Moneylines and Implied Win Probability

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What is a moneyline bet?

Suppose the Eagles are playing the Patriots on Sunday night. If you go online to place a sports bet, there's a good chance you'll run into a bet that looks like this:

Philadelphia Eagles	+200
New England Patriots	–220

This type of bet is called a **moneyline** bet. In fact, these were the opening moneylines for the Superbowl LII in Minneapolis (in 2018). The team whose moneyline is negative is the favorite to win the game (the favorite is more likely to win the game), and the team whose moneyline is positive is the underdog. Here's how moneyline bets work: since the Patriots are the favorite, if the Patriots win the game, then you win $100 for every $220 you bet on the Patriots. Since the Eagles are the underdog, if the Eagles win the game, then you win $200 for every $100 you bet on the Eagles.

Finding the implied win probability

Suppose that the favorite wins the game with some probability p, so $0.5 \leq p \leq 1$. Then the underdog wins the game with probability $1-p$. Let M_f denote the moneyline of the favorite, so in our example, $M_f = 220$; and let M_u denote the moneyline of the underdog, so in our example, $M_u = 200$. Let the moneyline M be the average of M_f and M_u, so in our example $M = 210$. Note that in general, M is an integer multiple of 10 and $M \geq 100$. We'd like to find the **implied win probability**, the probability that the favorite wins the game, given the moneyline. So, we seek an expression for p using M.

If you bet $\$B$ on the favorite, then your expected net return is

$$\mathbb{E}[R_f] = p \cdot \$B(\frac{\$100}{\$M}) + (1-p) \cdot (-\$B)$$

Similarly, if you bet $\$B$ on the underdog, then your expected net return is

$$\mathbb{E}[R_u] = p \cdot (-\$B) + (1-p) \cdot \$B(\frac{\$M}{\$100})$$

If $\mathbb{E}[R_f] > 0$, then more people would bet on the favorite than on the underdog, which would expose the sportsbook to a lot of risk, meaning the sportsbook would lose money if the favorite wins. Moreover, if $\mathbb{E}[R_f] < 0$, then people would be on the underdog more than the favorite, which would also expose the sportsbook to a lot of risk. So, sportsbooks want to create a "two-way betting action", in which the amount of money placed on the favorite and underdog are roughly equal, so as to minimize risk. In other words, it is in a sportsbook's best interest to set a line that implies $\mathbb{E}[R_f] = 0$. Solving $\mathbb{E}[R_f] = 0$ yields

$$\boxed{p = \frac{M}{M+100} \quad \text{and} \quad 1-p = \frac{100}{M+100}}$$

which are implied win probabilities of the favorite and underdog, respectively.