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Moneyball Applied: Econometrics and the Identification and Recruitment of Elite Australian Footballers

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Abstract

The best selling book *Moneyball* posited a theory on the success of a Major League Baseball franchise that used detailed match data to identify inefficiencies in the market for professional baseball players. These statistics were then exploited to the advantage of that team. An important part of this strategy involved using mathematical techniques to identify which player statistics were most associated with team success, and then using these results to decide which players to recruit. This paper uses a similar approach to analyze elite Australian Football, making use of various types of regression models to identify and quantify the important player statistics in terms of their affect on match outcomes.

Keywords: *Moneyball*, Australian Football, sports statistics

Introduction

The use of statistics to assist sporting organizations in making personnel and coaching decisions is not a new phenomenon. They have, however, been given increased prominence with the release of books and the publication of websites that aim, in part, to describe advantages that may accrue to those sporting teams who best utilize these statistical methods. Michael Lewis' *Moneyball* (2003), which deals with baseball; *The Wages of Wins* by Berri, Schmidt, and Brook (2006), which focuses primarily on basketball; and the website Football Outsiders (http://www.footballoutsiders.com), which analyzes American football, are prominent examples of this.

The purpose of this paper is to explore the possibility of whether statistical methods can be used to assist in the recruitment of Australian Football League (AFL) players, particularly to establish if there are any market inefficiencies to be exploited. Using various regression models the individual player statistics that are most highly correlated with team success are selected and quantified. That is, the statistical modeling in this paper is able to show the statistical relationship between individual player statistics and team winning margins.[1] This is something that has not previously been done for Australian Football.

Using the results from our model, club recruiting staff could use these statistics to identify potential players.

These player statistics would be used alongside, or in place of, the traditional more subjective methods of selecting players that are currently utilized.

This paper will proceed as follows. In the next section some of the previous research using statistics to recruit elite sportsmen is summarized. Then the data used in this study is explained. After this the econometric estimation and results are outlined. This is followed by a discussion of the implications of our findings, and lastly some conclusions are drawn.

Previous Research

Lewis' (2003) popular publication *Moneyball* has been a significant catalyst in the increased attention given to statistical analysis and sporting organization decision-making. The book, which was among the top 10 on the New York Times best-seller list every week of 2004, chronicled the exploits of the Oakland Athletics Major League Baseball (MLB) team. In 2002, the Athletics, despite having close to the lowest player payroll, won the equal highest number of games throughout the regular season. This outcome, according to the theory suggested by the author, was directly related to a strategic statistical approach that sought to exploit perceived irregularities and inefficiencies in the baseball player labor market. By focussing on recruiting older players (college rather than high school) and emphasizing the importance of a certain narrow range of baseball statistical measures over traditional approaches, the Athletics were able to build a roster of players that performed very well for relatively little cost.

Although the details of how the Oakland Athletics specifically formulated their player statistical valuations was not presented in great detail, it appears that some form of regression analysis (as is the case in the current study) was used. This is hinted at by Lewis, (2003, p. 127) where he notes that an Economics graduate employed by the Athletics,

…plugged the statistics of every baseball team from the twentieth century into an equation and tested which of them correlated most closely with winning percentage, and he had found only two, both offensive statistics, inextricably linked to baseball success: 'on-base percentage' and 'slugging percentage'. Everything else was far less important.

The analysis also revealed that many of the statistics that were commonly thought of as being important were not significantly correlated with success; examples of these were many of the defensive statistics (fielding and pitching).

Lewis (2003) also discussed parallels between financial markets and baseball. In the 1980s and 1990s financial markets were transformed with the development of derivatives products such as options and futures. This meant that for around 10 years there were large profits to be made by those with both the intellect and computer power to properly value these new financial products. The sorts of people that quickly grasped the opportunities were not typical traders, but mathematicians and statisticians.[2] The argument was then put that the Oakland Athletics were able to identify similar inefficiencies in the market for professional baseball players and then exploit this to their advantage. That is, as the market for baseball players was not efficient, and the general grasp of sound baseball strategy so weak, then superior management could outperform less well managed but wealthier clubs.

As the methods employed by the Athletics became widely known, one would expect that any advantage that may accrue would dissipate. This is exactly what would be predicted by the economic theory of efficient markets. Since 2000 the Athletics, however, have had considerable ongoing success utilizing and refining their methodological approach to recruitment. Club general manager Billy Beane, who is credited with developing the concept of *Moneyball*, explains the approach of seeking to stay ahead of the market as being one where "when everyone is zigging, we have to zag" (Bodley, 2006, n. page).[3]

Since 2000, with the exception of 2004, the Athletics have ranked in the bottom third of total payroll relative to the other 29 franchises in MLB, yet have recorded total regular season wins in the top third in this time period.

The approach taken by the Oakland Athletics has been tested in the academic literature. Hakes and Sauer (2006) examined Lewis' (2003) hypothesis by studying the baseball labor market in the period 1999 to 2004. Their results support the contention that the certain baseball skills were inefficiently valued. They found that teams such as the Athletics exploited this discrepancy in valuation; however, as knowledge of the inefficiency has become dispersed corrections have occurred.

The impact of Lewis' (2003) book has been further considered in a variety of contexts and has generated discussion at numerous academic conferences, including symposium sessions at recent conferences of the Academy of Management[4] and the North American Society for Sport Management.[5] The previously noted book by Berri, Schmidt, and Brook (2006) mentions the impact of *Moneyball* and the authors indicate that their book (largely, but not solely confined to basketball) tells a similar story, but one which offers systematic statistical evidence as opposed to Lewis' more anecdotal approach.

Roberto (2005) has produced a Harvard Business case on *Moneyball* and academics have positively reviewed the book's merits and place in spawning discussion and research (see for example, Gerrard 2004; Thaler & Sunstein, 2003; Moynihan, 2006). Ballard (2005) has noted the recent proliferation of statistical experts that teams in the U.S. National Basketball Association have hired to specifically identify opportunities in the labor market. He states that these "…new insiders have the same goals as their more celebrated baseball brethren: to identify, through complex statistical analysis, trends, talent and value that no one else sees" (p. 60). Ballard (2005) also notes that such evaluation is changing conventional approaches to player recruitment and team planning. Further across disciplines, Lewis' (2003) hypothesis has been extended to broader applications with Wolfe, Wright, and Smart (2006) in one published study contending that the *Moneyball* approach to human resource management has significant overlap and lessons for human resource professionals across a variety of industries.

It stands to reason that while the use of statistical techniques to evaluate athletes grows, its relevance and application to a wider range of sports be studied. In Australia the most popular sport in terms of both attendance and television audience is Australian Football. In 2006 total league attendance was over six million people[6], with 2.5 million people aged 15 years or over reporting they had attended at least one match in a 12-month period between 2005-06. This represents an attendance rate of 16% of the Australian adult population (ABS, 2007).

At the elite level Australian Football is played in a competition called the Australian Football League (AFL). The AFL is made up of 16 teams and operates under a salary (wage) cap to limit team spending. In 2006 this cap figure was $6.47 million per team.[7]

While many sports can claim a great deal of intricacy to their rules and structure, Australian Football is a relatively complex sport with 36 players being gathered on a large, oval shaped playing surface all being able to move the ball in any direction via hand or foot.[8] From a statistical perspective the game has traditionally focused on two elements, kicks and handballs that sum to disposals (or as otherwise referred to as possessions). Other popular measures include catches of the ball (referred to as marks), tackles, and points scored, which are divided up into goals worth six points and behinds worth one point.

The AFL can be seen as a league where statistics are generally considered as raw numbers. That is, total numbers of marks, disposals, and goals scored are usually presented as a measure of performance. This contrasts to other sports, such as baseball and cricket where efficiency measures (for example batting average in the case of both sports) are utilized to commonly judge performance. Berri, Schmidt, and Brook (2006) make the same distinction when comparing basketball measures to baseball and then seek to redress this by producing measures that allow basketball players' contribution to winning to be effectively measured. It can be argued that the same case can be made for Australian Football players, given the dearth of efficiency measures that currently exist. For example, time on playing field is not often reported in general statistics published by the media, and while this information is available to clubs, the information does not contain a breakdown of actual time where the player in question was actively involved in play. Given the size of an AFL playing field (which may be as long as 185 meters and as wide as 155 meters) it is quite possible that a player could be on the field for a considerable period of time, but not actively involved in any direct passage of play.

Prior to commencing this study, the authors discussed their ideas with Craig Cameron, the Melbourne Football Club General Manager of Recruiting and List Management.[9] The Melbourne Football Club was interested the notion of applying Moneyball theories to Australian Football and then arranged for us to gain access to the data provided to them by the ProWess Sports (the sports statistics firm employed by the football club).

Table 1. ProWess Player Statistics Definitions

Abbreviation	Statistic	Description of Statistic
1ST	First Possession	The first possession/disposal from an umpire control situation (centre bounce, ball up, throw in)
50P	50 Metre Penalty	A 50 metre penalty against the player as called by the umpire
BG	Ball Get	”Getting” the ball in a contested (hard) or uncontested situation (loose or gather)
BHS	Behind	A scoring shot registering one (1) point by a player
BNC	Bounce	Each bounce when running with the ball in general play
BUC	Ball Up Clearance	All clearances from a ball up
BUH	Ball Up Hit	All ruck taps, palms from a ball up
CBC	Centre Bounce Clearance	All clearances from a centre bounce
CBH	Centre Bounce Hitout	All ruck taps, palms from a centre bounce
CLE	Clearance	When the ball is cleared from the contest from an Umpires Ball (can be KCK, HBL or KNK)
DIS	Dispossess	Player, who has had prior opportunity to dispose of ball, has lost possession by tackle, knocked out of hands, etc.
DISP	Disposals	The sum of Kicks and handballs
DM	Dropped Mark	An attempted mark, which was markable, that was dropped
EFC	Effective Clearance	Effective clearance, meaning side retains possession, from a ruck contest (neutral/umps ball)
EFH	Effective Hitout	Effective Hit-out from a ruck contest (neutral/umps ball) to a teammate who has the next possession
F/A	Free Against	An infringement against the player as called by the umpire
F/F	Free For	An infringement in favor of the player as called by the umpire
FUM	Fumble	A dropped ball, fumble, etc in general play
GAT	Gather	A uncontested ball get which has specifically been put in the path of the player by a teammate
GLS	Goal	A successful scoring shot registering 6 points by a player
HBG	Contested Ball Get	A contested ball get in heavy traffic
HBL	H/Ball	All handballs in general play
HBR	H/Ball Receive	Receiving a direct handball from a team-mate in general play
HIT	Hitout	Hitout from a ruck contest.
I50	Inside 50	Player moving the ball inside the 50M are by disposal, run, bounce, knock on, hit out, etc.
KCK	Kick	All kicks in general play
KIN	Kick In	A kick In from a behind back into general play
KLG	Kick Long	Kicks considered traveling MORE than 40 meters
KNK	Knock On	A knock or distinct tap off the ground in general play
KOP	Kick To Opposition	A Kick in general play that goes directly to an opposition player
KSH	Kick Short	Kicks considered traveling LESS than 40 meters (not including off ground)
KTA	To Advantage	A Kick in general play that goes to the clear advantage of a team-mate
KTC	Kick To Contest	A Kick in general play that goes to a 50/50 contest
KTS	Kick To Space	A Kick in general play that goes into the open
LBG	Uncontested Ball Get	An uncontested ball get

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Table 1 continued

Abbreviation	Statistic	Description of Statistic
MCT	Contested Mark	A mark taken in a contested situation with the opposition
MIS	Missed Shot	An gettable shot on goal that was either considered "short" or "out on the full"
MRK	Mark	All marks in general play
PON	Play On	Each time a player plays on from a mark or free
R50	Rebound 50	Player moving the ball outside the 50M are by disposal, run, bounce, knock on, hit out, etc
RCK	Ruck Contest	Each time a player goes up in the ruck contest irrespective of whether anyone gets a Hit-out
RUS	Rushed Behind	A forced behind by the opposition by method of running through or punching
SHP	Shepherd	To "legally protect" a teammate who is in possession of the ball
SMT	Smother	A successful attempt to smother a disposal by the opposition
SPL	Spoil	A punch to spoil an opposition player (normally in marking contest)
SWI	Switch of play	A kick which is a definite change of direction, usually at right angles to open up the play
TAR	Inside 50 Target	The intended player/target when the ball is kicked into a teams forward line
TIC	Throw In Clearance	All clearances from a boundary throw in
TIH	Throw In Hitout	All ruck taps, palms from a boundary throw in
TKE	Effective tackle	A tackle that effectively disrupts or changes the way the opposition player dispossess the ball
TKL	Tackle Attempt	A reasonable attempt by the player to tackle the opposition

Source: Definitions taken from Pro-Edge User Guide. Pro-Edge is the software used by Prowes-Sportss to store their football data

The time spent with the Melbourne Football Club was also very useful, as it allowed the authors to ascertain the current and historic recruitment methods used in Australian Football. The organization employs specialist staff that assessed the player labor market through attendance at matches across various leagues and through appraisal of video footage. Broad statistical information is also supplied from statistical tracking companies that specialize in the sports area. Both the Melbourne Football Club and ProWess Sports were aware of and very interested in the approach outlined in *Moneyball* and were curious to test its application to the AFL.

The Australian Football League Data

This paper uses data from the 2002, 2003, 2004, 2005, and 2006 AFL[10] seasons to assess which statistics are the most likely to determine winning margins in AFL games. With both the regular season and finals (playoffs) there are 185 games each year. Therefore, 740 (= 185 x 4) games were initially considered in the analysis, although due to some data irregularities two games were omitted, giving a sample of 738. The player statistics were obtained from ProWess Sports[11] and are defined at Table 1.

Our initial analysis used models that predicted the probability of a team winning, therefore, the dependant variable was one if a team won and zero if it lost.[12] However, better results were obtained by using models that predicted winning margins (MARGIN), as this is a more informative dependant variable. The mean winning margin for a team over the years used in this study was just less than 34 points, with a median of 29 points. All variables were calculated by subtracting the score of the losing team from that of the winning team. Therefore, although MARGIN was always non-negative, the observations for the independent variables could be positive or negative.

Table 2. Summary Statistics

	Mean	Median	Maximum	Minimum	SD	Skewness	Kurtosis	Jarque-Bera	Probability
INDEPENDENT VARIABLES									
50P	-0.133	0	4	-4	1.140	-0.1955	4.100	41.878	0.0000
1ST	1.226	1	32	-32	9.607	0.0162	3.201	1.274	0.5289
BG	8.232	8	75	-50	19.104	0.0182	2.951	0.114	0.9448
BHS	1.846	2	16	-12	4.647	0.0619	3.145	1.116	0.5724
BNC	2.336	2	35	-27	8.702	0.0301	3.553	9.513	0.0086
BUC	0.477	0	16	-14	4.433	-0.0009	3.143	0.631	0.7294
BUH	0.486	1	18	-20	5.777	-0.0445	3.215	1.666	0.4348
CBC	0.701	1	20	-15	5.321	-0.0057	3.149	0.688	0.7089
CBH	1.003	1	38	-22	7.446	-0.0177	3.389	4.700	0.0954
CLE	1.682	1	26	-23	8.673	0.0624	2.883	0.896	0.6389
DIS	-0.432	0	18	-19	4.724	-0.0636	4.407	61.405	0.0000
DISP	25.228	24	160	-79	36.181	0.1894	3.111	4.788	0.0913
DM	0.022	0	12	-14	3.744	0.0254	3.131	0.605	0.7388
EFC	2.043	2	33	-17	6.680	0.3281	4.025	45.566	0.0000
EFH	1.348	1	24	-24	7.855	0.0684	2.991	0.578	0.7489
F/A	0.226	1	26	-23	5.864	-0.0120	3.483	7.195	0.0274
F/F	-0.226	-1	23	-26	5.860	0.0440	3.485	7.462	0.0240
FUM	-0.133	0	15	-20	4.595	-0.1063	3.331	4.770	0.0921
GAT	2.902	3	28	-27	8.756	-0.0480	2.784	1.724	0.4224
GLS	5.336	5	23	-1	4.119	0.9950	4.166	163.563	0.0000
HBG	0.280	0	34	-29	8.183	0.0927	3.269	3.287	0.1933
HBL	6.566	6	105	-74	25.973	0.0526	3.134	0.893	0.6399
HBR	5.589	5	96	-58	22.316	0.1602	3.258	5.199	0.0743
HIT	2.023	3	44	-42	14.678	-0.1075	2.890	1.795	0.4075
I50	6.705	7	41	-30	10.660	0.0299	2.985	0.117	0.9434
KCK	18.661	19	91	-53	22.285	-0.0167	3.055	0.129	0.9376
KIN	-1.911	-2	16	-18	5.219	-0.0866	3.185	1.979	0.3717
KLG	5.999	6	53	-26	10.691	0.1219	3.501	9.561	0.0084
KNK	1.324	1	21	-24	6.217	-0.0595	3.809	20.568	0.0000
KOP	-1.084	-1	13	-18	4.821	-0.0596	3.046	0.503	0.7777
KSH	12.336	14	79	-54	21.001	-0.0800	3.139	1.385	0.5004
KTA	10.337	10	85	-46	20.463	0.0909	3.221	2.520	0.2836
KTC	1.182	1	44	-34	11.187	-0.0163	3.042	0.088	0.9570
KTS	0.757	1	27	-21	6.904	0.0511	3.300	3.083	0.2140
LBG	5.103	5	59	-32	13.540	0.2008	3.053	5.045	0.0803
MCT	1.827	2	25	-15	5.459	0.2499	3.185	8.736	0.0127
MIS	0.412	0	9	-9	2.601	0.1314	3.817	22.649	0.0000
MRK	11.407	12	74	-66	20.577	-0.1295	3.130	2.580	0.2753
PON	1.615	1	34	-29	10.765	0.0949	2.947	1.195	0.5501
R50	-1.119	-1	28	-28	9.304	-0.0522	2.904	0.617	0.7346
RCK	0.060	0	4	-5	0.820	0.1263	10.235	1611.425	0.0000
RUS	0.001	0	2	-1	0.110	7.0079	191.046	1093401	0.0000
SHP	0.699	0.5	22	-13	4.449	0.2402	4.055	41.345	0.0000

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Table 2 continued

	Mean	Median	Maximum	Minimum	SD	Skewness	Kurtosis	Jarque-Bera	Probability
INDEPENDENT VARIABLES									
SMT	0.079	0	11	-9	3.102	0.0767	3.378	5.110	0.0777
SPL	0.058	0	24	-20	6.742	0.2826	3.375	14.151	0.0008
SWT	1.603	1	27	-21	6.068	0.1919	3.735	21.139	0.0000
TAR	3.767	4	37	-23	9.040	0.0128	3.266	2.197	0.3333
TIC	0.473	0	15	-16	4.769	0.0157	3.010	0.033	0.9835
TIH	0.537	1	23	-22	6.354	-0.0325	3.474	7.048	0.0295
TKE	0.388	0.5	32	-48	9.623	-0.1662	3.966	32.093	0.0000
TKL	-0.363	0	45	-58	15.654	-0.1168	2.912	1.917	0.3835
DEPENDENT VARIABLE									
MARGIN	33.863	29	148	0	25.566	1.051	4.345	191.5106	0.0000

Source: Developed from this study

The analysis began with the dependent variable MARGIN, which was the winning margin in each of the 738 games, and the 51 independent variables that are defined at Table 2. In the following section, econometric methods are used to find which of these independent variables were most strongly related to the dependent variable.

Table 2 shows the summary statistics for all variables used in the analysis. We would expect variables which have means close to zero to be of little value for predicting winning margins; examples would be 50P (50 meter penalties) and DM (dropped marks). On the other hand, KCK (kicks), with a mean of 18, are likely to be a good predictor. Also, for 33 of the 52[13] variables used in this study, we cannot reject the null hypothesis of normality. This implies that the tests of significance conducted on these variables are reliable.

The Economic Estimation and Results

Before the econometric models could be estimated, the data set needed to be reduced further. The variable DISP (disposals) was omitted, as it is the sum of KCK (Kicks) and HBL (Handballs), and so its inclusion caused exact multicollinearity. Also, the three scoring variables of GLS (Goals), BHS (Behinds), and RUS (Rushed Behinds) were omitted as together they are an exact predictor of the winning margin.[14]

As the dependant variable MARGIN is an integer with a minimum of zero and maximum of 148[15], integer models such as the Poisson and negative binomial were considered as well as several other alternatives. The best of these was the negative binomial using maximum likelihood estimation; however, it was inferior to Ordinary Least Squares (OLS) estimation based on the Akaike Information Criterion and Schwartz Criterion and the binomial predicted some unrealistically high values for the estimated winning margin. As the hypotheses of normality and constant variance were not rejected at the 5% level for the OLS model, this estimation technique was used for all of the models that are reported here.

The process we followed was to run OLS regressions with MARGIN as the dependent variable against the remaining independent variables, then to omit those variables that were not statistically significant in terms of their influence on winning margins. Regressions were run, and re-run a number of times, until eventually only the most important variables remained. This step by step process is reported in Table 3. Also, before omitting groups of variables F-tests for redundant variables were carried out. In some cases these showed that the high p-values for the t-statistics were the result of multicollinearity so further tests were done to determine which variables contributed significantly to the model.

Table 3. The Least Important Statistics (alphabetical order by group eliminated)

1st group eliminated p-value > 0.75		
50P	50 Meter Penalty	A 50 meter penalty against the player as called by the umpire
DIS	Dispossess	Player, who has had prior opportunity to dispose of ball, has lost possession by tackle, knocked out of hands, etc.
F/A	Free Against	An infringement against the player as called by the umpire
F/F	Free For	An infringement in favor of the player as called by the umpire
PON	Play On	Each time a player plays on from a mark or free
2nd group eliminated p-value > 0.5		
BUH	Ball Up Hit	All ruck taps, palms from a ball up
CBH	Centre Bounce Hitout	All ruck taps, palms from a centre bounce
EFH	Effective Hitout	Effective hitout from a ruck contest (neutral/umps ball) to a team-mate who has the next possession
FUM	Fumble	A dropped ball, fumble, etc. in general play
HIT	Hitout	Hitout from a ruck contest.
RCK	Ruck Contest	Each time a player goes up in the ruck contest irrespective of whether anyone gets a hitout
SMT	Smother	A successful attempt to smother a disposal by the opposition
TIC	Throw In Clearance	All clearances from boundary throw in
TIH	Throw In Hitout	All ruck taps, palms from a boundary throw in
TKL	Tackle Attempt	A reasonable attempt by the player to tackle the opposition
3rd group eliminated p-value > 0.25		
CLE	Clearance	When the ball is cleared from the contest from an Umpires Ball (can be KCK, HBL or KNK)
DM	Dropped Mark	An attempted mark, which was markable, that was dropped
EFC	Effective Clearance	Effective clearance, meaning side retains possession, from a ruck contest (neutral/umps ball)
MCT	Contested Mark	A mark taken in a contested situation with the opposition
SHP	Shepherd	To "legally protect" a teammate who is in possession of the ball
SPL	Spoil	A punch to spoil an opposition player (normally in marking contest)
TAR	Inside 50 Target	The intended player/target when the ball is kicked into a team's forward line
TKE	Effective Tackle	A tackle that effectively disrupts or changes the way the opposition player dispossess the ball
4th group eliminated p-value > 0.1		
GAT	Gather	A uncontested ball get which has specifically been put in the path of the player by a teammate
HBG	Contested Ball Get	A contested ball get in heavy traffic
LBG	Uncontested Ball Get	An uncontested ball get
MRK	Mark	All marks in general play

Source: Developed from this study

The first OLS regression had MARGIN as the dependent variable against the remaining 47 independent variables for the 738 games in the sample. Then the variables with p-values of greater than 0.75 were omitted and the regression was re-run. The first panel in Table 3 lists the five independent variables that were omitted using this rule. That is, these variables were deemed to be least the important in terms of their influence on game winning margins.

It is interesting to note that this first group of eliminated variables included many of the umpire determined statistics such as 50P (50 Metre Penalty), F/A (Free Against), and F/F (Free For). That is, these statistics were found to be insignificant in terms of their effect on match outcomes, although we are sure some fans, judging by their reactions to umpire decisions, may disagree. When we look at the summary statistics in Table 2, it shows that there is very little difference in the amount of free kicks (0.23 on average per match) and 50 meter penalties (0.13) between the winning and losing sides. The implication is that over the 738 games considered in this study, umpiring decisions have had little impact on the outcome of games.

The next regression was run with the remaining 42 independent variables and those with p-values greater than 0.5 were omitted (shown in the second panel in Table 3). This group of omitted variables includes many of the ruck[16] statistics, such as BUH (Ball Up Hit), CBH (Centre Bounce Hitout), EFH (Effective Hitout), RCK (Ruck Contest), TIC (Throw In Clearances), and TIH (Throw In Hitout). Again we find that when we look at the summary statistics for the difference between the winning and losing sides in Table 2 only one of these variables has a mean value greater than one, this being EFH (Effective Hitout) with a value of 1.35. This is a very small difference when compared with some of the other variables such as BG (Ball Get) with a value of 8.3 and KCK (Kick) with 18.6. These findings appear to be counter to some of the commonly held views that the ruckman (the name given to the playing position responsible for tapping the ball into play at stoppages) is critical to the outcome of the game.

A further regression was run with the remaining 32 independent variables. Then the eight independent variables with p-values of greater than 0.25 were taken out (presented in the third panel of Table 3). Therefore, the next regression had 24 independent variables and four of them were dropped as their p-values were greater than 0.1 (fourth panel, Table 3)

This process left us with 20 independent variables that were the most closely related to the winning margin in games. To rank these variables in terms of their order of importance we then calculated the correlation coefficients for each with MARGIN, and they are shown in Table 4.

These correlation coefficients shown in Table 4 tell us that I50 (Inside 50s) have the strongest positive association with winning margin, whereas KIN (Kick Ins) have the highest negative relationship. Some of these correlation coefficients initially may appear counter intuitive. For example, MIS (Missed Shots) increase winning margins, while R50 (Rebound 50s) reduces them. A literal interpretation of these coefficients may cause a coach to advise their team to try to miss shots for goal and if the ball is in their defensive 50 meter zone, that team should not try to repel the ball from this area. These conclusions are of course absurd; all these results are telling us is that if a team has many shots on goal it will probably miss quite a few, but as some will score it will probably win the game. Also, a team that is constantly defending has more chance of repelling some of its opponent's attacks, but that team is also more likely to lose.

Given that we were trying to develop a method whereby players could be evaluated in terms of their ability to collect match-winning statistics, we next went through a long process of using these remaining statistics to construct a model that: a) made intuitive sense and b) only included individual (not team based) player statistics. As a consequence, KIN (Kick Ins), I50 (Inside 50s), and R50 (rebound 50s) as well as SWI (Switch of Play) were all taken out, as they are team rather than individual statistics.

Using the remaining variables our preferred player-rating model was constructed and it is presented at Table 5. This was done by selecting the best one variable model by selecting the variable with the strongest correlation to the winning margin. We then proceeded to add the remaining variables one at a time to the estimated model and picked the one that gave the largest improvement in adjusted R^2. We continued adding variables in this fashion, rejecting those with coefficients with counterintuitive signs; for example, MIS (Missed Shots) had a negative sign as discussed previously. This process was continued until no

Table 4. The Most Important Statistics (sorted on correlation coefficient)

0.53	I50	Inside 50	Player moving the ball inside the 50M are by disposal, run, bounce, knock on, hit out, etc.
0.51	KCK	Kick	All kicks in general play
0.35	KSH	Kick Short	Kicks considered traveling LESS than 40 meters (not including off ground)
0.33	KLG	Kick Long	Kicks considered traveling MORE than 40 meters
0.29	BG	Ball Get	"Getting" the ball in a contested (hard) or uncontested situation (loose or Gather).
0.27	KTA	To Advantage	A Kick in general play that goes to the clear advantage of a teammate
0.26	HBR	H/Ball Receive	Receiving a direct handball from a team-mate in general play
0.25	HBL	H/Ball	All handballs in general play
0.22	BNC	Bounce	Each bounce when running with the ball in general play
0.16	CBC	Centre Bounce Clearance	All clearances from a centre bounce
0.14	1ST	First Possession	The first possession/disposal from an umpire control situation (center bounce, ball up, throw in)
0.14	BUC	Ball Up Clearance	All clearances from a ball up
0.11	MIS	Missed Shot	An gettable shot on goal that was either considered "short" or "out on the full"
0.10	KTC	Kick To Contest	A Kick in general play that goes to a 50/50 contest
0.08	SWI	Switch of play	A kick which is a definite change of direction, usually at right angles to open up the play
0.07	KNK	Knock On	A knock or distinct tap off the ground in general play
-0.01	KTS	Kick To Space	A Kick in general play that goes into the open
-0.09	KOP	Kick To Opposition	A Kick in general play that goes directly to an opposition player
-0.19	R50	Rebound 50	Player moving the ball outside the 50M are by disposal, run, bounce, knock on, hit out, etc.
-0.27	KIN	Kick In	A kick In from a behind back into general play

Source: Developed from this study

new variable significantly improved the explanatory power of the model, as measured by the adjusted R^2.[17]

As this is a linear model, the interpretation of the coefficients is straightforward. The coefficients associated with each variable indicate their marginal contribution to the winning margin. For example, the KCK (Kick) coefficient of 0.46 implies that each additional kick in general play will on average increase a team's winning margin by 0.46 of a point. If that kick also happens to be a long kick, then the 0.53 associated with KLG (Kick Long) means that the kick would contribute 0.99 (= 0.46 + 0.53) to the winning margin. If however, the kick were to a contest (KTC) then on average its contribution would only be 0.2 (= 0.46 – 0.26). Whereas, if the kick was to space (KTS) it would add only 0.12 (= 0.46 – 0.34) to the winning margin. A kick to the opposition (KTO) will reduce the winning margin by 0.16 of a point (= 0.46 – 0.62).

The coefficient associated with BUC (Ball Up Clearance) shows that an extra clearance from a ball-up adds on average 0.32 of a point to the winning margin, while a clearance from a center bounce (CBC) adds 0.51 of a point. This probably results from their being less con-

Table 5. Player Ranking Model – Dependant Variable MARGIN

Variable	Coefficient	Std. Error	t-Statistic	Prob.	
C	**17.94**	1.05	17.16	0.0000	
KCK	**0.46**	0.04	12.71	0.0000	All kicks in general play
KLG	**0.53**	0.08	6.74	0.0000	Kicks considered traveling more than 40 meters
KTC	**-0.26**	0.08	-3.18	0.0015	A kick in general play that goes to a 50/50 contest
KTS	**-0.34**	0.12	-2.99	0.0029	A kick in general play that goes into the open
KOP	**-0.62**	0.16	-3.88	0.0001	A kick in general play that goes directly to an opposition player
BUC	**0.32**	0.17	1.88	0.0611	All clearances from a ball up
CBC	**0.51**	0.15	3.55	0.0004	All clearances from a centre bounce
BNC	**0.56**	0.09	6.54	0.0000	Each bounce when running with the ball in general play
KNK	**0.35**	0.12	2.95	0.0033	A knock or distinct tap off the ground in general play
HBL	**0.13**	0.03	3.81	0.0001	All handballs in general play
BG	**0.12**	0.05	2.38	0.0176	”Getting” the ball in a contested (hard) or uncontested situation (loose or gather)

R-squared	0.41	F-statistic 45.32 n = 738	
Adjusted R-squared	0.40	Prob (F-statistic)	0.0000
S.E. of regression	19.83		

Source: Developed from this study

gestion at center bounce clearances, therefore the next possession has more chance of being uncontested, thereby making it more likely to lead to scoring opportunities.

The BNC (Bounce) coefficient is 0.56. This implies that on average each bounce contributes more than half a point to the winning margin. This means that bounces are approximately equivalent to a long kick in terms of their contribution to winning games. This probably occurs as players almost always are running the ball towards the goals they are attacking when they bounce and they generally cannot successfully bounce the ball unless they are well clear of opposition players. So in effect they are in control of the ball, moving towards their team's scoring area and are clear of the opposition, thus making bouncing a rewarding part of play. In terms of the other statistics KNK (Knock-Ons) adds 0.35 to winning margins, HBL (Handballs) 0.13 and BG (Ball Gets) 0.12.

Also, note that although these are the most important statistics in terms of their ability to explain the variability in the dependent variable of MARGINs, collectively they are only able to account 41% of this variability. That is, there are many other factors that affect a team's winning margin. Nevertheless, this model is able to determine which are the most important statistics and quantify their contribution to winning.

The other application of our player-rating model is to apply these statistics to current AFL players and assess which players are the most important in terms of their contribution to winning matches. Table 6 shows the AFL's top 20 players in 2006, as calculated by our player-rating model, when the coefficients are applied to those players' statistics for that season and aggregated.

Our model rates highly players who gain a lot of possessions (generally mid-field players), who kick the ball

Table 6. Twenty Top Ranked AFL Players in 2006

Rank	Player	Team From	Season Score	Games Played	Average Score Per Game Played
1	Judd	West Coast	316.6	22	14.4
2	Goodwin	Adelaide	314.1	24	13.1
3	Scotland	Carlton	306.1	22	13.9
4	West	W. Bulldogs	295.3	24	12.3
5	Mitchell	Hawthorn	293.9	22	13.4
6	Gilbee	W. Bulldogs	293.8	24	12.2
7	Hodge	Hawthorn	281.0	22	12.8
8	Black	Fremantle	280.9	24	11.7
9	Gram	St Kilda	275.2	23	12.0
10	Power	Brisbane	272.7	22	12.4
11	Dal Santo	St Kilda	270.5	23	11.8
12	Cousins	West Coast	264.2	21	12.6
13	Goodes	Sydney	263.4	24	11.0
14	McDonald	Melbourne	262.5	24	10.9
15	Johnstone	Melbourne	261.4	22	11.9
16	Montagna	St Kilda	261.1	22	11.9
17	Goddard	St Kilda	261.0	22	11.9
18	Bowden	Richmond	260.9	21	12.4
19	Edwards	Adelaide	259.8	22	11.8
20	Johnson	Collingwood	259.4	23	11.3

Source: Developed from this study

Note: Players are ranked on their season's score, which is a summation of their contribution to their team's winning margin per game played. Average is calculated on games actually played, not total season games.

accurately, and are able to run and bounce the ball. Therefore, taking a lead from the Oakland Athletics, the implication is that AFL recruiters should firstly ensure that such statistics are collected from competitions in which they are considering selecting players, and then use the statistics highlighted in our model to recruit.

Discussion and Implications

The implications of these findings are clear. If AFL teams are to adopt a similar strategy to that used by the Oakland Athletics, as explained by Lewis (2003), they should take note of and ensure they understand the appropriate statistics when recruiting AFL players. To do this they may need to collect more accurate information in the AFL feeder competitions than is presently the case and contract suitable staff that can readily analyze and interpret statistical data.

As can be expected of many sports, Australian Football is a game of possession. The emphasis, as described by the clubs themselves, is to maximize control of the football while endeavoring to create a scoring opportunity. As such, the individual statistic that contributes most to winning is that of a player bouncing the ball. Each bounce adds 0.54 of a point to the teams winning margin. This form of advancement is particularly valuable in that it is a relatively safe way to move closer to a scoring opportunity as the ball is not required to be transferred to a teammate, eliminating the possibility of an interception.

Players in Australian Football may move with the ball freely, but must bounce the ball off the playing surface (or touch the ball to the ground) once every 15 meters. Typically, statistics reported on AFL matches have given little attention to player bounces and the current study suggests that they be given considerable prominence.

Another often under-reported statistic worth highlighting is the knock-on, which is where the ball is knocked or tapped forward off the ground in general play. A knock on contributes 0.35 of a point to the teams winning margin. As the modern Australian Football game features a large number of aerobically fit athletes, considerable congestion can occur at points across the field. This has been exacerbated in recent years by a defensive coaching technique referred to as "flooding." This approach calls for many players to congregate in the defensive area of the field in order to create limited space for opposition scoring attempts. A knock-on can free the ball from congested areas and if teammates are cognizant of its use, allow them to retrieve the ball before the opposition.

Given the emphasis on possession the relative importance of clearances, both from a ball-up in general play and a center bounce (which occurs at the start of quarters and after a goal is scored) is not surprising. Center bounce clearances are particularly important as the rules limit each team to four players in the immediate vicinity of such bounces, making possession highly rewarding. A single center bounce clearance increases a team's winning margin by 0.51 of a point. AFL teams have for many years emphasized the extreme value on such clearances and the results of this study validate this long-held belief. Notably, however, the importance of the rucking contest (where players tap the ball after a center-bounce or ball-up) was limited, suggesting that the ability to read the play and anticipate opposition ruck players was more important than winning the ruck contest itself.

Long kicks have been noted in the findings as particularly valuable provided that they are transferred to a teammate. Our model shows that each additional long kick that hits its target adds 0.99 of a point to a team's winning margin.[18] While kicks in themselves are valuable, errant movement of the ball that sees it turned-over to the opposition or simply put in a situation where the opposition has a chance of regaining possession are particularly harmful. For example, our model shows that a kick to the opposition reduces a team's winning margin by 0.62 of a point. This is because the opposition regaining possession is often well placed to formulate uninterrupted progression, as the team that has turned over the football is caught out of position. The message for AFL recruiters is obvious here. Not only do they need to find players who can kick the ball over distance, they need to find players who can do so with great accuracy.

While this discussion highlights some areas that AFL clubs could focus on, it is also worth noting that some statistics are not as important as expected in their contribution to overall winning margin. These include the aforementioned ruck contests and associated hit-outs, umpiring decisions as well as tackles and dropped marks. It should be noted that all of these areas are generally considered key components of modern AFL football. Coaches, media, and fans often blame umpires for losses and similarly lament that their ruck player was unable to win enough contests in hitting the ball out following stoppages in play. What this study indicates is that who hits the ball out in a ruck contest is not as important as who is able to effectively clear the ball from such a stoppage. As such ruck contests and hit-outs are of little value unless they directly lead to teammates being able to make a clearance from that situation.

Tackles are a very visible sign of team ferocity and the concept of tackling is often linked by coaches and supporters to aspects of aggression and endeavor. It stands to reason, however, that the team who has less possession of the football will have more opportunity to perform tackles, thus reducing the value of this statistic in contributing to winning margin. For a team to tackle more they may need to have less possession, which is counterintuitive to successful modern playing styles.

Dropped marks generally take the ball from a situation where it would be uncontested (i.e., following a mark) to a situation where a contest (i.e., other players have a chance to gain possession) is more likely. However the limited impact of dropped marks has largely come about because modern skilled players drop relatively few marks and further because players are unlikely to be kicking to situations in the first instance where opposition players will be congregated. As such, a dropped mark may be

recovered readily in some instances, with the player who failed to take the mark able to still move the ball forward. Similarly modern AFL play promotes movement, rather than static possession, so a player taking a mark will very often continue to run with or immediately dispose of the football, rather than stopping to take a protected kick from a safe position. Clearly, however, it is not OK to keep dropping marks, particularly where such marks may alleviate pressure in a team's defensive area or provide direct scoring shots in the attacking area.

All of this statistical interpretation is of little direct use to AFL clubs if they are unable to grasp mathematical concepts. The Oakland Athletics profited from the hiring of an economist to help formulate and manage their methodological approach. AFL teams should consider contracting appropriate staff if they are to fully exploit statistically proven inefficiencies in the player labor market. As Ballard (2005) has indicated, this hiring of experts has become common in US basketball and we suspect in other major sporting codes also.

This paper has also suggested a new player ranking model that helps clubs value players in terms of their contribution to a team winning. This ranking is based on the application of the key statistics derived from the detailed analysis of matches in previous years. A cursory examination of this ranking highlighted several players who, whilst ranked highest for their team, did not receive the same recognition in various league and club ranking approaches which directly recognize the achievements and contributions of players. These are typically most valuable player awards as recognized by the media, match umpires, or clubs themselves. These discrepancies naturally provide a direct outcome to the purpose of this paper in assisting the identification and recruitment of elite footballers who may provide excellent value. That is, players who are ranked as strong contributors to a team winning using the statistical criteria outlined in this paper, who may as a result of other more general or existing recruitment measures, be undervalued.

While this paper has sought to enhance appropriate recruitment of elite sportsmen, even without explicit rankings of players, we feel that the information highlighting key statistics related to winning can be of value to organizations. This would occur if teams utilized such information in the coaching of current players and in establishing game plans and tactics. Lewis (2003) highlighted the importance of "on-base percentage" and the Oakland Athletics could instruct players to "take" pitches in an effort to enhance the opportunities where they could end up on base. Similarly in the AFL, coaches could use data as produced in this study to advise players to run and bounce the ball more frequently. In effect this does not aid recruitment but provides better skills for the current workforce, which in an era of salary caps and drafts may be a more erudite approach.

Conclusions and Further Research

We feel that there is a plethora of future research that could follow that deals with the extension of statistical measures to the recruitment of athletes in various sports. The authors are aware, for example, of research being conducted in the application of these approaches to an English Premier League club and in completing this current study it was evident that AFL clubs were interested in the application and testing of concepts.

While the information gleaned from statistical analysis in this study has focused on elite players, the tracking of information at levels below the AFL will be necessary if statistical techniques such as those posited here can be of value in the recruitment of new players. AFL potential recruits at present play in a wide-ranging series of feeder leagues across various locations, making the application of standardized and rigorous statistical collection methods difficult. Our findings in this paper have also suggested a player-ranking model that may expose undervalued (or overvalued) players currently contracted in the AFL. Undervalued players, where highlighted, would serve as recruiting targets of clubs who are allowed to trade for players at the conclusion of each season. Ideally, complete data across all feeder leagues would allow this statistical recruitment to occur with all potential AFL players.

As has been previously noted, Australian Football is a relatively complex sport given its free-flowing structure. This is quite distinct from baseball, the topic of Lewis' (2003) book, where a game is essentially composed of a series of discrete interactions. This suggests that in sports such as Australian Football, their very nature makes it

inherently much more difficult to accurately measure the individual player statistical data that relates to the effectiveness of a team winning. While we concede this is the case, the aim of such work is not to be perfectly predictive, but to allow organizations to gain advantages, however slight, over the opposition in the recruitment of players.

The authors encourage the continued application and testing of so called Moneyball philosophies in sport, particularly as they assist sports managers to become more effective and efficient decision makers in assessing the highly remunerated pool of labor resources common in modern sport.

References

Australian Bureau of Statistics. (2007). Sports Attendance Australia 2005-06, Catalogue Number 4174.0

Ballard, C. (2005). Measure of success, *Sports Illustrated*, 103(16), pp. 60-63.

Berri, D. J., Schmidt, M. B., & Brook, S. L. (2006) *The wages of wins: Taking measure of the many myths in modern sport*. Palo Alto, CA: Stanford University Press.

Bodley H. (2006). *'Moneyball' equations retooled for this A's club*. Retrieved January 26, 2007, from http://www.usatoday.com/sports/baseball/columnist/bodley/2006-09-21-bodley-on-baseball_x.htm

Champion Data. Retrieved July 2006, from http://www.championdata.com.au

Football Outsiders. Retrieved August 2006, from http://www.football-outsiders.com

Gerrard, B. (2004). Moneyball: The art of winning an unfair game, book review. *European Sport Management Quarterly*, *4*(1), 53-54.

Hakes, J. K., & Sauer, R. D. (2006) An economic evaluation of the Moneyball hypothesis. *The Journal of Economic Perspectives*, *20*(3), 1.

Lewis, M. (2003). *Moneyball: The art of winning an unfair game.* New York, NY: W. W. Norton & Company.

Moynihan, D. (2006). What can baseball teach us about performance management? *Public Administration Review, 66*(4), 647-648.

ProWess Sports webpage: http://www.prowess-sports.com/default.asp and their AFL page: http://www.pro-stats.com.au/ps/web/ft_index.

Roberto, M. A. (2005). *Billy Beane: Changing the game*. Harvard Business School Case, /9-305-120, Boston, Harvard Business School Publishing.

Thaler, R. H., & Sunstein C. R (2003). Who's on first. *New Republic*, September, 27-30.

Wolfe R., Wright, P., & Smart, D. (2006). Radical HRM innovation and competitive advantage: The Moneyball story. *Human Resource Management*, *45*(1), 111-126.

Wolfe, R., Babiak, K., Gerrard, B., Mason, D., & Frisby, W. (2006). *Moneyball: Its influence on sport and sport management*. Symposium presented at the North American Society for Sport Management Conference, Kansas City.

Wolfe, R., Wright, P, Terborg, J., Gerrard, B., Babiak, K., Smart, D., Cameron, K., & Quinn, R. (2005). *A new vision of management for the 21st century: Moneyball as a reframing phenomenon*. All-Academy Symposium presented at the Academy of Management Conference, Honolulu.

Endnotes

[1] An example of this is that our model shows that each additional long kick that hits its target adds 0.99 of a point to the teams winning margin (or reduces the teams losing margin by an equivalent amount).

[2] Page 130 of *Moneyball* has a good explanation of the similarities between financial markets and baseball.

[3] USA Today (Sept. 9, 2006). http://www.usatoday.com/sports/baseball/columnist/bodley/2006-09-21-bodley-on-baseball_x.htm

[4] Wolfe, R., Wright, P, Terborg, J., Gerrard, B., Babiak, K., Smart, D., Cameron, K., & Quinn, R. *A New Vision of Management for the 21st Century: Moneyball as a Reframing Phenomenon*. (All-Academy Symposium). Symposium presented at the Academy of Management Conference, Honolulu, 2005.

[5] Wolfe, R., Babiak, K., Gerrard, B., Mason, D., Frisby, W. *Moneyball: Its Influence on Sport and Sport Management*. Symposium presented at the North American Society for Sport Management Conference, Kansas City, 2006.

[6] http://www.afl.com.au

[7] This figure is slightly higher for one club.

[8] For the uninitiated to this sport it is recommended that they consult http://www.afl.com.au for an overview of the game, including highlights of play, as well as the extended information on the way the game is played in the Appendix. The authors also recommend http://www.aflpa.com.au/media/2007%20Laws%20of%20the%20game.pdf for a copy of the official laws, http://en. wikipedia.org/wiki/Laws_of_Australian_football for a brief, but helpful, summation of the key rules and for North American readers http://www.afana.com which carries a good overview of the game for people in that region, including applicable broadcast schedules and explanations of the games particular nuances.

[9] The Melbourne Football Club (MFC) is one of the 16 clubs playing in the AFL; Australia's premier Australian Football competition. MFC is the Australian equivalent of an NFL club in the US or a Premier League club in the UK.

[10] Data from 2002 to 2005 was used to construct our player evaluation model; this model was then used to evaluate player performance for the 2006 season.

[11] Prowess Sports web page: http://www.prowess-sports.com/default.asp. Their AFL stats page is http://www. pro-stats.com.au/ps/web/ft_index

[12] That is, binary choice models were fitted (logit, probit, and extreme value). Also, drawn games needed to be omitted.

[13] Fifty-one independent variables and the dependent variable MARGIN.

[14] Having to omit the scoring statistics may be considered a weakness in our player rating model, as it makes it more difficult for key position forwards (whose main job is kick goals) to be rated highly.

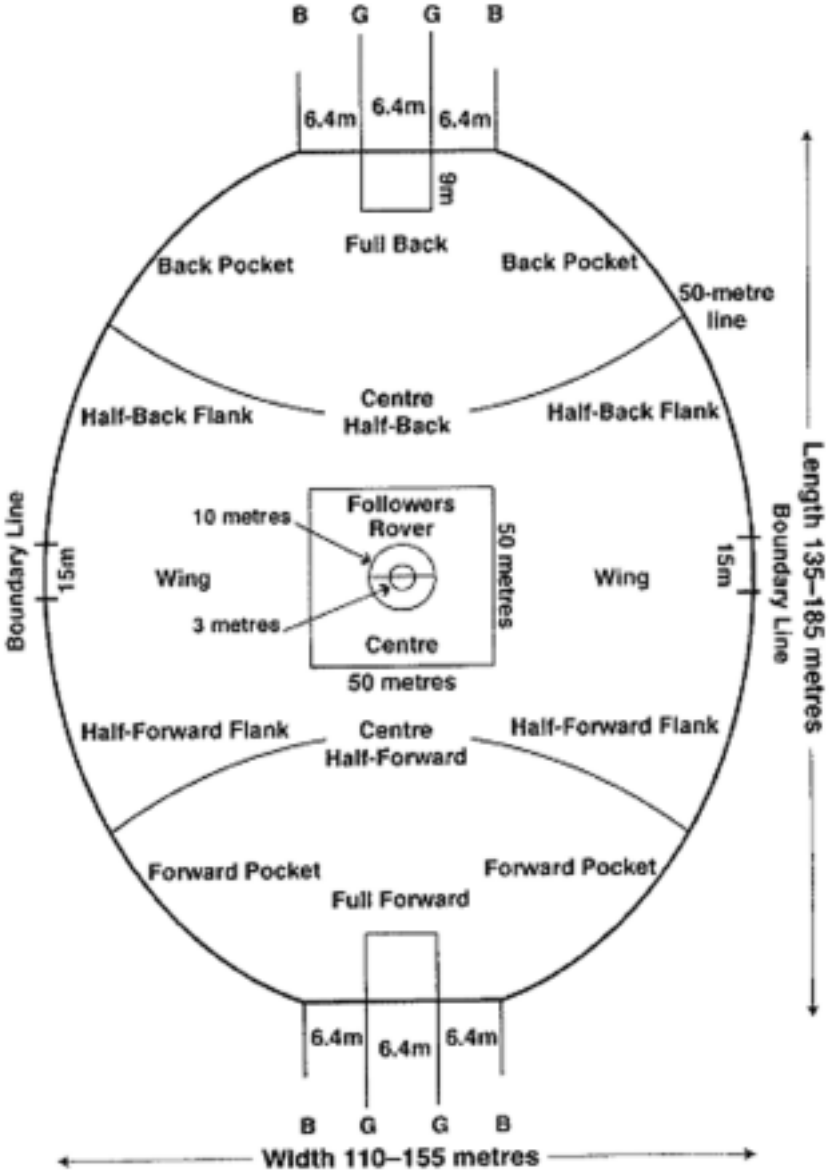
[15] That is, 148 was the largest winning margin, while drawn games (where the scores are level) represent the smallest margin.

[16] The ruckman is the name given to the playing position responsible for tapping the ball into play at stoppages.

[17] The same results were obtained if the Akaike Information Criterion was used.

[18] Alternatively, all of these statistics can be interpreted as reducing a teams losing margin by the same amount.

Figure 1: Australian Football Playing Field and Playing Positions



Source: 'Laws of Australian Football 2007' Australian Football League, Melbourne, Australia, p.16

Appendix – Expanded Description of Australian Football

The competition, acknowledged today as the Australian Football League (AFL), began as the Victorian Football League in 1897 and was comprised of eight foundation clubs (Carlton, Collingwood, Essendon, Fitzroy, Geelong, Melbourne, St. Kilda, and South Melbourne). The competition expanded three decades later to include new teams. A more national outlook in the latter part of the last century saw relatively rapid expansion. Two teams were admitted to the competition from both Western Australia and South Australia, the South Melbourne team was relocated to New South Wales to form the Sydney Swans and the Queensland capital city of Brisbane was given a team. This club

began life as the Brisbane Bears, but amalgamated with the Fitzroy (originally Melbourne based) in the mid-1990s to rebrand themselves as the Brisbane Lions.

The power base of the AFL is in the state of Victoria; however it is played in an organized manner in every state and territory. Of the 16 teams in the AFL, a disproportionate number of 10 come from Victoria. This reflects the code's historic beginnings and the high levels of interest the sport holds in the state. Australian Football is the dominant football code in the states of Tasmania, South Australia, Victoria, and Western Australia also, but falls away relative to the rugby codes in the more northern states of Queensland and New South Wales.

Of the 16 teams in the AFL, the top eight at the end of the season based on win-loss record qualify for the playoffs, known as "the finals." The two teams who remain after three rounds of the finals meet in the "Grand Final," which is the showcase event of the competition, with the winning team winning the Premiership Trophy and being referred to as the 'Premiers."

The ultimate object of an AFL match is to score more points than the opposition. Points are scored by scoring goals (worth six points) or behinds (one point), the sum total of which decides the winning team. Goals are scored by kicking the football between the two goal posts that are being attacked by a team (teams change attacking ends each quarter), with shots that miss that pass between the goal and behind posts being classified as behinds. A behind is also recorded if the ball crosses the goal or behind line area after being touched in any manner by the opposition or if it does not come from a legal kick from the team attacking that goal. Thus, for example, it is not possible to handball the football through for a goal.

An AFL match consists of 20-minute quarters, with time added on for some stoppages in play. Each team may select 22 players for each match, 18 of which are on the field at any one time. The other four players sit on an interchange bench and may be freely substituted at any time. Each player has a position (see Figure 1); however, all players are free to move around the playing surface at all times, with the only exception being a limit of four players in the centre square when there is a ball-up following a goal or to begin a quarter. The constant movement of the players in modern times has rendered some of the position names somewhat meaningless.

AFL matches are played at high speed and with relatively high levels of foot and hand skills. Players may dispose of the ball legally in one or two ways, by foot known as a kick, or by hand known as a handball or handpass. Players can be disposed by tackles from the opposition and the only time they can handle the ball without fear of such tackle is if they are awarded a free-kick for an infringement of the rules by an opponent, or if they have taken a mark. A mark is awarded to a player who catches a kick that has traveled at least 15 meters without hitting the ground or being touched by another player.

Even when marks or free-kicks are awarded it is common to see players not stopping and "playing-on" in an effort to prevent their opponents from organizing a strong defense. In recent years it has become common for teams to adopt tactics build on strong aerobically fit players who can move swiftly from attack to defense to prevent opposition scoring opportunities. This has increased the speed of play accordingly.

A wide variety of skills are required for a team to win a premiership. Clubs have rosters of 38 players and are limited by a salary cap and draft system to ensure a relatively even spread of talent across the league. The high contact nature of the sport means numerous injuries occur, so it is not uncommon for almost all players on a roster to have some playing time each season. Aside from strong teamwork skills involved in the sport teams must strike a balance of tall players who can hit the ball to advantage in ruck situations, players who can mark the ball (particularly close to the goal area), and players who can adroitly and swiftly move the ball from congested areas and down the field to create scoring opportunities. It is also important that shots at the goals are accurate given that the score weighting is heavily biased in favor of goals rather than behinds. Studies such as the one contained in this paper can help teams strike this balance more appropriately.

In recent years teams have experimented with a wide-range of player types and sizes looking for an appropriate playing list. The nature of the game nowadays requires physically strong players so an emphasis exists on weight-room work and building muscle, although the aforementioned aerobic nature of the game also means players with high levels of endurance or explosive speed are required. Players who can catch the ball in contested situations are very valuable close

to the goal area and these players are normally required to be accurate kickers also in order to score more goals than behinds. As has been noted in this study, players who can run and bounce the ball, can kick accurately, knock the ball on, and can limit errors that turn the ball over to the opposition are of particularly high value.

The modern AFL game strongly emphasizes maintaining possession of the football at all costs. It is not uncommon to see a team move the ball sideways or backwards if they feel opportunities for moving forward are limited. Coaches now encourage players to only dispose of the ball when they are relatively certain they can deliver the ball, with a kick or handball, directly to a teammate. As handballs are generally more accurate than kicks (although typically cover less distance) there has in recent years been a growth in the number of such disposals.

The ability of a player to effect an accurate disposal is largely impacted by pressure from the opposition. A player who is tackled by an opposition player must immediately release the ball by hand or foot. This leads to many players being pressured and not being able to accurately deliver the ball to a teammate, or if they do, finding that this teammate is quickly tackled an/or disposed.

Another increasingly important aspect of the game is clearances from general play and stoppages. After goals, at the start of quarters and in situations where the umpire feels the play is too congested, a ball-up occurs with the ball bounced or thrown into the air. At this point opposing ruckmen seek to hit the ball to their advantage. This is known as a hit-out. Such a strike does not always fall to a teammate, and the team that can anticipate or remove the ball from such a situation is often well placed to forge a productive attacking move. The most important clearances are those from centre-bounces (which follow goals and the start of a quarter) as all players, except four from each team, are restricted at this point from being in close proximity to the ball, creating an excellent opportunity to gather the ball in space.

The AFL and its member teams have become increasingly sophisticated in their approach to their activities in recent years. These have seen considerable advances in a range of areas from marketing, sport science, use of technology, and application of learning from other sports. Up until the mid-1990s it was common for almost all players to only be part-time footballers (i.e., they had full-time jobs outside the sport) and for club administrators to all work on a voluntary basis. Current day AFL players, coaches, and administrators are full-time professionals. The rapid development of the professionalism of the game has transformed it radically and more change is expected in the near future. While this is lamented by some fans that pine for the "good old days," the scope for the continued application of modern business, sport, science, technology, and associated practices to Australian Football appears considerable. This current study assists in that progression.

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