1.011 Uncertainty Note
Did Belichick Make the Right Call?
J. Sussman
February 19, 2010

Back in November, 2009, Coach Bill Belichick (BB) of the New England Patriots made a highly controversial decision late in a game with the Indianapolis Colts. The Pats had the ball on their own 29-yard line with a 4th and 2 with only 2 minutes or so to go in the game. BB had two options. The conventional choice would have been to punt the ball to the Colts. In that case, the Colts would have had the ball on their own 30 (or so), 70 yards from the winning touchdown. If the Pats went for the first down, and made it, they would retain possession and be able to run out the clock and win. If they didn't, the Colts would take over on the Pats 29, 29 yards away from the winning touchdown.

BB went for the first down and failed to make it. The Colts took over and scored a touchdown winning the game. Belichick was castigated by the fans and the press for his "mistake". BB is widely perceived as a coaching genius. Did he just have a brain cramp? Let's think about this:

Suppose BB's assessment of the probabilities is as follows:

P(Pats make the first down) = P1 (in which case the Patriots win with probability = 1)

P(Colts win if they start from the Pats 29) = P2

P(Colts win if they start from their own 30) = P3

Here are the decision trees.

They punt

Pats win with probability (1-P3)

Pats lose with probability P3

They try for the first down

Pats make first down
with probability P1

Pats win with probability=1

Pats lose with probability=0

Pats fail to make first
down with probability
(1-P1)

Pats win with probability (1-P2)

Pats lose with probability P2
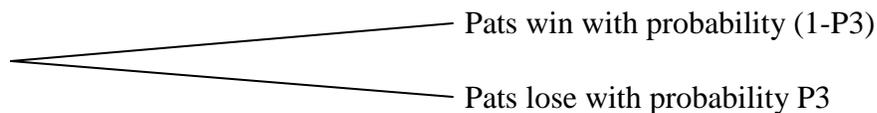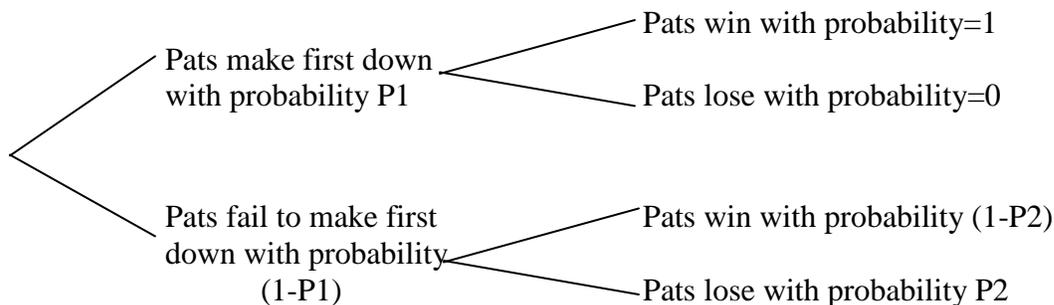
If BB chooses to punt, the Pats' chance of winning are simply 1-P3

If BB tries for the first down, the Pats' chance of winning is

   P1 + (1-P1) (1-P2) = 1- P2(1-P1)

In this second case, they have 2 chances to win—they make the first down, in which case they win with certainty or they fail to make the first down in which case, they can still win if the Colts fail to score from the Pats 29.

So I am speculating that BB felt he had a good chance to make the first down, so let's say BB thinks P1=0.8.

So, again, the Pats' chance of winning if they punt are 1-P3

Their chance of winning if they go for the first down are 1-P2(0.2).

What should BB do?

So if 1-0.2(P2) > 1-P3, BB should go for the first down.

Rearranging:

If 0.2P2< P3, BB should go for the first down.

So, if for example, BB believes P2 = .7 and P3= .5, you should try for the first down

But if P2 = .7 and P3 = .1, you should punt.

You can try it for some other numbers.

When fans, asked by the radio host on talk radio if they thought BB had made the right or wrong decision—in the real situation, they went for the first down--- they would say things like "Obviously, it was the wrong decision. They didn't make it and lost the game, didn't they?" That doesn't prove it was a bad decision, anymore than it would prove it was a good decision if the Pats made the first down, thereby winning the game.

The point is that the outcome of this one-time event doesn't tell us whether it was a good decision or not. However, it may cause BB to reevaluate his expert estimates of P1, P2 and P3.

Now, on a more serious note, consider the snowstorms that brought Washington to a standstill. Some people were saying "it looks like global cooling, not global warming is going on". Just as BB wasn't wrong simply because his strategy didn't work that one time, a big snowstorm in Washington doesn't tell us anything about climate change. And to be even handed, the folks out

in Vancouver for the Winter Olympics who are saying the unusually warm temperatures are evidence of global warming are equally incorrect. One instantiation tells us very little.

Back to football—my own sense of this is that BB felt Peyton Manning, the Colts quarterback, had a very good chance to drive the Colts to a winning touchdown whether the Colts started on the Pats' 29 or their own 30. Manning was playing very well, and the Pats defense seemed bushed. Let's say BB thought P2 = .8 and P3 = .6

In this case, the chances of the Pats winning if they punt is .4

The chances the Pats win if they go for it = 1-.8 (1-P1), so if BB believes his chances of making the first down is > .25, he should go for it.

I personally think it was the right call, but as Mrs. Albert Einstein supposedly said about her husband, "Ah, what does he know?"

Belichick – Part 2
J.Sussman   March 10, 2010

Now, suppose our question is a different one. We now want to *predict* what decision BB (or some other coach) will make before the fact. Let us assume we are all agreed on the values of P1, P2 and P3 to take that out of the mix.

But let's add in another twist—call it the embarrassment factor. Football coaches often make the decision that will avoid embarrassment rather than the decision that gives them the best chance to win.

In this instance, the conventional decision would be to punt. Almost no-one would criticize a coach who punted even if the team lost.

Now BB is interested only in winning and doesn't care about embarrassment. So the earlier decision trees applies. But suppose we have a less confident coach (LC). He cares only about avoiding embarrassment and not at all about winning. In this case, the coach would always punt, unless s/he is certain that the Patriots will make the first down (P1=1)

A more general approach is the following:

Each result on our decision trees now has two outcomes:

Did the Patriots win?   If they win, W=1 and if not W=0
Is the coach embarrassed by the outcome? If embarrassed, E= -1 and if not E=0

Now BB doesn't worry about embarrassment—only winning—and LC really wants to avoid embarrassment at all costs—if s/he wins, fine—but first and foremost s/he wants not to be embarrassed! So we know how to solve the BB case and the LC case too. But consider a more nuanced coach who balances winning and embarrassment. Let w be the weight Coach NN (for nuanced) places on winning and e be the weight NN places on embarrassment, where

$$w+e =1$$

So for BB, w=1 and e=0
For LC, w=0 and e=1

Let's now do our decision trees again and calculate the value of each outcome, using W, E and the weights w and e.

Here are the decision trees.

The choice is punt

Here are the decision trees.

| They punt		W	E	V=Ww+Ee
Pats win with probability (1-P3)		1	0	w
Pats lose with probability P3		0	0	0
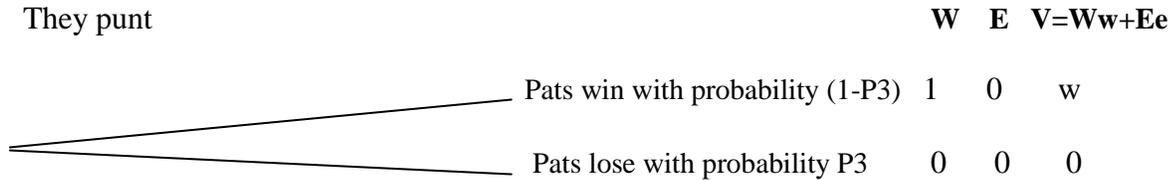
The value (V) of this strategy is simply as follows:

$$V^*=w\,(1-P3)$$

Note there is no embarrassment! How could there be? They took the conventional choice

The choice is to try for the first down.

Here are the decision trees

		W	E	V=[Ww+Ee]
Pats make first down with probability P1 → Pats win with probability=1		1	0	w
Pats lose with probability=0		0	0	0
Pats fail to make first down with probability (1-P1) → Pats win with probability (1-P2)		1	0	w
Pats lose with probability P2		0	-1	-e
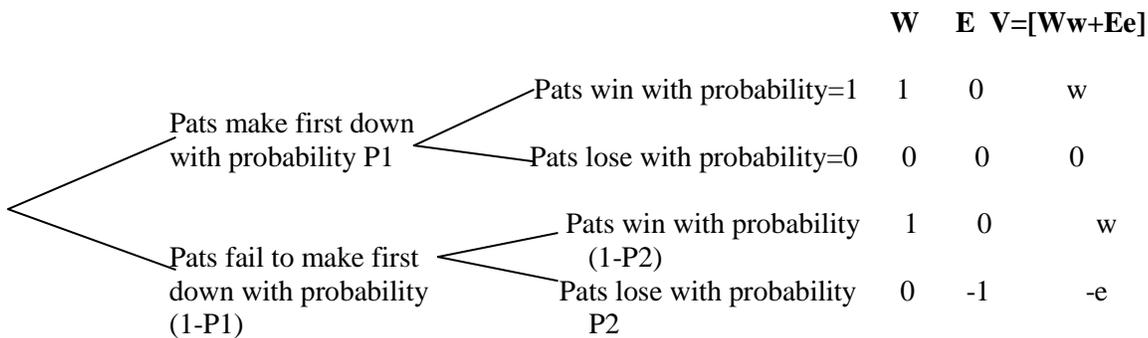
In this case,,

$$V^{**}= w(P1) + w\,(1-P1)(1-P2) + (-e)(1-P1)(P2)$$

The third term shows embarrassment coming into play. They tried for the first down, didn't make and lost. We assume if they try for the first down, don't make it, but still win, no embarrassment occurs

So for NN to go for it, $V^{**} > V^*$

So let's see what P1 has to be for NN to try for the first down, as a function of P2, P3, w and e.

Rearranging term, we eventually obtain:

$$P1 > 1 - \frac{wP3}{P2}$$

as the condition for the coach going for the first down. Note that e is in this expression implicitly since $w + e = 1$

So suppose that P2= .8 and P3= .6

Then $P1 > 1 - .75w$ is the condition for trying for the first down.

If the coach is BB, w= 1 and P1> .25. So the coach who just cares about winning and cares nothing about embarrassment will go for the first down even with a relatively low P1.

Coach LC who has an e=1 and a w=0, will punt unless s/he believes P1 = 1

Let's suppose Coach NN cares about winning and embarrassment about equally, so w=.5, e= .5. For Coach NN, P1 must be > .625 for him/her to go for the first down

And if w= 2/3 (.66666…), for that coach, s/he will try if s/he thinks P1> .5, a toss-up.

Try it for other values of P2 and P3 and see what happens

So, if you are interested in predicting what the coach will do in this situation, you have to know what his/her w and e are. Are we dealing with BB, LC or the many versions of NN? Beyond that, we likely need to recognize that w and e will likely change for an individual over time. And some of that may be unknowable to us—the coach had a fight with his star player at half time and is distracted. So this prediction is non-trivial.

The question of predicting what a football coach will do is not earthshaking. But other predictions may be more important, such as predicting what mode a traveler will choose—public transit or car—or what a shipper will choose—truck or rail. Many economic models assume the chooser will maximize the value to him/her in making the choice and will make an "economically rational" selection. Of course, what the economist modeling the situation thinks is economically rational and what the chooser decides to do can be different. In our football example, if the modeler thought that all football coaches maximized the chances simply of winning -- a "rational" decision – they would make bad predictions of what the coach would do because they didn't recognize the coach's rationality gave some weight to embarrassment too!

1.011 Project Evaluation
Spring 2011