(iii) Probability in action: Gambling, the US Presidency and the market for car insurance

1. Introduction.

Probability theory is very important in the study of many areas of economics. Its importance to the betting industry is perhaps most explicit. Upwards of £50 billion is staked every year in the UK with bookmakers and on person-to-person betting exchanges, where those wishing to bet, offer and take odds from each other directly.

2008 was a very interesting and unusual year in this industry. In the world of football we saw a series of unexpected results in the FA Cup. It was the first time in 21 years that there was a semi final which did not include Arsenal, Chelsea, Liverpool or Manchester United.

2008 was also the year of a very hard fought nomination for the democratic presidential candidate in the U.S.A. While most of the money bet in the UK is on horse racing, dog racing and football, there is also a rapidly growing interest in betting on politics. The biggest political betting market is the election to choose the President of the United States. In this case study we use this race to illustrate how we can infer probabilities from the odds that bookmakers offer and to deepen our understanding of probability theory.

Probability theory is important in other areas of economics, such as in the insurance and financial markets. Probability theory is highly relevant in many aspects of life. We consider briefly the example of car insurance and so demonstrate the significance of the concept of conditional probability

2. Car Insurance and conditional probability

The Association of British Insurers reports that in 2006 the net written premiums of car insurance amounted to close to £10.3 billion. An important market segment is that of young drivers. But, many young people pass their driving test prior to going to university and consider the possibility of running their own car only to be put off by the very high insurance premiums they will be required to pay. An 18 year old that has just passed their driving test can pay several times as much as their parents for apparently identical insurance.

Is this discrimination against the young? No, it is merely a consequence of conditional probability theory. Before returning to the premiums paid by young drivers for car insurance let us consider a straightforward example to illustrate the concept of conditional probability. This is the probability of some event A, given the occurrence of some other event B. It can be written as P(A/B).

One important formula in conditional probability is:

$$P(A/B) = \frac{P(A \cap B)}{P(B)}$$

P(B) is the probability of B occurring. $P(A \cap B)$ is the probability of A and B both occurring and is referred to as the joint probability of A and B.

To make our conditional probability operational consider the 7 days of the week. Let A be a weekday and let B be a day with a letter n in its spelling.

P(A)= $5/7$ (Monday-Friday out of 7 days)

P(B) = $3/7$ (Monday, Wednesday and Sunday)

$P(A \cap B)$ = $2/7$ (Monday and Wednesday)

$$P(A/B) = \frac{2/7}{3/7} = 2/3$$

This is intuitive as you are given B which is a day with an n. There are three of these days. Two of these three days are weekdays.

Now let us return to the premiums of young drivers. The main reason an insurance company charges, for example, 5 times the premium for a new young driver is that they believe that the new young driver is about 5 times as likely to make a claim.

There are 2 reasons for this. Firstly, the conditional probability of having an accident if you are 18 years old is significantly higher than the conditional probability of having an accident if you are over 40 years old.

Secondly a person over 40 may have a significant "no claims discount" whereas an 18 year old will not have had the chance to build up a "no claims discount". The logic here is that probability of having an accident given you have not claimed for 5 years is significantly less than the probability of having an accident if you are opening a completely new policy.

Differences in the prices of car insurance occur mainly as a consequence of the above 2 types of conditional probability.

3. Probability and betting odds

There is no example where the importance of probability is more explicit than that of the betting industry. But, before considering the odds being offered during the US Presidential race in 2008 will must first consider three alternative ways of expressing probability: the standard approach, the Betfair approach and the bookmakers' odds approach.

In the standard approach a probability of winning of 0.4 (alternatively $\frac{2}{5}$ or 40%) implies an individual is expected to win 40% of the time and not to win 60% of the time. The sum of probabilities should add up to 1(100%). In the bookmaker's odds approach this will be expressed as odds of 3 to 2. This implies you win £3 for a £2 stake. This implicitly assumes the ratio of losing to winning is 3:2 implying you win 2 times out of 5.

Betfair is the world's biggest betting exchange. In the Betfair approach the same probability would be expressed as 2.5. If you make a £1 bet you receive £2.50. As the £2.50 includes the original stake you win £1.50 on a £1 bet which is equivalent to winning £3 on a £2 stake.

One interesting thing to note is that while actual probabilities add up to 1, the sum of the probabilities offered by betting companies may add up to a total which is different to 1. The probabilities they offer are not totally objective but depend a little on market situations. This is not a serious problem and will be dealt with later.

4. US party nominations in 2008

By examining betting odds for the 2008 US presidential race we illustrate the importance of probability theory to bookmakers. The US election is contested by at least two candidates, the candidate nominated by the *Democratic Party* and the candidate nominated by the *Republican Party*. It was the media's attention on the race for the Democratic nomination that dominated the early coverage of the 2008 US Presidential race. This saw a hard fought contest between Senators *Hillary Clinton* of New York and *Barack Obama* of Illinois.

We begin by considering what could have been inferred from the odds taken at **6pm on Sunday, 8th February, 2008** for the probability of Clinton or of Obama being nominated for the Democrats. Further, we consider two bookmaker's odds and compare the implied probabilities.

Betfair was offering odds for Obama of 1.58 and for Clinton of 2.72. A £1 bet on Obama would pay £1.58 if Obama was the Democratic nomination. Similarly, a £1 bet on Clinton would pay £2.72 if nominated. Each pay-out includes the original £1 stake so Obama winning would see the individual profit by £0.58 on a £1 bet, while Clinton winning would see the individual win £1.72.

Obama's odds imply that the ratio of losing to winning is 0.58:1. Hence, the implied probability in these odds of Obama winning the nomination was 1/(1+0.58) = 1/1.58. This is equivalent to a 63.29% probability of winning the nomination. Clinton's odds imply that the ratio of losing to winning is 1.72:1. The implied probability in these odds of Clinton winning the nomination was 1/(1+1.72) = 1/2.72. This is equivalent to a 36.76% probability of winning the nomination.

We noted earlier that the probabilities offered by bookmakers may not add up to 1 or 100%. In this case, the percentages sum to 100.05%. If we *deflate* the raw probabilities by 1/1.0005 (=100/100.05) they will then sum to 100%. The adjusted implied probability of Obama winning was **63.26%** (=63.29/1.0005) while that for Clinton winning was **36.74%** (=36.76/1.0005).

The best bookmaker odds available[1] for Obama were 4 to 7 and for Clinton 6 to 4. The way in which these are presented means that a £7 bet on Obama would return a profit of £4 plus the £7 stake (a total of £11) if Obama won the Democratic nomination. On the other hand, a £4 bet on Clinton would return a profit of £6 plus the £4 stake (a total of £10) if Clinton was nominated.

If the odds are expressed as a (losing) to b (winning) the implied probability in the odds of winning is calculated as b/(a+b). Therefore, the implied probability of Obama winning the nomination was 7/(4+7) = 7/11 or 63.64%. Similarly, the implied probability in these odds of Clinton winning the nomination was 4/(6+4) = 4/10 or 40%.

Again our percentages do not sum to 100. This time they sum to 103.64. So for convenience we will deflate the raw probabilities by 1/1.0364 (=100/103.64) to sum to 100%. This results in an adjusted implied probability of Obama winning of **61.40%** (=63.64/1.0364). This compares with 63.26% under Betfair. The adjusted implied probability of Clinton winning was **38.60%** (=40/1.0364) compared with 36.74 under Betfair.

5. Probability of being President

At the same time as betting on a Democratic or Republican candidate getting their party's nomination an individual could simply bet on a candidate winning the Presidential race. Hence, the individual would be betting on two events occurring: being the party's nominee and the President. The odds offered would be reflecting a joint probability resulting from an intersection of events.

Betfair was offering odds of 2.42 for Obama and 4.2 for Clinton being elected President. We can use these odds to calculate the implied probabilities that each would win the Presidency. Betfair's odds include the original stake of £1. So Obama's implied ratio of losing to winning was 1.42:1 while Clinton's was 3.2:1. Based on these odds, Obama's probability of winning the Presidency was (1/(1+1.42) = 1/2.42. This is equivalent to a 41.32% chance of winning the Presidency. The odds for Clinton suggested she only had a 1/4.2 (=1/(1+3.2)) or 23.81% chance.

The 2 Republican candidates running for the Presidency at the time were Senator *John McCain* of Arizona and Governor *Mike Huckabee* of Arkansas. Their respective Betfair odds of 3.05 and 70 implied that McCain has a 32.79% chance of winning the Presidency and

[1] The odds were available from www.oddschecker.com and www.bestbetting.com

Huckabee a 1.43% chance. The percentages across the 4 candidate sum to 99.35%. We can inflate the raw probabilities to sum to 100 by applying an adjustment factor 1/0.9935 (100/99.35). Our focus is on Obama and Clinton. The adjusted implied probability of Obama becoming the Presidency is **41.59%** (41.32/0.9935) while that for Clinton is **23.97%** (23.81/0.9935).

The best bookmaker odds for Obama and Clinton being President were 11 to 8 and 5 to 2 respectively. The implied probability for Obama winning the Presidency was (8/19) 42.11%. Meanwhile the implied probability for was Clinton (2/7) 28.57%. Summing the implied probabilities across the 2 Democratic and the 2 Republican gave 107.05[2], so we deflate the raw probabilities by 1/1.0705 (100/107.05). This gives an implied probability of Obama winning the Presidency of **39.34%** (42.11/1.0705), slightly less than was inferred from the Betfair odds. The implied probability for Clinton of **26.69%** (28.57/1.0705) is slightly higher than was inferred from the Betfair odds.

For each candidate to run as their party's nominee they needed to first be nominated by their party. We can use the implied joint probabilities for Obama and Clinton of being elected as President <u>and</u> of being the Democratic nomination to calculate the conditional probability of each being elected President **IF** nominated by their party. To do this we use the formula in section 2 linking intersection events to conditional events. We will do this using the Betfair odds.

Betfair was offering the adjusted implied probability of 41.59% of Obama being elected President. At the same time they were offering the adjusted implied probability of Obama being the Democratic nominee of 63.26%. From these two figures we can calculate that the conditional probability of Obama being elected President **IF** nominated by the Democrats was **65.74%** (0.4159/0.6326).

We now calculate the conditional probability of Clinton being elected President **IF** nominated by the Democrats. To do we use the adjusted joint probability of 0.2397 of her being a Democratic president and the adjusted probability of 0.3674 of her winning her party's nomination. Therefore, the conditional probability is **65.24%** (0.2397/0.3674).

Obama was clearly the favourite to get his party's nomination. But, bookmakers' odds infer that the likelihood of Obama or Clinton becoming President, if nominated by the Democrats, was practically the same.

Tasks

Use the **Betfair odds** below to undertake the following calculations. The odds were taken at 12 noon on 11th and 12th February, 2008.

(i) Calculate the adjusted implied probabilities for Obama and Clinton being nominated by the Democrats and for McCain and Huckabee being nominated by the Republicans.

(ii) Calculate the adjusted implied probabilities that each would be elected President

(iii) Calculate the conditional probability of each being elected President **IF** nominated by their parties.

(i) Democrat nominee

Obama: 1.46; Clinton: 3.1

(ii) Republican nominee

McCain: 1.07; Huckabee: 24

(iii) To be elected President

Obama: 2.16; Clinton: 4.8

McCain: 3.3; Huckabee: 60

[2] The odds (probabilities) for McCain and Huckabee were 7 to 4 (36.36%) and 100 to 1 (0.01%) respectively.