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Wald's Series

This story belongs not to baseball or world history, but to the development of quantitative financial trading strategies.

Anachronistic pitching revealed instance limitations, finally occluding operational loss situations

All baseball fans know the story of Miriam Wald's dramatic presentation at the January 1905 baseball owner's meeting at Holes Golf Resort in Black, South Carolina. The beautiful Hungarian-born financial innovator successfully pitched a financial proposal that created the modern business of professional baseball. But baseball has always downplayed the story due to its suggestion that gamblers were an important early influence on the professional game. This attitude caused the neglect of the papers that became available upon the bankruptcy of Wald & Berg (W&B) in 1989, just as the Pete Rose gambling scandal was surfacing. Actually, at that time, association with gamblers would have been less scandalous than association with Wall Street.

Wald's series had some important and unexpected effects on world events, but political historians treat it as an amusing fad. They use it to give color to their accounts, but it is not considered worthy of serious scholarly attention.

There is yet another reason the Wald series story has not been told earlier. Recent advances in volatility structure modeling are required to understand its true nature.

Disorganized baseball

From the founding of the first professional baseball team, the Cincinnati Red Stockings, in 1867 to 1904, professional baseball was chaotic. League organization was weak because there was no staff or funding above the team level. Leagues came and went, and often failed to enforce their rules on teams or players. The National League of Professional Base Ball Clubs managed to survive from 1876, but could not maintain a stable set of franchises, nor establish itself as the only major league. Perhaps most important, it could not organize an annual championship that fans would recognize. Baseball was also deeply enmeshed with gamblers, game throwing was common.

By 1900, 14 leagues had signed a "triparte agreement," which brought some structure into baseball. In 1903 complete reconciliation seemed to be near. The best National League team played the best American Association team to crown a consensus national champion in an exciting, well-played and popular contest. But the peace collapsed in 1904, agreement cheating soared and there was no championship game. The chaos drove fans away.

The Wald's series story is familiar. At a crisis summit that winter, plan after plan was proposed and rejected until an uninvited guest strode confidently into the room. She set up an easel, made her proposal in two minutes before stunned club owners could object to a woman in the room; and had a signed deal five minutes later. W&B records tell a less dramatic story. Wald had written all the team owners almost a year earlier, had extensive correspondences with several, and was invited to the January meeting. Granted the owners were shocked to discover she was a woman, but prejudice melted away when it became obvious she had the only plan. Then it took four days of arguing to finalize the terms.

Wald's idea was that there be two major

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leagues, the National League and the American League. The pennant winners of each league would meet for seven championship games at the end of the season. The players would be paid from the receipts of the first four games only, to remove the incentive to throw games to lengthen the series. The receipts of any additional games would be paid to a newly-created National Commission.

The key to Wald's proposal is what we now call a "swap," but was called a "series" at the time. She would pay the National Commission $10,000 every year in January in return for $6,000 for every game played beyond the first four in the championship, paid at the time of the games in October. Wald's Series would run for ninety-nine years. This gave the National Commission the stable budget it needed to become effective, and paid for itself with the championship games it made possible. It increased public trust in the games because everyone involved with baseball had an incentive to maximize attendance per game, not number of games.

Pricing Wald's series

To analyze this contract today, with 99 years of data, we would look at the distribution of number of games played in the annual baseball championships. But in 1905, there were no directly comparable data. There had been 14 generally recognized annual championships, but there were wide variations in how the teams were selected and how many games were played. Even the rules of the game were not completely standard. The table below gives the game record from the standpoint of the winning team.

This problem is tricky even today, even viewed as a pure statistics problem to compute the expected value of number of games in a best-of-seven-games championship. Assume (as Wald did) that each game is independent, with constant probability p of team A winning. There are reasons to doubt those assumptions, but it's the most natural one-parameter model, and two parameters are too many to fit with these data.

Suppose two teams play (without ties) until one team wins n games. For the contest to end after the kth game, the winning team must have won $n-1$ games out of the first $k-1$. This can happen $n-1$ choose $k-1$ ways. Under the assumptions above, the probability of each of those ways is $p^n(1-p)^{n-k}$. This is simple. But how do you use the data to estimate p?

Year	Wins	Losses	Ties
1884	3	0	
1885	3	0	1
1886	4	2	
1887	10	5	
1888	6	4	
1889	6	3	
1890	3	3	1
1892	5	0	1
1894	4	0	
1895	4	1	
1896	4	0	
1897	4	1	
1900	3	1	
1903	5	3	

One popular technique is maximum likelihood, select the p that gives the maximum probability of observing the data. In the 1903 series, Boston won five games and Pittsburgh won three. That is most likely to happen if Boston had a five-eighths chance of winning each game. This is a well-known result.

But Wald realized the problem with that. We don't care about the probability that Boston will beat Pittsburgh, we care about the probability that the better team will win. That means maximizing not $p^n(1-p)^{n-k}$ but $p^n(1-p)^{n-k} + p^{n-k}(1-p)^n$. It's easy to show that the maximum likelihood p is 0.5, and that holds true as long as the total number of games played is greater than or equal to the square of the difference in wins (in this case, 8 is greater than 2 squared).

For a seven game contest, it's unsatisfying that 5-2 and 4-3 results both argue for the same maximum likelihood p, 0.5. A better-known problem is that a 4-0 series yields a maximum likelihood p of 1. It doesn't make sense that seeing team A win four games would lead you to be absolutely certain it will win all future games. Only a 4-1 result gives a reasonable value for p, one-half of one plus one divided by the square root of three (0.7887).

The golden path to $10,000

Wald's published pricing formula will strike modern readers as bizarre. She considered maximum likelihood and other techniques, rejecting each on theoretical grounds. She also criticized the quality and applicability of the data. She then argued from frankly mystical principles that the correct price was obtained by assuming p equals the inverse golden ratio (the golden ratio is one-half of one plus the square root of five, strikingly similar to the maximum likelihood p for a 4-1 result). For that p the probabilities are 17 per cent of a 4-0 result, 28 per cent of 4-1, 29 per cent of 4-2 and 26 per cent of 4-3. The expected value of the contract is $6,000 times (1*28 per cent + 2*29 per cent + 3*26 per cent) or $9,919. She ignored risk premium (indeed, any discounting at all) and rounded up to $10,000.

The computation makes more sense by the standards of the time. Few people were comfort-

able with empirical parameters. They sought explanations based on deep principles expressed in simple equations. Everyone accepted that measurements were inexact, but not that underlying phenomena were driven by parameters with no natural meaning. Statistics was supposed to strip the noise away from messy data to reveal the simple truth, not just give a number. Although many people disagreed with Wald's numbers, all used a mathematical constant for p and came up with a philosophic justification for it. If you do the complete maximum likelihood estimate on the sample of games above, you get something very close to the square root of one half, which implies Wald's series value of $8,095. Other people objected to considering the data year by year, that was conditioning the results on games that might have been played if the results were different. Instead they threw all the data together in one big maximum likelihood estimate. They decided the true p was $(e+\pi)/8$, and the contract was worth $7,449.

Most people at the time, and every writer since, concluded that Wald overpaid. She paid $120,000 to the National Commission from 1905 to 1916 and received only $96,000 back. The W&B records show Wald had no interest in making money from the series. She set the money terms based on what it would take to close the deal, long before coming up with the golden ratio price.

The plan behind the plan

Wald's plan was far bolder than making a few thousand dollars on the trade. She had set up a world-wide network of correspondent banks to take orders in a secondary Wald series market. From 1905 to 1914, a staggering two billion sterling of notional transactions were executed, every one cleared through Wald & Co. in New York. This was a money laundering operation, pure and simple. In any large city in the world you could buy either side of Wald's series from a local correspondent, then transfer it instantly and secretly to anyone else, anywhere else in the world. The recipient could borrow money against the position to buy the offsetting position (simply closing out the position for cash would have looked suspicious). A "loan" could be arranged against the now riskless position, which would be automatically repaid at the conclusion of the baseball championship, regardless of outcome. The genius of the scheme was that Wald's series could be represented as a financial investment, a sports bet, a mathematical gambling game of skill or a pure lottery game of luck; and each could be tailored for laws in various places that forbade, regulated or taxed some but not all of these things.

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Money laundering, then and now, is a delicate matter because the same financial services are needed by tax evaders and people protecting their property rights from illegitimate governments; by crooks and oppressed minorities; by terrorists and freedom fighters; in fact there's no consensus on these distinctions. However, financial institutions that tolerate money laundering deserve censure, even if half their clients have arguable defenses for their actions. If you sell illegal services to anyone, it's a poor defense that not all your customers are doing wrong.

The next phase of Wald's series was triggered by the world's first rogue trader, Jack Keefe. He was an untrained mathematical genius, who delighted in acting like a slow-witted bumpkin. Wald hired him to manage the trading flows. The money transfer basis of the business meant contracts were net bought in places with poor investment opportunities, such as Central Europe and the Ottoman Empire, and net sold in places with much higher returns on capital, such as South Africa and Latin America. Within Asia, the money moved from rural India and China to Southeast Asia. Wald did not want price volatility or systematic pricing differences in different places as it made her series less attractive for transferring funds. Keefe's job was to dampen price movements by absorbing temporary imbalances in either supply/demand or geographic flows.

Apparently, from the day he was hired, Keefe did exactly the opposite. He tried to exploit all these differences for profit. Investor-nations had a strong cultural bias to price with high implied p's, and therefore low contract prices, while in the developing countries a less stable outlook encouraged investors toward a p of 0.5 and high contract prices. World average implied p always rose from near 0.5 in late October, when next year's teams were not known, to as high as 0.75 just before the games were played. Wald forbade any trading during the actual play of the games.

Keefe took huge risks and made huge profits. While he didn't blow up, the world did. He was siphoning hundreds of millions of pounds sterling out of rigid, old-fashioned economies. And the amount understates the effect. Keefe took the most aggressive, innovative, modern money in these countries. Losing it shut down an opportunity for reform from within. On top of that was the scandal with the Archduke Franz Ferdinand in June 1914. The usual story is he had welshed on a Wald's series investment with the Black Hand hedge fund, and their enforcers rubbed him out. In fact, Black Hand was a quasi-government Serbian revolutionary group that received funds from Serbs in the United States via Wald's series. Ferdinand wanted to set up an independent clearing entity in Austro-Hungary, ostensibly to keep trading profits within the empire, but also to shut down funding for dissi-

dent and terrorist groups. His assassination was engineered to stop this plan, and it turned into the spark that started World War I.

Wald after Keefe

The war destroyed the money laundering business overnight and brought disrepute on Wald's series in general. Wald fired Keefe, who decided playing baseball would be more fun than betting on it, he became a pitcher for the Chicago White Sox.

Now Wald decided to pursue a stable and risk-controlled version of Keefe's strategy. Here is where she made her seminal contribution to quant finance. In order to increase trading volume, she had to offer more products and be a market maker in all of them. That was only practical with cross-product hedging. She couldn't be matched long and short on each type of contract. If she tried, she wouldn't be able to quote prices fast enough and on narrow enough spreads. But she also had to limit her portfolio risk.

She chose to run a p- neutral portfolio. That is she evaluated the entire portfolio at every p from 0.5 to 1 to ensure the minimum value was an affordable loss. For example, the most popular contracts were always the sweep (paid $10,000 if the result was 4-0, these sold for around $3,000 at the time) and seven-game (paid $10,000 if the result was 4-3, these sold for about $2,500). If you sell the sweep and $p = 1$, you have an expected loss of $7,000. If you sell the seven game and $p = 0.5$, you have an expected loss of $1,125. But if you sell 2.8 seven-games and 1 sweep, you take in $10,000 and at the worst case p (either 0.5 or 1) your expected payout is $10,000. At intermediate values of p, your expected payout can be as low as $6,327.

That means you can go ahead and sell both popular products, without being forced to raise either price to attract sellers, or even to curtail dealing. With a wider variety of products (and every imaginable combination was traded) you get even more benefit. Whenever an exposure builds up to some value of p, your traders can look for the most efficient way to offset.

For the next four years, from 1915 to 1918, the idea worked beautifully. The championship results were all 4-1 or 4-2 during the period, so Wald didn't have to pay out on either of the popular contracts. By 1919, profits were so good, Wald persuaded the National Commission to increase the length of the championship to nine games from seven. The Wald Series payment went up to $13,700 (using the same golden ratio p, the odds are 5-0, 10 per cent, 5-1, 20 per cent, 5-2, 24 per cent, 5-3, 24 per cent and 5-4, 22 per cent).

Keefe's revenge

Unfortunately, Jack Keefe realized the flaw in Wald's p-neutral strategy. It guaranteed and expected profit for every p, but it did not control for event risk. Using the numbers above, if Wald sold 1 sweep contract for $3,000 and 2.8 seven-game contracts for $7,000, she had an expected profit for every p. But that expectation was made up of zero profit if the result were a sweep, $10,000 profit if the result were 4-1 or 4-2 and an $18,000 loss if the result were 4-3.

Keefe figured this out at least by 1916, but needed to find a favorable opportunity for revenge and profit. By 1919, Wald's increasing faith in p neutrality, combined with increasing interest in baseball and the new nine-game format led Keefe to calculate he could bankrupt Wald if the championship went to nine games. As luck would have it, Keefe's Chicago White Sox were not only in the championship, but heavily favored to win.

The 1919 "Black Sox" scandal is one of the most confused chapters in the history of baseball. Although there was clearly a fix, no one could figure out the motive, or get clear stories from either the players or gamblers. Almost no bribe money was paid out. Professional sports bookies lost quite a bit of money on the games, because the White Sox won games. No one looked to a Wald's series fix as an explanation, because the series payoffs didn't depend on which team won.

Keefe persuaded eight of his teammates they could get rich and still win the series, by making sure it lasted nine games. He bought all the nine-game Wald contracts he could afford and distributed some among his fellow-conspirators. However, none of them seem to have understood the nature of the scam, they just did what Keefe told them.

In his autobiography *The Blackest Sock* (ghost-written without attribution by Ring Lardner) Keefe explained "it was simple mathematics." He figured the White Sox had two chances in three to win each game. That made the chance of a nine-game series 17 per cent if played honestly. He resolved to make each game result the one that improved these odds the most (this is called a "myopic" or "greedy" strategy). A more certain approach would be to play hard until Chicago won four games, then throw all the rest. But Keefe was a trader, he knew he would have to sell his contracts after the seventh game, because Wald would be bankrupt and unable to pay off after the eighth. Although Wald refused to trade after the start of the championship games, an there was an active secondary market for the contracts.

Losing game one boosted Keefe's chances from 17 per cent to 26 per cent, losing game two got him up to 33 per cent. Game 3 made no difference, the odds stayed at 33 per cent whoever won so Keefe just let the teams play and Chicago won. A loss in the fourth game brought the odds up to 40 per cent. Chicago should have won the fifth game, bringing the odds up to 44 per cent, but they lost, bringing them down to 30 per cent. Keefe claimed his experience in the first four games convinced him that Chicago's actual chances of winning were better than 75 per cent, so the loss made statistical sense. In any event, Chicago then won the sixth game. Using the original p of two-thirds, this brought the chance of a nine-game series up to 44 per cent, wiping out the effect of the game five error (if that's what it was).

Chicago won game seven handily improving Keefe's chances to 67 per cent, four times the level at the start of the championship. A Chicago win in game eight would force a nine game series, so Keefe cashed in his contracts huge profits. Now the trader struggled with the avenger. He realized he could double his profits by going short the nine-game contract and throwing game eight. But that would save Wald, in fact it would make this her most profitable year ever. Greed won out over vengeance, Keefe went short and directed Chicago to lose game eight.

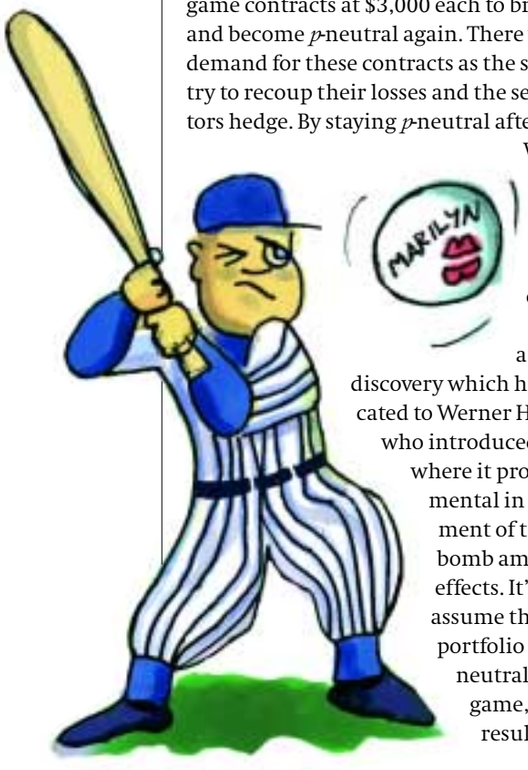
Enough confused pieces of the story leaked out that Keefe's eight teammates were banned from baseball for life. What of the ninth player

on the field? Keefe was expunged from the game, all record of his name destroyed. You can still find his name in old newspaper accounts of White Sox games from 1914 to 1919, but you won't find it in the record book.

Berg steps up to the plate

Wald learned from her near-miss that being p-neutral was not enough. She hired a 17 year old polymath named Morris Berg to be the first financial risk manager. Berg's first innovation was to persuade Wald to allow trading between games. That meant he could rebalance the contracts so that no result could mean a crippling loss.

Consider the example above where Wald sells one sweep contract for $3,000 and 2.8 seven-game contracts for $7,000. Suppose the first two games are split, so the sweep contract is now worthless, but the 2.8 seven-game contracts have appreciated from $7,000 to $10,000. Buying them back will use up the $10,000 revenue from the initial sale. A better solution is to sell 1.4 five-game contracts at $3,000 each to bring in $4,200 and become p-neutral again. There will be demand for these contracts as the sweep bettors try to recoup their losses and the seven-game bettors hedge. By staying p-neutral after each game, Wald could not lose money regardless of the outcome of the games.



Berg made a surprising discovery which he communicated to Werner Heisenberg, who introduced it to physics where it proved instrumental in the development of the atomic bomb among other effects. It's natural to assume that a p-neutral portfolio remains p-neutral after the first game, whatever the result. If you don't know anything about the probabilities of either team winning, it shouldn't matter to you that one or the other team won. After all, someone has to win the first game.

However, the first game causes a symmetry breaking. Before it is played the expected value of a seven-game contract is $20\,[p^4(1-p)^3 + p^3(1-p)^4]$. This is maximized at $p = 0.5$, when it equals 0.3125. After the first game is played the probability is $10\,p^2(1-p)^3$, where p is now the probability of winning of the team that won the first game. This is maximized at $p = 0.4$, when it equals 0.3456. The original p-neutral portfolio, one sweep contract and 2.8 seven-game contracts has a maximum expected payout of $10,000 for any p before the first game is played, and a maximum expected payout of $10,372 after the first game; regardless of which team wins.

Implied p

The next advance was Berg's invention of implied p in 1922. Just as from p you can compute the expected value of a contract, from the value of a contract you can compute p. Berg computed the historical average p. He instructed the traders to buy any contract trading less than its value under the average historical p, and sell any contract trading at more than its value. This innovation changed Wald's business again, she started making more money trading contracts back and forth than holding p-neutral positions. Wald & Co. transformed from a dealer to a the first true broker-dealer.

When Berg turned 21, Wald gave him twin birthday presents: a partnership in Wald & Berg and contract as a major-league baseball player. Remembering her experience with Keefe she wanted to keep an insider's eye on the game. "Moe" Berg's 17 year baseball career is so remarkably bad, people have trouble figuring out how he kept playing. Wald's influence was such that Berg not only played steadily, he was selected to the first All-Star team (along with greats such as Babe Ruth and Joe Dimaggio) despite being famously known by the quip "he could speak seven languages, but couldn't hit in any of them."

The same year, the seeds were sown for the next leap forward. The championships of 1924, 1925 and 1926 all went to seven games. The next two years were sweeps. The implied p strategy made W&B short both seven-game and sweep contract, as these looked the richest under historical p. While Berg's techniques prevented large losses, Wald was not satisfied breaking even. Berg insisted it was a random run of luck, but Wald thought the discrepancy was not an investor error, it was real and persistent.

Thinking about this led Wald to invent the concept of risk-neutral p. As long as she could buy and sell at market implied p, she didn't have to worry about what actual p was. "Suppose," she wrote Berg in a 1929 letter, "that I can bet on any game at even odds. I sell a $10,000 seven-game contract. After the first game, I bet $625 on the loser for the second game. I then bet $1,250 on whichever team is behind for the third game and fourth game (if it's tied, I don't bet). If one team wins the first four games, I lose $3,125. If the tally stands at 3-1, I've lost $625. If it's 2-2, I've won $1,875. Now I bet $2,500 on the team that's behind (again, nothing if it is 2-2). If the championship ends at 4-1, I've lost $3,125. If it goes to 3-2, I'm ahead by $1,875. Now I bet $5,000 on the team with two wins. If that team loses, the championship is over and I've lost $3,125. If that team wins, I'm ahead by $6,875; but I have to pay off $10,000 on the seven-game contract I wrote. So whatever happens, I've lost $3,125. That makes $3,125 the price of this contract, by arbitrage. I don't care what the real probabilities are, just the betting odds. And the calculations are easy, I just pretend I'm risk neutral and every contract's price is its expected value. Even if the contracts are mispriced, I still have a perfect hedge."

Berg was forced to agree, but the idea proved difficult to implement directly. The individual game gambling markets were neither liquid nor efficient. The firm began to use the market prices of contracts to estimate implied p, then use the average implied p to price all contracts. Instead of selling contracts that were rich according to historical p, W&B starting selling contracts that were rich according to risk-neutral p estimated from all contracts.

Although this worked well enough to make a profit, with much less risk than before, statistical

evidence was mounting that there was a problem. Over a 31 year stretch there were 18 seven-game series, something that should happen only once in 17,000 years, regardless of the value of p. Investors were also consistently pushing the price of the seven-game contract above its theoretical limit of $3,125. There was no implied p that could justify those prices.

Post war advances

It was not until Berg returned from his career as a spy in World War II that he could turn serious attention to the subject. It was clear that there were far too many seven-game series and sweeps for the constant-p model to hold, moreover, it was clear that investors knew this. If W&B did not adapt its models to the new market data, it could not survive.

Berg's first attempt was a local p model. The idea is similar to forward interest rates. He kept the assumption that games were independent and p was known in advance, but he allowed p to vary from game to game. His initial idea was to use different p for home and away games, but this would not fit the data. It could increase the value of the seven-game contract, but only by reducing the value of the sweep contract. Berg needed a model that increased both.

Rather than reconstructing Berg's analysis, let's look at the data from the last 83 baseball championship series. Fifteen of them have been sweeps, a frequency of 0.1807 (15/83) which is the expected frequency if $p = 0.6355$. That value is unrealistically high compared to individual game betting odds and regular season won/loss per centage. However the implied ps for 4-1 and 4-2 results are even higher. For 4-3, no value of p gives a probability of more than 0.3125 so the observed 0.4096 is inconsistent with the idea that p is constant and independent.

Result	Count	Frequency	Implied p
4-0	15	0.1807	0.6355
4-1	16	0.1928	0.9377
4-2	18	0.2169	0.7535
4-3	34	0.4096	None

We'll follow Berg's reasoning and get the same result, although of course he was looking at different numbers. The 0.1807 frequency of sweeps implies a p of 0.6355. So assume this is the p for the first four games. If that's true, there is a 0.3742 chance the better team will be ahead 3-1 at the end of four games, and a 0.1231 chance it will be behind by 3-1. So solve for p such that $0.3742\ p + 0.1231\ (1 - p) = 0.1928$. That gives a p for the fifth game of 0.2774 (of course the symmetry is broken, so this p must be assigned to the team with the 0.6355 chance of winning the first four games, which we will call Team A). That's already unrealistic, but it gets worse. Under these assumptions, the probability of a 3-2 result 0.3597 with Team A ahead and 0.2668 for a 3-2 result with Team B ahead. Whatever p we use for game 6, there must be at least a 0.2668 probability of the series ending 4-2. Since the actual frequency is 0.2169, we can't do it. Berg played with the numbers for months before concluding there was no reasonable local p model.

It was Wald who told Berg to go to stochastic p. She was aware that it meant the final crumbling of the world she had known of mathematical constants, philosophic principles and riskless hedging. Local p can be hedged perfectly. If you know what p is at every state in the future, you can convert any Wald's series contract to another by buying and selling the right quantities. If p is random, no hedge is riskless. The risk-neutral argument still works in principle, but since you don't know the odds you will get in future games, you cannot compute the price of a contract today.

Looking at today's data, a pretty good model is that the team that's ahead has a 57 per cent chance of winning, except at 3-1 or 3-2 in which case it has a 35 per cent chance. If it's tied, you don't care what the odds are because we haven't broken symmetry. That makes some sense, you would expect the team that's ahead to be the better team, but a team facing elimination that has already won at least one game may be tougher to beat than average. Sensible or not, it fits the data. Of course, a good stochastic volatility model has to look at the game-by-game results.

The end of an era

Wald and Berg died in the same year, 1972, just before the Black-Scholes paper was published. I like to think that if either had lived long enough to read it, we could have saved ourselves 30 years of reinventing the wheel in finance. It is an irony of history that the W&B research only became public after we had been through exactly the same experience trading derivatives. It's still worthwhile for students to work through the W&B math, which is much less intimidating that stochastic partial differential equations and ten-dimensional parameter spaces.

Mysteries remain. Who was Miriam Wald? We have no record before 1904. You sometimes read that she was related to the great statistician Abraham Wald, but I know of no evidence for this. Does the name "World's Series" come from confusion with or homage to "Wald's series?" There is no good account of the name that explains the possessive and the word "series," which only came to mean a slate or stand of games as a back formation from World's Series. What happened to the vast fortune accumulated by W&B? When the partners' estates were probated, W&B was solvent, but not fantastically rich.

The document actually specified 99 annual championships. Since the 1994 championship was cancelled due to a player's strike, the contract should have lasted until 2004. However with no netting terms (1904 was pre-ISDA) the W&B estate did not make the $10,000 payment. Since the Red Sox won in four games, no payment was due the estate. So a glorious financial innovation expired with a whimper.

Bayesians get around these problems in theory by using a prior distribution. That's little practical help in this situation since there are several natural uninformative priors which give substantially different answers.

It would go back to seven games in 1922, where it remains today.

Berg was later recruited by United States intelligence to assassinate Heisenberg. Berg traveled to Switzerland, collected a gun, and met Heisenberg at a scientific conference. Afterwards, the two old friends went for a late night walk to discuss Wald's series. When Heisenberg returned alive, Berg told his superiors that his misunderstanding of bomb physics was so profound, he would slow any Nazi effort down. Heisenberg later claimed that he played dumb on purpose, to prevent anyone from getting an atomic bomb.