A Markov Model of Baseball: Applications to Two Sluggers

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Notes are not intended to be a complete discussion or the text of my presentation. The notes contain additional and supplementary material not presented.

If a graph or chart is too small to read, use Acrobat's magnification percent to enlarge it.

Some of the slides were skipped during the presentation.

Overview

- Markov model description
- Cards pitchers batted 8th after 1998 All-Star Game
  - Get more men on for McGwire, fewer walks
  - Was it good for McGwire, bad for team?
- When to walk Barry Bonds (2001-02)
  - Prevent certain number of runs
  - Based on Giants' lineups

Cardinals manager Tony LaRussa was criticized by some saying he was hurting the team. One of the critics was one of his players, Ron Gant, after Gant left the team, who said McGwire should have hit 4th instead.

Walking Bonds has become a common tactic. When is it advantageous?

Both of the applications were presented at the annual meetings of the Society for American Baseball Research, SABR, www.sabr.org

Versions of these presentations are on my web site:

www.pankin.com/baseball.htm, which also has other presentations and details about the Markov model

Markov Process Model (1)

- Inning moves through states
  - 24 runners and outs combinations
  - 3 outs, absorbing state
  - Additional states can be included
    - 1, 2, 3 runs on third out
    - Runs scored so far in inning
    - Non-batter plays: SB, CS, WP, PB, balk

1) Others, notably session chair Bruce Bukiet, have also developed Markov baseball models

2) I handle non-batter plays not with additional states but with a pre-batter Markov chain. I chose that method due to limited personal computer power when I first developed the model.

3) The are other Markov processes in a baseball game:

a) the progress of the ball-strike count during the plate appearance

b) the first batter in each inning; this one is incorporated into my run scoring model

Markov Process Model (2)

- Calculates expected number of runs per 9 innings that a lineup will produce
- Internal calculations yield probabilities of runners and out situations, runs scored
- Major assumption: each batter performs the same in all batting order positions, essentially the same in all runners/outs situations

Other assumptions:

A) running events except for SB try are according to league averages (advancement on hits and outs, hitting into a DP, WP, PB, balks); reaching on error also by ML average

B) stolen base attempts with runner on first only; about 80% of all cases; greatly simplifies model calculations

C) only pitchers try sac bunts, but that can be overridden (not done for this analysis)

No adjustments are made for pitcher handedness, but that is possible. In effect, batters are assumed to hit at the overall average performance levels

Markov Process Model (3)

- Applications
  - Analysis of strategies (sacrifice, SB, hit & run)
  - Effects on scoring of player performance
  - Batting order optimization
- Model details, formulas, applications at "www.pankin.com/baseball.htm"
- Data source: "www.retrosheet.org"

One recent example of batting order optimization for the Phillies was in the June 1, 2006 Philadelphia Daily News. Of particular interest is that the reporter showed it to Phillies manager Charlie Manuel and got his reactions.

The article is on my web site at the URL shown.

McGwire Situational Data

- Before and after 1998 All-Star Game
- Runners:
  - bases empty
  - 1st occupied
  - runners on, 1st open

McGwire Plate Apps. In 1998

	Before ASG	After ASG	Total
Empty	187	181	368
1st occ.	111	91	202
1st open	64	47	111
Total	362	319	681

- Lineups significantly different before and after
- Model is needed to study effects of batting pitcher 8th

Now we turn to the batting the pitcher 8^{th} question. LaRussa wanted to reduce the chances McGwire would be walked in order to help him break the HR record and hit more than Sammy Sosa who also was challenging Maris' record.

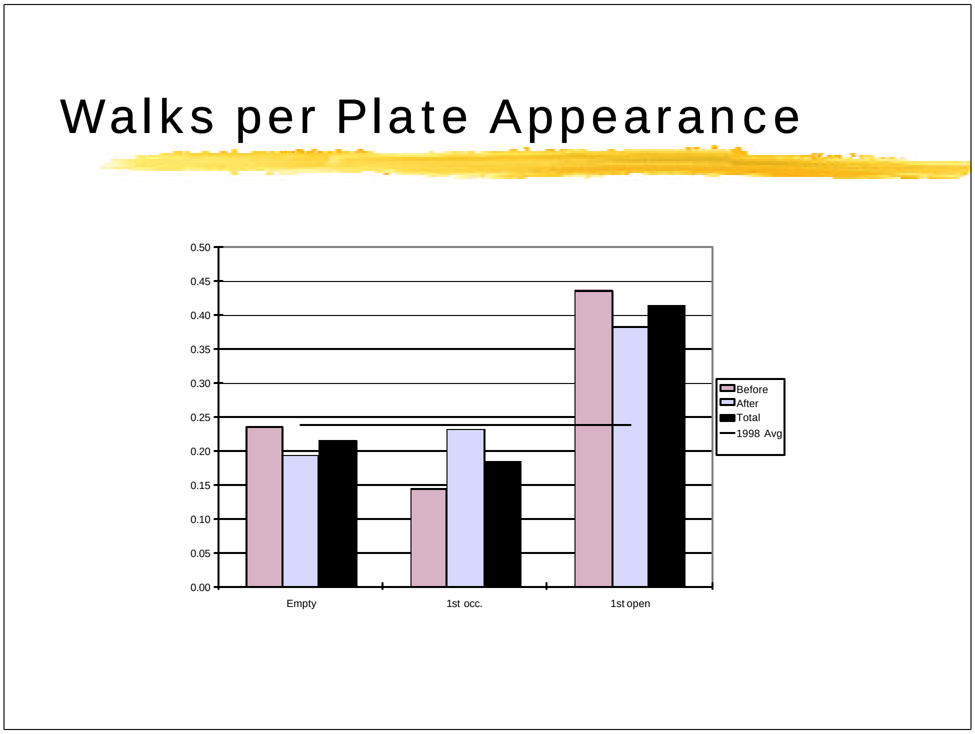
1) situational stats can mislead due to small numbers:

A) 187 pa at 4+/g --> 45 games, < 2 months

B) don't take BA seriously at end of may

2) empty about same, but many fewer men on sits after (P bat 8) – discussed later

3) A graph follows with Mac's walks per plate appearance by situation. The SABR talk on my web site has additional situational performance graphs.



A) three groupings by runners

B) three bars--before ASG, after, total season for situation--in each group

C) horizontal line is season average for all situations

More walks with 1st open (no surprise)

Bases empty vs. 1st occupied before ASG may be what LaRussa was thinking about (but reversed after ASG). However, small numbers of cases may affect the comparisons.

Why Model is Needed

- 72 Mac starts each with P batting #8, #9
- More runners on when P batted #9
- Many lineups used
- Hitters ahead of Mac did better when P #9
- Model can produce valid comparisons

OBP of hitters before McGwire

(games when he started, no DH)

	Pitcher bats	
	#9	#8
#1 batter	0.312	0.278
#2 batter	0.386	0.391
Combined	0.349	0.334

Table shows why there were more PA with runners on before ASG, when pitchers batted last.

1) LaRussa used more lineups than any other mgr in 1998 (influenced by P bat 8th, but frequent changes common)

2) Mac always batted #3 when he started (152 games -- 8 in al parks)

3) comparisons between the pairs of 72 games (BB Weekly article; LaRussa cost Mac shot at RBI title) not valid due to different players and performances

4) model holds performance of players constant, so valid comparisons are possible

Lineups Used in Model

	1998 Full Season		vs. RHP - vs. LHP		
Player	OBP	SLG	OBP	SLG	Notes
DeShields	0.374	0.429	0.053	0.056	
Jordan	0.370	0.534	-0.044	-0.103	Bats 4th vs. LHP
McGwire	0.473	0.752	0.012	0.163	
Lankford	0.394	0.540	0.025	0.113	Bats 2nd vs. LHP
Gant	0.333	0.493	-0.087	-0.107	
Tatis	0.329	0.415	-0.009	0.086	
Marrero (M)	0.319	0.370	-0.058	-0.118	Bats 9th when P is #8
Ordaz (O)	0.261	0.235	0.103	0.123	Bats 7th when P is #8
Pitcher (P)	0.174	0.176	<-- NL average (Cards in 1998 were similar)		

M,O,P = lineup above (P bats 9th); O,P,M = lineup with P batting 8th

1) most frequent starters after ASG

2) Positives in second group of columns mean batter did better vs. RHP

3) M,O,P / O,P,M / M,P,O will be used in following

4) analysis will be based on full season, but comparisons based on pitcher handedness are similar

Modeled Runs per 162 Games

- Full season data
- Similar results by pitcher hand
- First four are near “optimal”
- Differences among first four are minor

	Normal	Pitcher bats 8th		"Gant"	Worst?
1	DeShields	DeShields	DeShields	DeShields	Tatis
2	Jordan	Jordan	Jordan	Lankford	Ordaz
3	McGwire	McGwire	McGwire	Gant	Marrero
4	Lankford	Lankford	Lankford	McGwire	Pitcher
5	Gant	Gant	Gant	Jordan	Gant
6	Tatis	Tatis	Tatis	Tatis	DeShields
7	Marrero	Ordaz	Marrero	Marrero	Jordan
8	Ordaz	Pitcher	Pitcher	Ordaz	Lankford
9	Pitcher	Marrero	Ordaz	Pitcher	McGwire
Runs	865.2	864.9	867.6	865.4	815.5

1) best lineup found was a little less than 869, so the first four are not significantly less than the theoretical optimal batting order

2) “Gant” batting order (see earlier note about his comments) assumes DeShields 1st and McGwire 4th

3) models not designed to find low scoring orders; tried reversing and “optimizing”, but might be worse ones

4) 10 runs approx. Equal 1 win (to provide perspective)

5) similar relationships (different run values) using pitching hand splits

McGwire Summary

- Batting pitcher 8^{th} had very minor effects
  - No meaningful differences in modeled runs when pitcher bats 8th
  - Slightly increased chance of men on for Mac (see presentation on my web site for details)
  - McGwire did hit 70, but probably would have hit about the same with normal batting order
- Other teams: P batting 8^{th}, little difference

1) according to model, batting pitcher 8th did not hurt and might have produced a couple more Mac PAs with men on, but differences are small, within error bounds of model

2) in effect, no difference between pitcher 8th and 9th

3) batting Mac 4th would not increase scoring and would reduce his PAs by about 18 per season, which would cost 2 HR based on his 1998 PA/HR --> Gant not right

4) I have tested batting the pitcher 8th with several teams, and it makes very little difference; in a few cases the expected scoring goes up by a very small amount

When to walk Barry Bonds

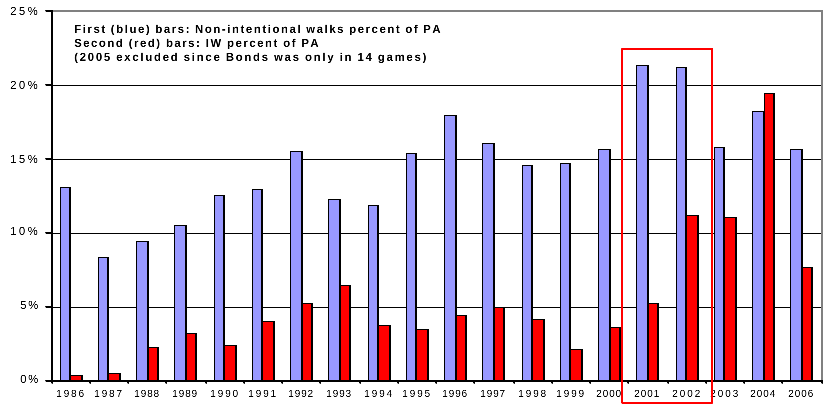
- Opposing manager's objectives
  - Minimize chance of 1,2,3,4 runs scoring
  - No IW if trying to prevent > Bonds HR
  - Reduce expected runs in rest of inning
  - Can be conflicting objectives
- Strength of following batters is critical
- Opposing pitcher not considered; used average hitting performance

In late innings, may have a specific objective to prevent a certain number of runs from scoring. In any situation, the largest such number would be what would score if Bonds hit a HR because if want to prevent a high number should pitch to him because even a HR won't have much of an effect on that objective (2002 WS, game 2 for example). In earlier innings, reducing the overall scoring may be more important than preventing a specific number of runs.

Reducing chance of some number of runs with IW may increase chance of a larger number, so IW that increases chances of winning game may also increase chance game is tied is tied or lost in same inning (but not both)

Strength of following batters is obviously quite important.

Bonds Walks as % of PA



- Much higher non-IW % in 2001-02

In 2001-02, more of Bonds non-IW walks were really "unintentional intentional" as can be seen by the much higher percentage of officially non-IW walks in comparison to his previous history. That indicates that his walk percentage for analytical purposes should be scaled back. I chose 15% as typical, and it is the 1998-2000 average.

After 2002, the non-IW percentage has gone down (2005 excluded since Bonds missed just about the whole season), but he has been walked intentionally with greater frequency.

Note that some of the walks in other years were also unintentional intentional, but it is probably OK to include them since pitchers will still be careful and may end up walking him when they fall behind in the count rather than risking throwing a fat pitch.

Bonds hit #1 early in his career with Pirates, so fewer then.

Bonds Hitting in Model

- Use 15% of PA non-IW walks
  - Many in 2001-02 really intentional
  - 15% is rough average for prior few years
- Remove all IW for pitch to him analysis
- Combined 2001-02 data with adjustments
  - BA: 0.347 (same since AB not affected)
  - SLG: 0.834 (same since AB not affected)
  - OBP: 0.463 (reduced from 0.547 actual)

In trying to analyze whether or not it makes sense to give IW, need to remove those from his performance when pitched to.

The two adjustments do not affect the numbers of hits or AB, so BA and SLG are the same. Because all IW and some non-IW BB are removed, the OBP is reduced quite a bit. Values are still very high.

Hitters Following Bonds

2001, Bonds bats 3rd		
PLAYER	SLG	OBP
KENT J	0.507	0.376
SNOW J	0.379	0.375
DAVIS E	0.365	0.271
SANTIAGO B	0.369	0.299
MARTINEZ R	0.353	0.327

2002, Bonds bats 3rd		
PLAYER	SLG	OBP
KENT J	0.503	0.358
SNOW J	0.360	0.348
SANDERS R	0.455	0.328
SANTIAGO B	0.450	0.320
SHINJO T	0.370	0.355

2002, Bonds bats 4th		
PLAYER	SLG	OBP
SANTIAGO B	0.450	0.320
SNOW J	0.360	0.348
SANDERS R	0.455	0.328
BELL D	0.429	0.337
PITCHER	0.176	0.174
SHINJO (PH)	0.370	0.355

- After Bonds and at most five hitters, inning over, Bonds out, or Bonds will have scored
- Sufficient to find runs objectives probabilities

Use typical Giants batting orders and the other players' seasons' stats. When Bonds, Kent switched batting positions 3, 4 in mid-2002 and Santiago moved into 5th, #9 hitter could be involved. Used typical pitcher performance based on ML average a few years ago. Also looked at if Shinjo would PH for pitcher. Did not have much of an effect because only affects cases where Bonds up with none out, and by time get down to #9, which has low probability of affecting comparisons, differences due to PH are not enough to change advantage of IW or pitching to him.

Bonds + 5 (or +4 if one out, +3 if 2 outs) is enough for objectives shown previously (& because always pitch to him if idea is to prevent more than his HR would produce).

Example of Model Output

- 2001 Giants
- Bases empty, two outs
- If pitch to Bonds, probability of a least one run is 17.5%
- If IW, probability is 15.8%
- Good situation for IW for objective of preventing any runs in rest of inning

Threat of Bonds HR (or extra base hit and being driven in by next hitters) is great enough that probability of scoring is reduced by 1.7% if Bonds is IW. This would not be the case for just about any other hitter ever, so this is an "unusual" IW situation.

Assumption that Bonds advances on hits at ML average probably has no meaningful effect (at most 0.1%?) on the comparison.

When to IW Bonds (1)

- With 2 outs, to keep him from scoring
  - none on, prevent one run
  - one on (any base), prevent two runs
  - two on (any bases), prevent three runs
  - bases loaded, prevent four runs
- Improves probability of prevention:
  - 2001: 1.7% - 2.6%
  - 2002: Bonds 3/2.2%-3.1%; 4/2.9%-3.9%

These are essentially the same case. and are non-standard IW situations. Note that it makes sense to IW him some times even if it forces in a run.

The 1.7% for 2001 is the case on the prior slide.

Because 2 outs and Kent and Snow were better in 2001 than 2002, bigger advantage of IW in 2002, Bonds #3. Since Kent better than Santiago, advantage is even greater when Bonds hit #4.

When to IW Bonds (2)

- With runner on 2nd or 3rd, but not both, any number of outs, to prevent any runs
- Improves probability of prevention:
  - 2001: 1.2% (3,0) - 5.5% (2,1)
  - 2002: Bonds 3/0.6% - 5.8%
  - 2002: Bonds 4/0.5% - 6.5%
- Obvious situations for IW

He probably would always be walked in these situations. IW not effective with runners on both 2nd and 3rd if following hitters have high enough OBPs, so they are likely enough to generate a run with bases loaded.

Least and most advantages come from same situations in all three cases. Small with runner on 3rd, none out; greatest with runner on 2nd, one out.

Note that ranges of advantages from IW are wider and have some larger values than prior case.

When to IW Bonds (3)

- Runners on 2nd and 3rd, one out, to prevent one run or to prevent two runs
- Improves probability of prevention:
  - 2001: 0.3% (prevent 1) - 5.4% (prevent 2)
  - 2002: Bonds 3/1.7% - 5.7%
  - 2002: Bonds 4/2.2% - 6.5%
- Obvious situations for IW

Another situation when he is virtually certain to be walked. Note large advantage if trying to prevent two runs, much smaller to prevent one run due to loading bases makes it possible to score on a walk.

Relative comparisons between the cases: least advantage to IW in 2001, most in 2002 Bonds #4 as before due to quality of following hitters. However, differences are not that great.

When to IW Bonds (4)

- 2nd and 3rd, 1 or 2 out, prevent 2 or 3
- Improves probability of prevention:
  - 2001: 1.9% (2 out, prev 3)-5.4% (1, prev 2)
  - 2002: Bonds 3/2.4% - 5.7%
  - 2002: Bonds 4/3.3% - 6.5%
- Fairly natural situations for IW
- Overlaps with other good IW situations

This includes some situations covered previously. They are repeated to show similarities between the situations. The prevent 3 runs may be a bit non-standard since an IW puts that run on base. However, with one out, it sets up a DP.

Weaker Followers>More IW

- 2002 Bonds batting 4th
- Weaker following hitters (no Kent)
- Additional favorable IW situations:
  - Two on, two outs, to prevent any runs
  - First base open, one out, prevent 2 runs
  - 2nd & 3rd, none out, prevent 2 runs
  - Bases full, two outs, prevent 2 runs(+1.6%)! [pays to walk him and pitch to Santiago]

Because of weaker following hitters when Bonds hit #4, there were some situations where the IW was favorable that were not the case when he hit #3.

IW Bonds (2001-02 Giants)

	Prevent				Prevent				Prevent			
Runners	1	2	3	4	1	2	3	4	1	2	3	4
None	n				n				Y			
1	n	n			n	n			n	Y		
2	Y	n			Y	**			Y	Y		
3	Y	n			Y	**			Y	Y		
1 & 2	n	n	n		n	n	n		**	n	Y	
1 & 3	n	n	n		n	n	n		Y	n	Y	
2 & 3	n	**	n		Y	Y	n		**	Y	Y	
Full		n	n	n		n	n	n		**	n	Y
	0 outs				1 out				2 outs			

Y = Pays to IW Bonds for all 2001-02 Giants lineups

** = Pays to IW Bonds only with 2002, Bonds hitting #4

n = Better to pitch to Bonds

Blank areas are when IW never right for any hitter

Summary of the favorable IW situations.

Except for the rightmost Ys in the 2 outs portion, these mostly are standard IW situations for any good hitter up.

It is interesting to note that 2nd & 3rd, no outs, to prevent any runs, should not IW Bonds (or likely anyone else). This is likely a common IW situation, but risk of loading bases with none outs so run will score on any non-out play by next two batters is greater than risk of pitching to Bonds.

Walking him with bases loaded (and two outs) seems extreme, but it happened on 5/28/98 in the bottom of the 9th with Arizona ahead 8-6. Bonds had entered the game earlier as a pinch hitter and was in the #7 spot to be followed by Brent Mayne who was at best an average hitter at that point in his career. Pitcher was Gregg Olson (RHP) and Mayne also hits lefty. It worked as Mayne lined out.

Bonds Summary

- There are “non-standard” game situations when IW of Bonds is advantageous
- Not true for other Giants hitters
- IW unlikely to decrease total runs
  - Three cases in 2002/4 with slight decreases
  - Did not consider future innings; IW to Bonds may bring him and better hitters up sooner

Tested what would happen if Aurilia 2001 (next best season by a Giant) batted in Bonds spot. Did not get any of the non-standard IW situations being advantageous. With weaker hitters, number of good IW situations dropped, and was zero with Eric Davis in Bonds’ spot!

In 2001, actual IW in non-standard situations (all with 1st occupied) were not favorable according to model, but pitcher could have a strong effect. In 2002, about half of them (1st occupied or bases empty) were favorable.

Conclusion

- Markov model can “answer” quite a few questions about baseball
- Although controversial, LaRussa batting pitcher 8^{th} had very little effect
- There are “unusual” times when Bonds should be walked, but he probably was (and is) walked too much
- More at “www.pankin.com/baseball.htm”, including this talk notes, other info and added

Like any model application, the input values (assumed player performance) and underlying assumptions are critical. In general, baseball management has not made great use of quantitative models, perhaps because they lack sufficient understanding of them.

The one exception may be recognizing the importance of high OBP, particularly at the top of the batting order, to scoring more runs.

A few teams have incorporated some quantitative ideas in their decision making process. The most notable ones are Oakland (*Moneyball*), Boston (willing to lead off with slow, but high OBP Youkilis rather than speedy Crisp (0.381 OBP vs. 0.317 in 2006), and Toronto.

I am not aware of any managers who make tactical decisions based on models. Markov model can incorporate their thinking about likely levels of performance.