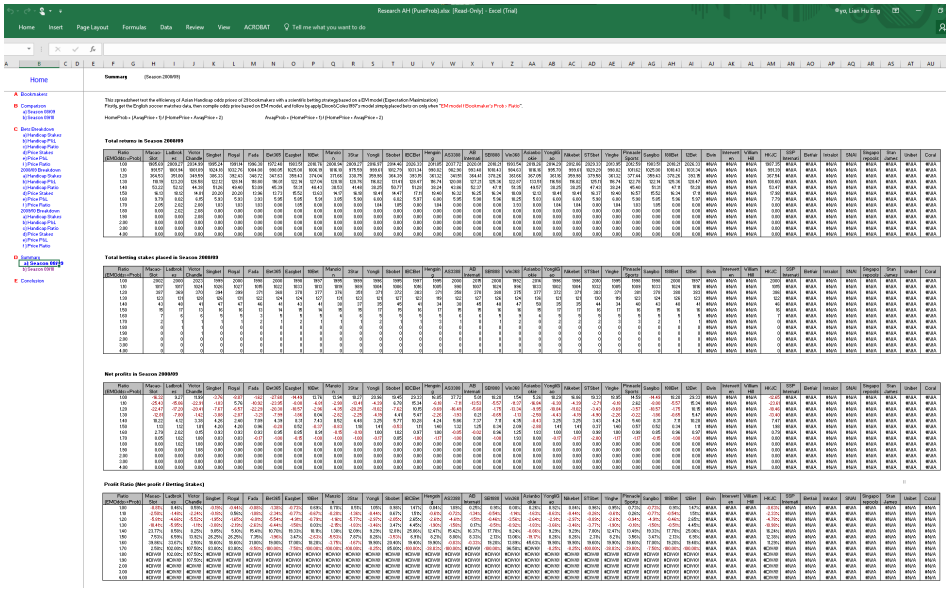

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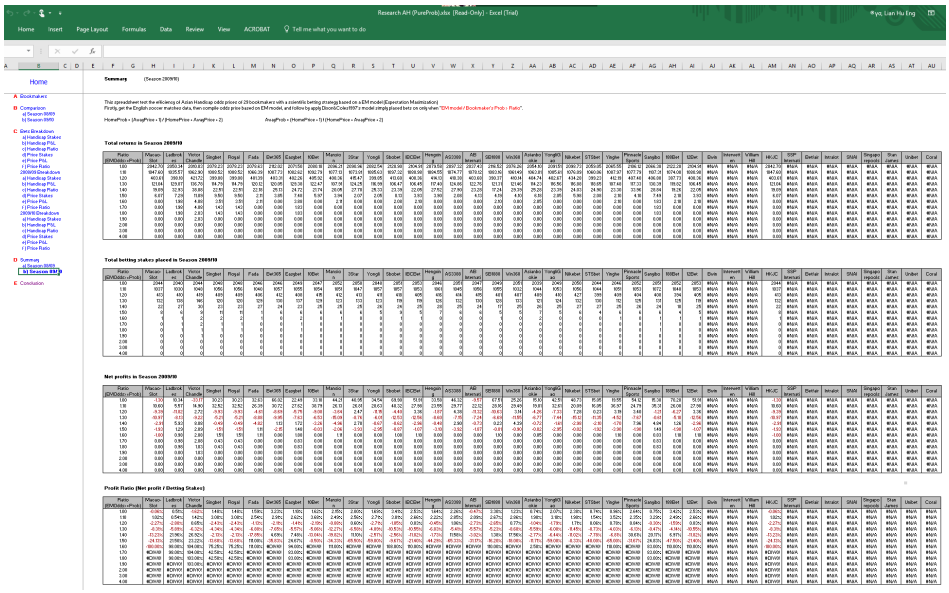

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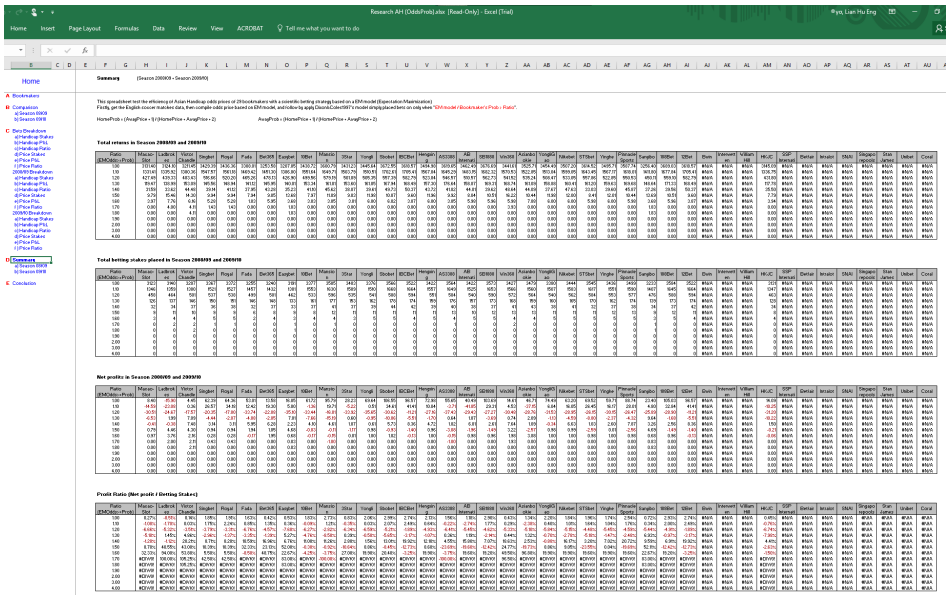
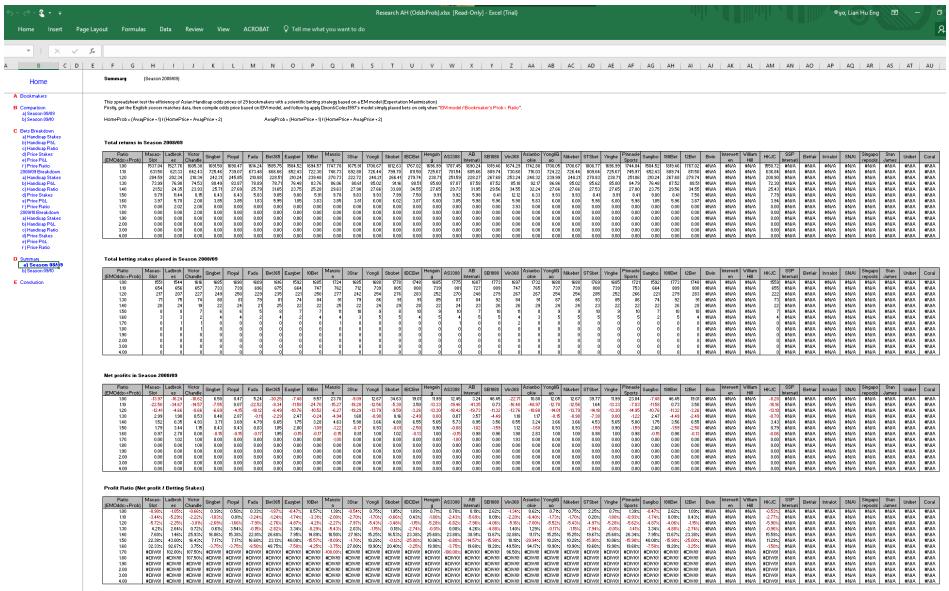
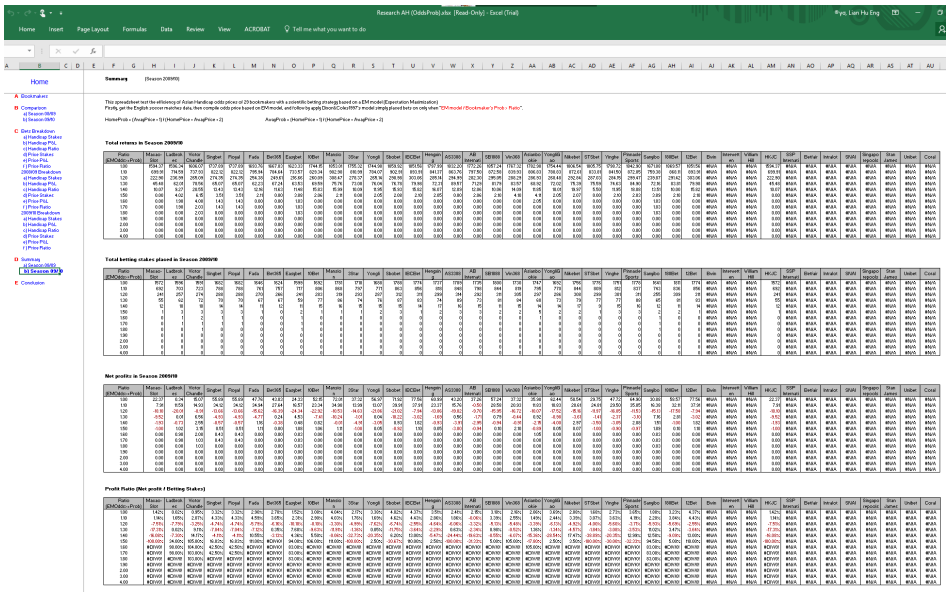


Above figure shows a staking breakdown on every single edge on Asian Handicap odds price with vigorish of total soccer matches in season 2008/09 and 2009/10.

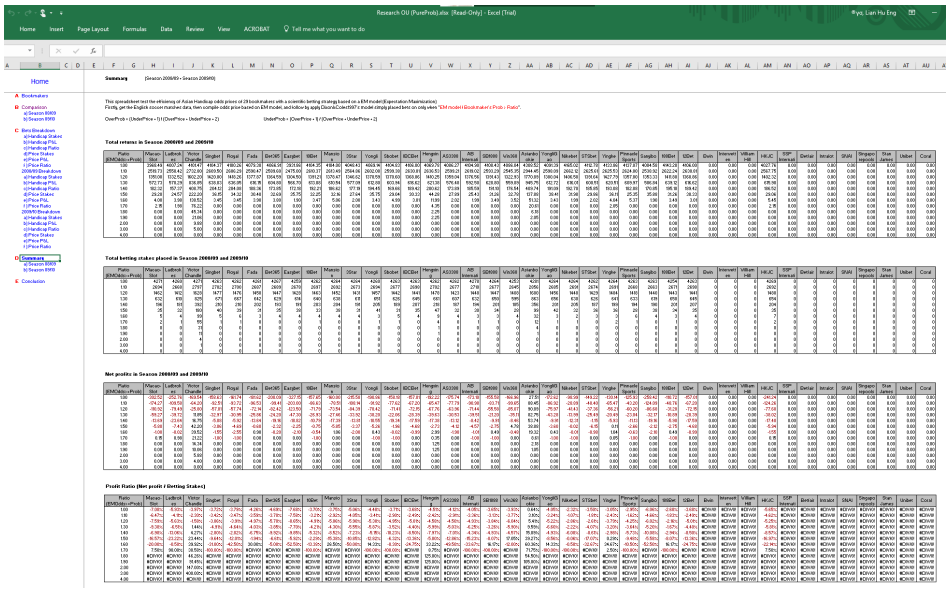


Above figure shows a staking breakdown on every single edge on Asian Handicap odds price with vigorish of total soccer matches in season 2008/09.

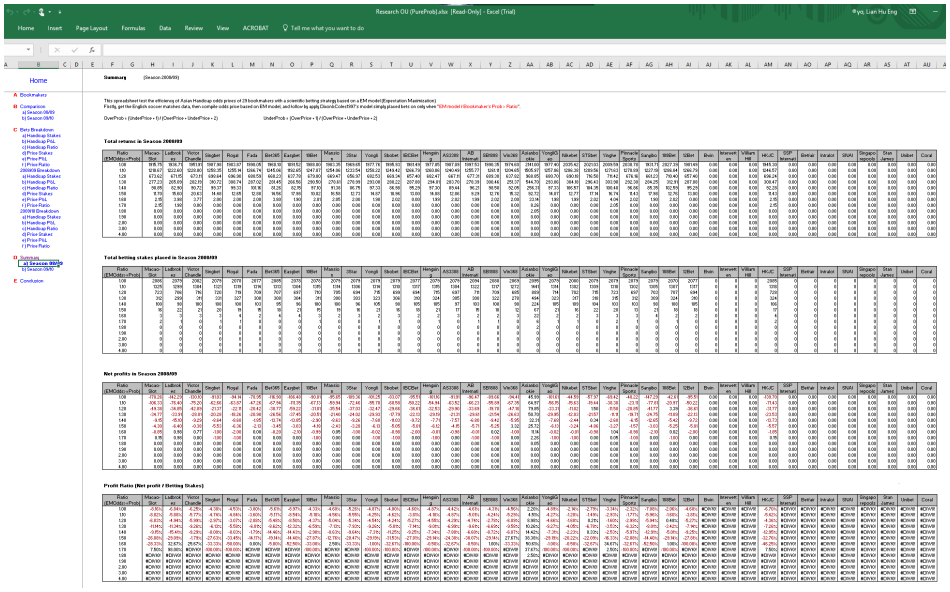


Above figure shows a staking breakdown on every single edge on Asian Handicap odds price with vigorish of total soccer matches in season 2009/10.

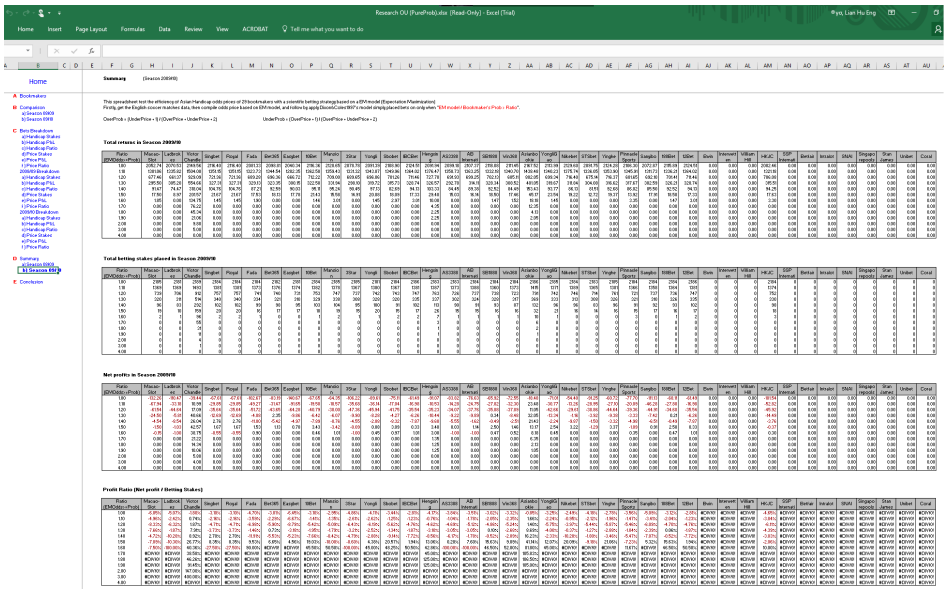
Research OU (PureProb)



Above figure shows a staking breakdown on every single edge on Goal Line odds price without vigorish of total soccer matches in season 2008/09 and 2009/10.

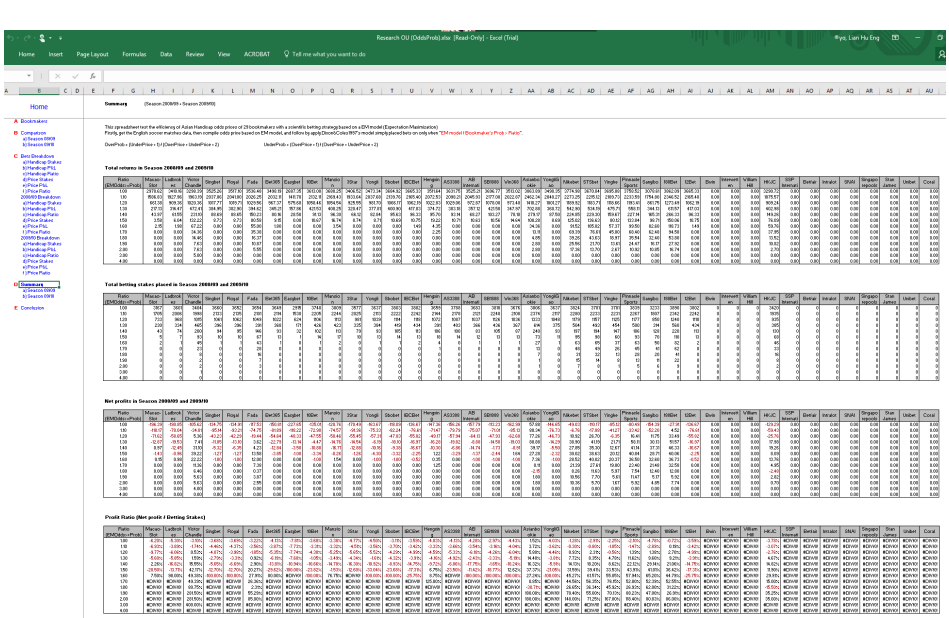


Above figure shows a staking breakdown on every single edge on Goal Line odds price without vigorish of total soccer matches in season 2008/09.

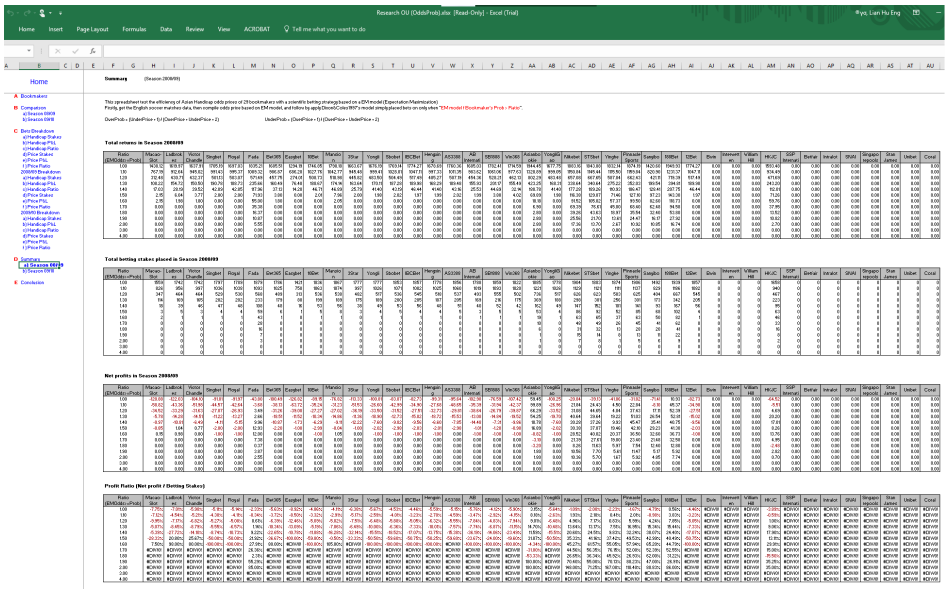


Above figure shows a staking breakdown on every single edge on Goal Line odds price without vigorish of total soccer matches in season 2009/10.

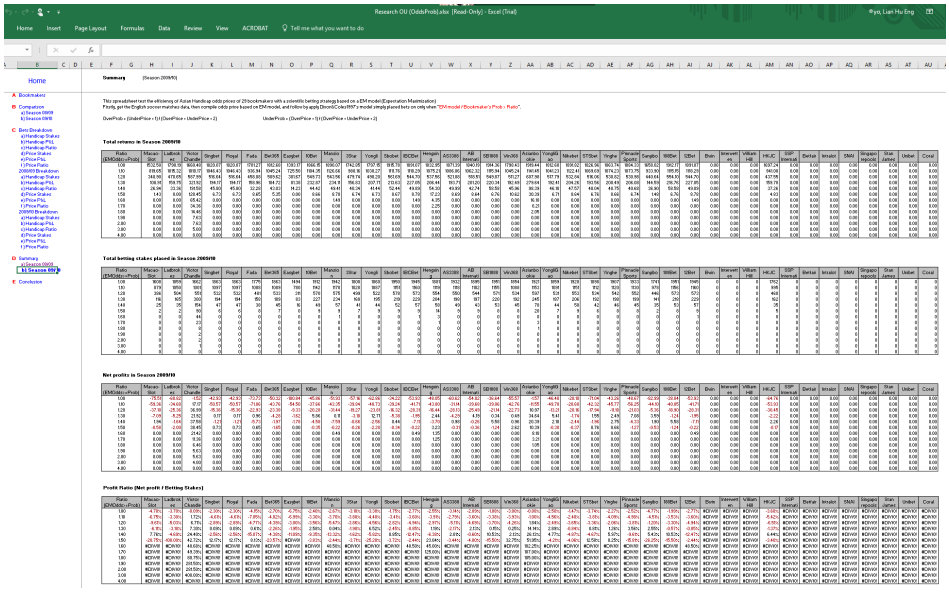
Research OU (OddsProb)



Above figure shows a staking breakdown on every single edge on Goal Line odds price with vigorish of total soccer matches in season 2008/09 and 2009/10.



Above figure shows a staking breakdown on every single edge on Goal Line odds price with vigorish of total soccer matches in season 2008/09.



Above figure shows a staking breakdown on every single edge on Goal Line odds price with vigorish of total soccer matches in season 2009/10.

5. Conclusion

5.1. Conclusion

This spreadsheet test the efficiency of Asian Handicap odds prices of 29 bookmakers with a scientific betting strategy based on a EM model (Expectation Maximization)
Firstly, get the English soccer matches data, then compile odds price based on EM model,

based on that model simply placed bets on only when "EM model / Bookmaker's Prob > Ratio".

From the result of this research on 2 Seasons English Soccer Leagues, we conclude the below points:

- proof that nowadays we are hard to make profit from 29 bookmakers based on simple betting strategy (EMProb / BKProb).
  - there are no Asian Handicap betting models in academics research industry, somemore sophisticated betting model needed.
  - furthermore, some matches have no odds prices may caused the betting made a lose result.
  - the most importance point is that bookmakers take a very high advantages which is higher than norminal virogish (refer to application of Malay odds, and also Ryo handicap.xlsx spreadsheet to know the calculation of real vigorish).

5.2. Future Works

I applied **Kelly model**[14] next to this research which generated profit (positive return of investment) more than 30% every year.

While now I am using dataset from European famous sportsbook consultancy firm to test thier staking model and efficiency. Wher I need to modify existing Kelly model to be half, quarter etc to control the risk similar with *Moya 2012*.

There has a weakness in this paper which is gathered dataset are history odds price while I am learning to build a real time trading system now. However a profit return from my few years research and put my all time and affort in this sportbook research is worthable, happier and stimulated to be more aggresive to continue my journey to setup own hedge fund company **Scibrokes**.

6. Appendices

6.1. Documenting File Creation

It's useful to record some information about how your file was created.

- File creation date: 2016-05-06
- R version 3.2.3 (2015-12-10)
- R version (short form): 3.2.3
- **rticles** package version: 0.2
- File version: 1.0.0
- File latest updated date: 2016-05-05

[14] Refer to Testing Inefficiency of Sports-Bookmakers by Kelly Model

- Author Profile: ®yo, Eng Lian Hu
- GitHub: Source Code
- Additional session information

[1] "2016-05-05 21:21:34 EDT" setting value
version R version 3.2.3 (2015-12-10) system x86_64, linux-gnu
ui X11
language (EN)
collate en_US.UTF-8
tz America/New_York
date 2016-05-05
sysname release "Linux" "3.10.0-229.20.1.el7.x86_64" version nodename "#1 SMP Tue Nov 3 19:10:07 UTC 2015" "scibrokes" machine login "x86_64" "unknown" user effective_user "ryoeng" "ryoeng"

6.2. Speech and Blooper

Firstly I do appreciate those who shade me a light on my research. Meanwhile I do happy and learn from the research. I do appreciated to take some spared time to write this thesis where the research has start from 2008 and finish in 2012. Infact I've finished my research on 2010 before I wrote a proposal to acquire the Ladbrokes[15] trading and hedge fund project in Scicom (MSC) Bhd and extended dataset soccer matches until 2012. Unfortunately the project has closed but I keep up learning journey to run my own company Scibrokes[16] some other days. I'll started work as customer service executive but in somewhere else next week, I am currently studying distance course data science at Coursera.org. You are feel free to browse over my CV at ®yo Eng Lian Hu.

I started my research journey when I decided to resign from Caspo Inc. to be an customer service operator in Scicom (MSC) Bhd. I've search, collected and read through thousands of research papers to get the applicable model in our real life investment. Fortunately I found and know a person Boffins -vs- Bookies (The Man Who Broke the World Leading Bookmakers) and start my learning from an outsider which don't know any statistical tools for modelling until successfully completed the research in year 2012. Kindly refer to My personal WordPress blog for more experience and bloopers.

Now I would like to share some bloopers during process this thesis.

- **Remarks** : Due to the mathematical LaTeX formula and greek letters unable use in **rticles** package. Here I forced to use some image for substitution.
- Due to the Microsoft Excel file inside my previous project dataset for **Odds Modelling and Testing Inefficiency of Sports-Bookmakers** *2008-2010 by ®yo Eng Lian Hu* is very huge in xlsx format and set with a struture frame. Therefore I just omit to apply `openxlsx` to read the data for further process.

[15]Ladbrokes is a world leader in the betting and gaming industry with over 2,700 betting outlets in the UK, Ireland, Belgium and Spain and over 800,000 active online customers. British public listed company which in the Fortune 500 and over hundred years business group.
[16]A registered company but not yet in operation. A prospective statistical hedge fund company.

- I tried to convert the xlxs files to pdf format and attached as appendices but system keep endless processing there but no outcome. Secondly, huge dataset make it trouble to read into ®Studio and summarise and plotting some d3 graphs.
- The embed figures always not align in order, some figures will always align to other topic after knit.

6.3. Reference

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URL: https://github.com/scibrokes/owner

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