Simple Tennis MODELs

1) Tennis Game MODEL #1

" You need to hit a ball into the opponent's court, until the opponent misses to hit a ball back to your court. There's no opponent's service, and your service is just hit a ball
Into opponents court."

If an opponent always misses the first ball at 100% of the time, you need to make 1 ball in at least 50% to win a match.

If an opponent always misses the 2nd ball at 100% of the time, you need to make 2 balls in at least 50% to win a match, which means that you have to make each ball in with
$(1/2)^{-1/2}$ (71%).

If an opponent always misses the 3rd ball at 100% of the time, you need to make 3 balls in at least 50% to win a match, which means that you have to make each ball in with
$(1/2)^{-1/3}$ (79%).

Likewise, if an opponent always misses the n-th ball at 100% of the time, you need to make n balls in at least 50% to win a match, which means that you have to make each ball in with an average fraction of $(1/2)^{-1/n}$.

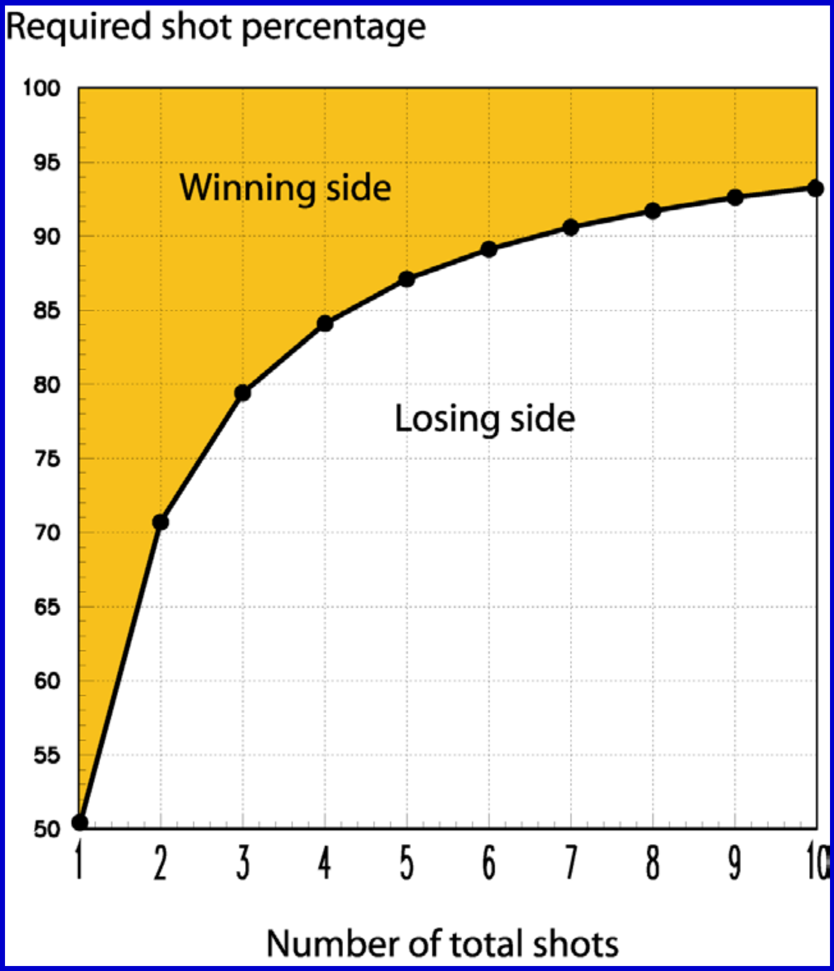

Figure 1 Required shot percentage as a function of number of shots

Figure 1 shows the required shot percentage to win a match, as a function of number of shots to make. If the average shot percentage is below the curve in Figure 1, you'll lose a match.

Opponent's strength(consistency) is shown in how many balls he/she can hit balls back to you. If you have 80% of shot consistency(if you can make 80% of balls in), you can compete with an opponent who can hit 2 balls back. If you can make 90% of balls in, you can compete with an opponent who can hit 6 balls back.

2) Tennis Game MODEL #2

"Suppose a player A and a player B are playing a tennis match, and player A gets a constant fraction, X (0.5 < X < 1.0) to get a point, and player B gets a fraction, (1-X) to get a point on all points throughout the match"

In this tennis game model, the expected probability(Y-axis) of the following can be calculated easily as a function of X (a player A's point winning fraction):

1) *player A's winning a game (Figure 2)*
2) *player A's winning a 6-game set (Figure 2)*
3) *player A's winning a best 3 set match, (Figure 2)*
4) *player A's winning a deuce game (Figure 3)*
5) *player A's winning a 7 point tie-breaker (Figure 3)*
6) *Player A's winning a best 3 set with 2 straight sets (Figure 4)*
7) *Player A's winning a best 3 set with 3 sets (Figure 4)*
8) *Player B's winning a best 3 set with 2 straight sets (Figure 4)*
9) *Player B's winning a best 3 set with 3 sets (Figure 4)*
10) *Player A's winning a game with love (Figure 5)*
11) *Player A's winning a game with 15 (Figure 5)*
12) *Player A's winning a game with 30 (Figure 5)*
13) *Player A's winning a game with Deuce (Figure 5)*
14) *Player A's winning a set with 6-0 (Figure 6)*
15) *Player A's winning a set with 6-10 (Figure 6)*
16) *Player A's winning a set with 6-2 (Figure 6)*
17) *Player A's winning a set with 6-3 (Figure 6)*
18) *Player A's winning a set with 6-4 (Figure 6)*
19) *Player A's winning a set with 7-5 (Figure 6)*
20) *Player A's winning a set with a tie-breaker (Figure 6)*

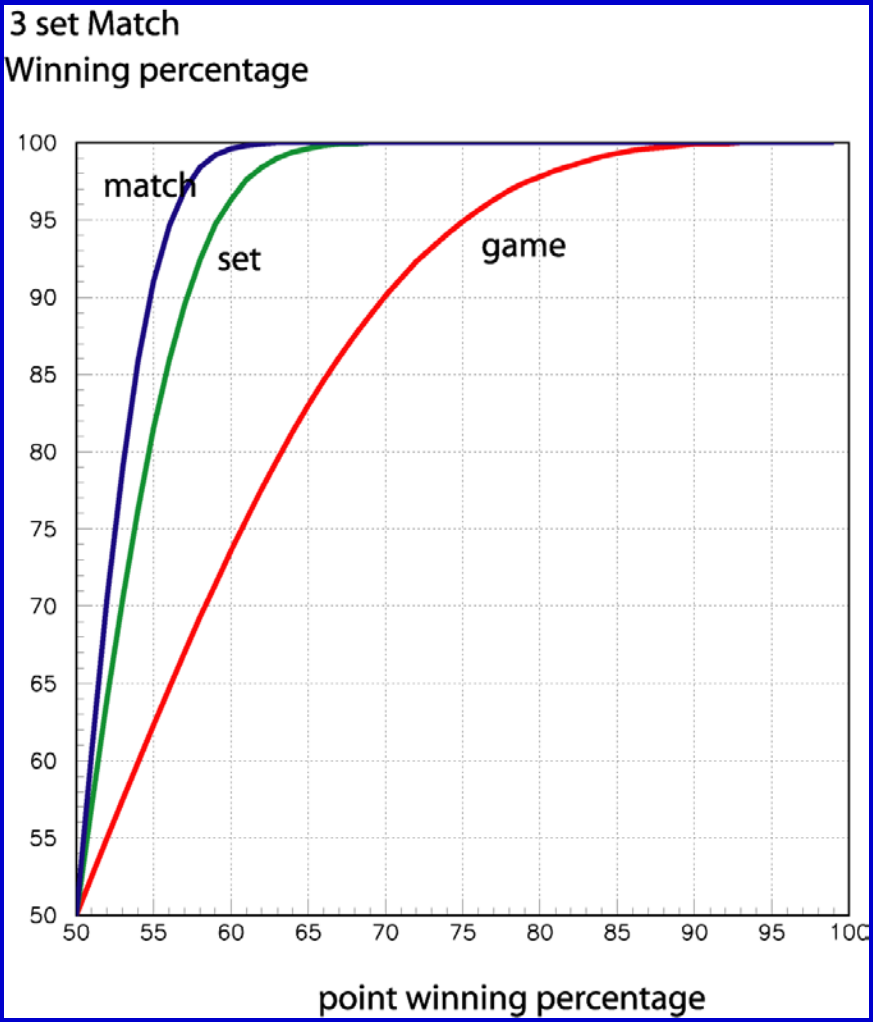

Figure 2 Winning percentage as a function of point winning percentage

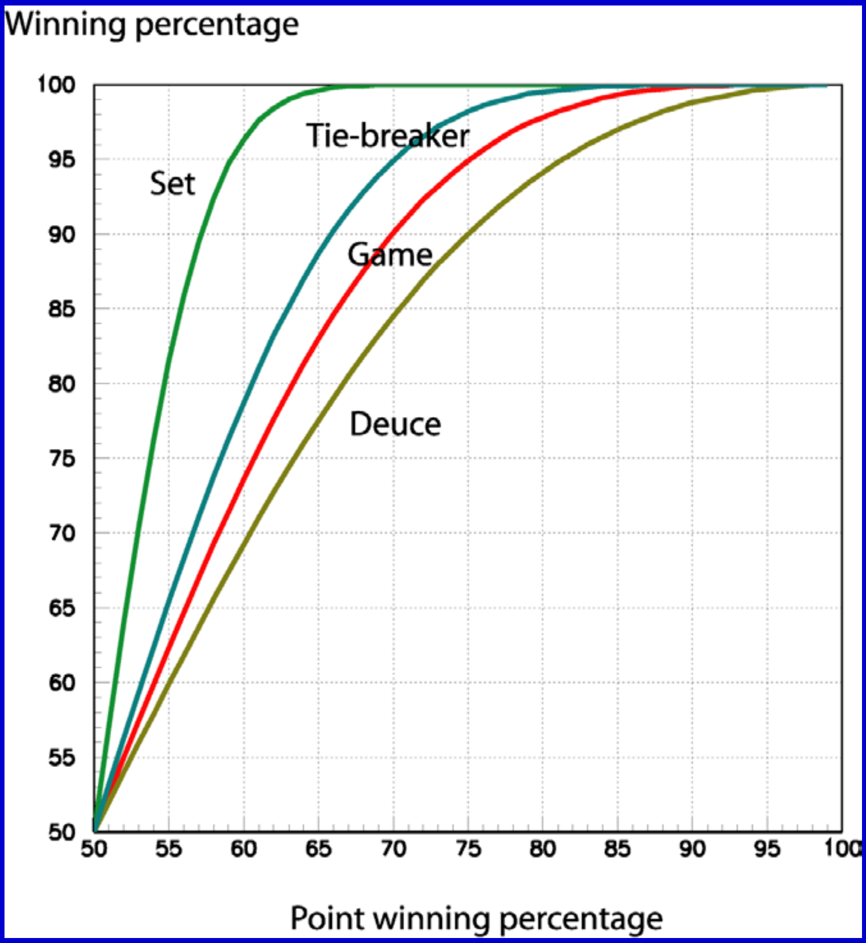

Figure 3   Winning percentage as a function of point winning percentage

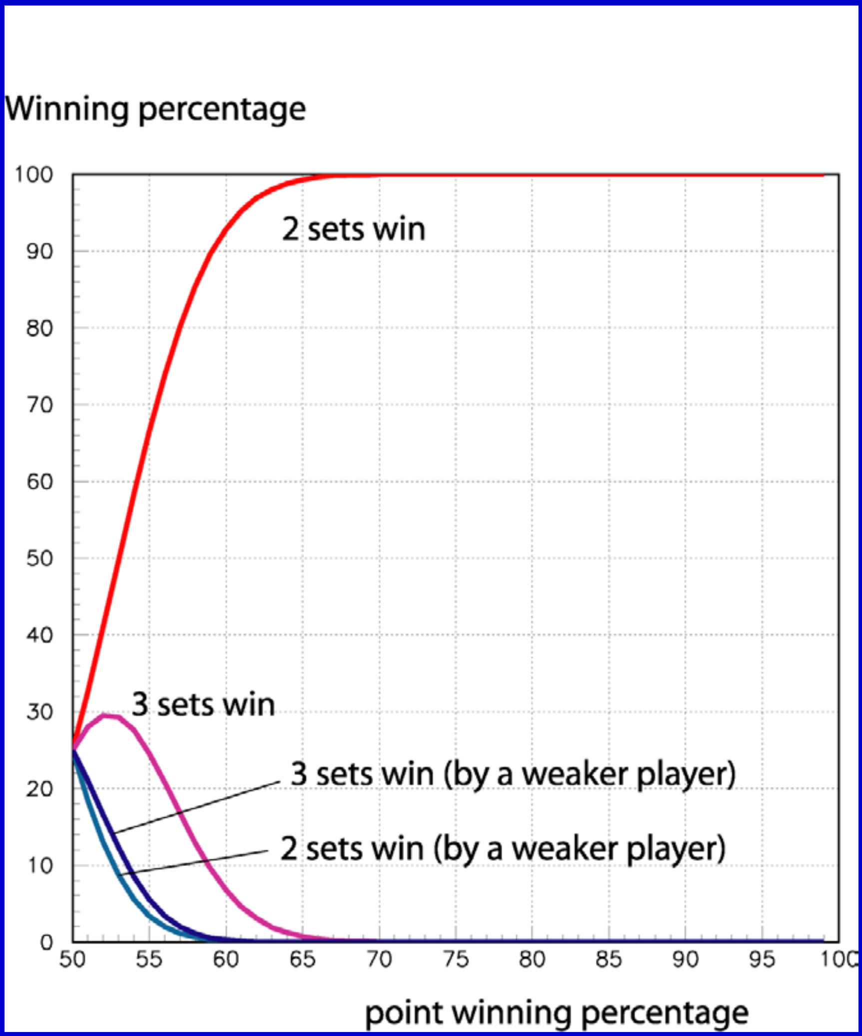

Figure 4 Winning percentage as a function of point winning percentage

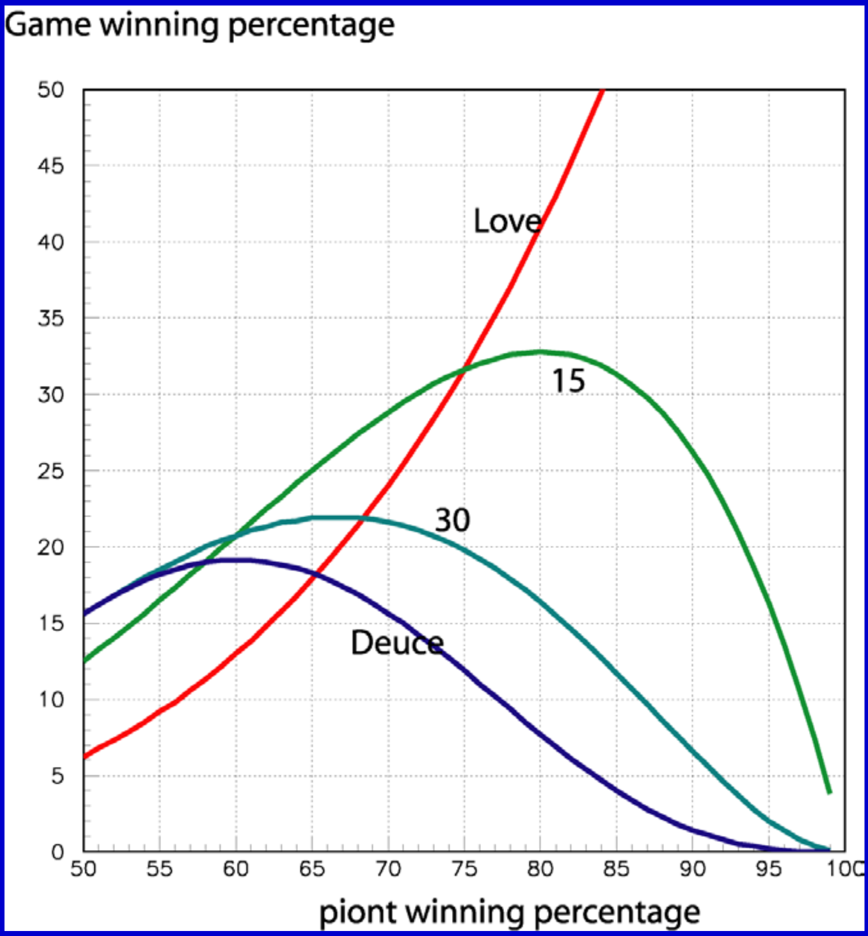

Figure 5 Game winning percentage as a function of point winning percentage

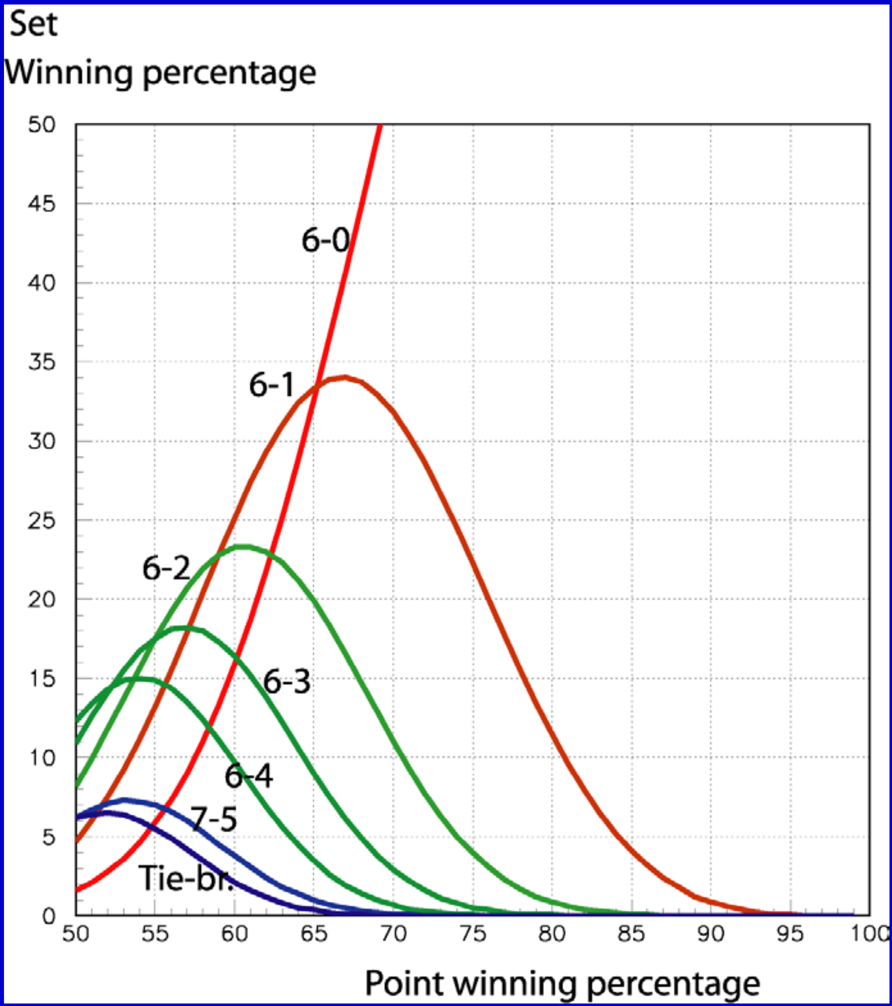

Figure 6 Set winning percentage as a function of point winning percentage

If a player A gets 60% of points, Player A wins 74% of games(69% in a deuce), 96% of sets(78% in a tie-breaker), and 99.6% of matches against a players B with 40% of point winning percentage. At the same percentage, player B with 40% of point winning percentage wins 26% of games(31% in a deuce), 4% of sets(22% in a tie-breaker), and 0.4% of matches. Player A has 2 sets win 93% of time and 3 sets win 7% of time. Player A with 60% point winning percentage win a game by mostly 15 or 30 in a game, followed by deuce games, and the player A wins a set mostly with 6-1 or 6-2, for example with the point winning percentage. A weaker player(with lower point winning percentage) has more chances to win in a deuce game(so called "Break (in) Deuce"), in a tie-breaker, and in a 3 set matches (Figures 3 and 4).

Interestingly, at 50-50 point (EQUAL)winning percentages of players A and B, most games are 30-games or deuce games, and set counts are mostly 6-4 or 6-3(Figures 5 and 6).

For example, let a, and b represent events that player A or player B get a point in a match. Any tennis match is then represented completely by a sequence of a or b.

If a player gets 4 points with 2 or more points difference from the sum of opponent's points, a player gets a game. If both a player and an opponent gets 3 points in a game, the game is called as a deice game. 0 point is called Love, 1 point is called as 15, 2 points are called as 30, and 4 points are called as 40, in a game.

If a player gets 6 games with 2 or more games difference from the sum of opponent's games, a player gets a set. If both a player and an opponent gets 6 games in a set, a tie-breaker game is played, till a side gets 7 points with 2 or more points difference.

The best of 3 set match is won by a player by taking 2 sets.

If a player A gets a love-game, which is 4 points in a row in a game, the probability to have the case aaaa happen is:

X^4 *,which is shown in "Love" curve in Figure 4.*

If a player B gets 2 points(30) in A's winning game, 2 b's and 3 a's must happen before A's getting the 6th point. An example is abaaba. The number of cases for arranging a and b in that way is $_5C_2$ $=(5x4)/2=8$ *. So the probability of A's 30-game is*

$8xX^4(1-X)^2$ *,which is shown in "30" curve in Figure 4.*

A deuce game happens if ab or ba follows after 30-all. Probability to have this happen is $_2C_1x_4C_2X^3(1-X)^3$ *. For a player A to win a deuce game, the following have to follow: aa, or (ab or ba)aa, (ab or ba)(ab or ba)aa, ... , which probability is:*

$X^2 + {}_2C_1X(1-X)X^2 + \{{}_2C_1X(1-X)\}^2 X^2 + \ldots = X^2 / \{1- X(1-X)\}$ *. So the A's winning probability in a deuce game is:*

$_2C_1 * {}_4C_2X^3(1-X)^3 * X^2 / \{1- X(1-X)\} = 12X^5 (1-X)^3 / \{1- X(1-X)\}$.

Other winning probability is calculated in the same way. Please try to figure out the other probability functions by your self.

Reference: "The science of Tennis" by K. Miura and T. Chomabayashi, Koubunsha Publishing Company, Japan, 1980.

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