The Crash of '87: Was It Expected? The Evidence from Options Markets

David S. Bates

Summary by Dan Wouden

Big Picture:

Bates examines S&P 500 futures options transactions prices from 1985-1987, before the 1987 crash to see if the market knew, or had inclinations towards the crash of 1987. The first part of the paper talks about, how deep out of the money put options became very expensive one year prior to the crash. The second part of the paper or main finding of the paper is where I start to get confused. Bates derives a "model for pricing American options on jump diffusions with systematic jump risk ". This jump diffusion in the model suggests that the crash was anticipated. The implicit distributions were negatively skewed during October 1986 to August 1987, backing Bates theory. The reasons aforementioned indicated that the market had no strong crash fears two months prior to the actual crash but did expect it much earlier.

What Bates is really researching here is the hypothesis that the U.S. stock market crashed since it was an expected crash. Which is very interesting!

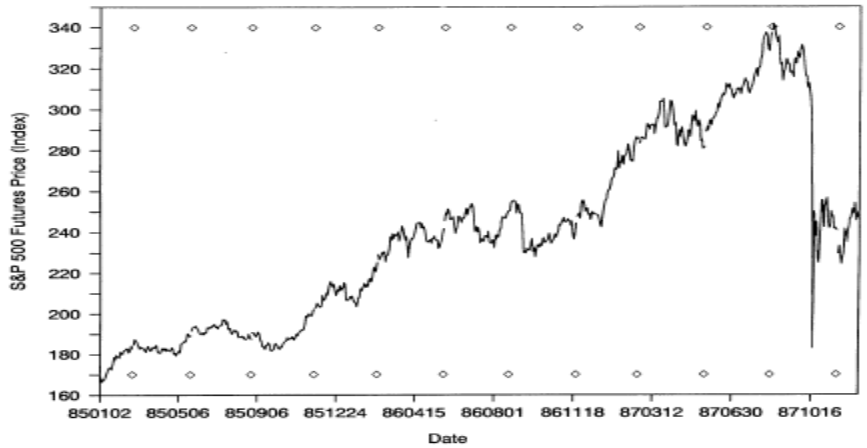

Figure 1. S&P 500 futures prices, 1985–1987. Futures contracts with 1 to 4 months maturity, noon quotes. Diamonds (◇) indicate maturity shifts.

By simply looking at the above graph, many thought the crash could be accredited to a self-fulfilling prophesy, a rational bubble. From the looks of it, I can see why many people thought it was a bubble. Others have thought this and even done research on it. One in particular was Shiller. He sent out surveys right after the crash, most investors and individuals said that they thought the market was overpriced before the actual crash.

Bates looks at options prices to determine whether the crash was expected. Option prices take into account what actually happened. They don't suffer from hindsight bias like Shiller's survey since people put money where their mouths were at the time. Call options pay off when the underlying price is in excess of the exercise price and put options payoff when the underlying price is below the exercise price. If the market thinks that there will be market crash, this leads to put options with exercise prices well below the current futures being priced higher than calls with exercise prices well above the futures price. Puts have a higher probability than calls of ending up in the money if a large downward movement in the market occurs. Bates finds that out of the money put options on the S&P 500 futures were more expensive relative to out of the money calls, one year prior to the crash. He finds this phenomenon was especially true from October 1986-February and June-August 1987. The market peaked in August 1987 and incidentally, out of the money put prices subsided and normalized two months before the crash.

Data

Bates uses transactions prices of call and put options on the S&P 500 futures for his analysis. The data they sampled had some very explicit restrictions on it. Only contracts of single maturity, with relatively short maturities between 1 and 4 months. Bates avoided "thin trading" days. He also only used days in which at least 20 calls and 20 puts were traded. Last of all, transactions in at least 4 strike classes for calls and 4 for puts.

Section 1

In Section 1, Bates discusses the theoretical foundations and empirical evidence that led him to find that out of the money put options were "unusually" expensive relative to call options. He relies on prior research that implies out of the money puts should trade at a discount relative to out of the money calls. Bates states that the transactions prices of American options of S&P 500 futures show us that either markets participants expected impactful negative jumps(i.e., crash) in the market during the year preceding the crash or that they thought market volatility would sky rocket if the market did crash.

If the cost of carry is significantly positive, American puts have a greater probability of being exercised early compared to American calls. Thus American puts will require a greater price relative to European prices. We know that the distribution will be skewed since OTM call and put prices will be significantly different like previously stated. The image below shows a symmetric distribution, and that put and call prices would be the same if this was the case.

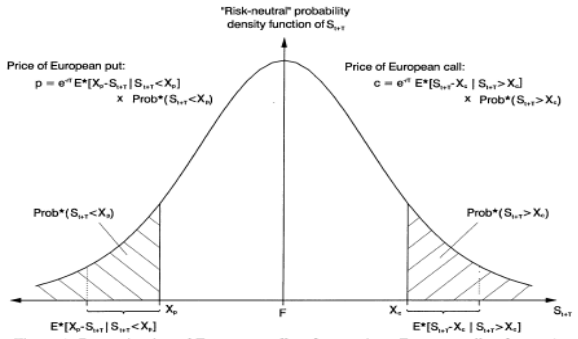

Figure 2. Determination of European call and put prices. European call and put prices are determined by the relevant discounted conditional expectation times the tail probability, using the "risk-neutral" probability measure. A symmetric distribution implies call and put options symmetrically out-of-the-money (OTM) will be priced identically. Skewed distributions induce systematic divergences between OTM call and put prices.

The cost of carry for American options on futures contracts, is zero. This allows us to determine the symmetry or asymmetry of the distribution easily. Therefore, we can use the prices of out of the money calls and puts as a quick reference of the symmetry or skewness of the risk-neutral distribution. Bates call this the "skewness premium". Which is defined below

$$SK(x) \equiv c(S,T;X_c)/p(S,T;X_p) - 1 \text{ for European options in general,} \quad (3a)$$

$$SK(x) \equiv C(F,T;X_c)/P(F,T;X_p) - 1 \text{ for American futures options,} \quad (3b)$$

where

$$X_p = F/(1+x) < F < X_c = F(1+x),\ x > 0,$$

Where F is the forward price of the underlying asset. The skewness premium is directly related to the skewness of the risk-neutral distribution.

Previous research has been done on the deviation between out of the money call and put prices, measured by the skewness premium. The three major classes of stochastic processes were used to analyze the above mentioned deviation. 1) CEV 2) Stochastic Volatility 3) Jump-Diffusion. This previous research found that x% out of the money calls should only trade at 0% to x% premium over relative out of the money put options. Bates needed to have a wider range of prices for out of the money call and put options so he used nonstandard parameter values. This is what he came up with:

1) $0\% \le SK(x) \le x\%$ *for* i) *arithmetic and geometric Brownian motion*
   ii) *"standard" CEV processes*
   iii) *benchmark stochastic volatility and jump-diffusion processes*
2) $SK(x) < 0\%$ *only if* i) *volatility of returns increases as the market falls,*[13] *or*
   ii) *negative jumps are expected under the risk-neutral distribution*
3) $jSK(x) > x\%$ *if and only if* i) *volatility of returns increases as the market rises, or*
   ii) *positive jumps are expected under the risk-neutral distribution.*

By taking this approach, prices of American options on S&P 500 futures can be used to determine the skewness of the distribution.

In late 1986, strong negative skewness premia became apparent, and were most pronounced during October1989-February 1987 and June-August 1987. In August 1987, 4% out of the money puts were 25% more expensive than relative out of the money calls. Standard distributional hypotheses state that the puts should have been 0-4% cheaper! Bates states that there may have been fears of a crash in the market one year prior to the actual crash.

Section 2

In Section 2, Bates looks at the previously accepted hypothesis. The previous research used an option pricing model for American options on jump-diffusion when jump risk is systematic and non-diversifiable. They also used parameters of "risk-neutral" process implicit in transactions prices of calls

and puts for a given day are estimated via nonlinear least squares: 1) Volatility condition on no jumps, 2) probability of a jump, 3) the mean jump size conditional on a jump occurring, and 4)the standard deviation of jump sizes conditional on a jump occurring. According to the market, negative jumps were being expected starting in October 1986, with the distributions implicit in options prices were in particularly negatively skewed during October 1986-February 1987 and June-August 1987.

Bates decided to re-estimate the parameters daily for two reasons: 1) Chronology of parameter estimates and of implicit moments over time, skewness and kurtosis as well as volatility could thereby be generated, which allowed him to view market sentiment on a daily basis. 2) Stylized facts for the future specification of more complicated dynamic models could thereby be generated. Bates concludes that after October 1986, expectations of negative jumps were evident in option prices especially during the time periods already discussed. He also shows that expected jumps per year were high during the aforementioned time periods, which highlights the strong crash fears that accompanied the stock markets peak in August 1987. The fear of a crash subsided when the stock market peaked, even though expectations of negative jumps remained strong until right before the stock market crash. Obviously, stock market crash fears returned and remained strong one the stock market actually crashed. The graphs presented in the paper show that the implicit distributions became negatively skewed starting in the aforementioned dates and after the crash. Two months before the crash, the negative jumps were not enough to skew the distribution. Bates shows that the phenomenon of high prices for out of the money put options cannot be explained by the previous research.

Bates provides many graphs to back up his research. I feel that the graphs and tables Bates used are able to paint a better picture than words.

Conclusion

Bates concludes that there indeed was a strong perception of downside risk on the market one year prior to the actual crash. Fear of the crash first started out when the stock market decreased by 6% in September 1986 and were most significant during October 1986-February 1987, June-August 1987 and after the crash. Out of the money puts provide insurance in case of a crash. These options were expensive relative to out of the money calls. Bates found that expected negative jumps started one year prior to the stock market crash of 1987. Negative implicit coefficients of skewness, was most noticeable in October 1986-February 1987, June-August 1987, and after the crash. 2 months before, even the Friday before the crash the market was relatively calm, it wasn't fearful or boastful. Bates proves that if the crash was due to a bubble in the stock market it would have burst in August not in October.

Questions:

Would you discuss how this wasn't a bubble? The market had a bubble like experience, leveled off for a short period of time and popped. Isn't the market "fixing" the bubble that was there? Isn't the best way to define a bubble is a market being over inflated and pop, there is a market crash. I feel like the time of the pop is not that relevant.

I would really like to talk about Jump Diffusion models in class. We could even try to program one in computational methods.