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Options and the Future: What Do Markets Think?

by Ben Craig

Each business day, and particularly after major events, millions of people closely read reports of the Dow Jones Industrial Average, the S&P 500, long-term interest rates, and the value of the dollar. These people are not just checking the value of their portfolio or scanning interest rates before buying a house. Rather, they know these prices contain valuable information that can help them gauge the impact of current events or monetary policy on the economy as a whole. And the prices of stocks and bonds have a fair claim to provide this information—they are the amalgamation of buy and sell decisions of many investors, each putting their money on the line. The information in asset prices is often surprisingly correct: using information in frozen orange juice futures prices, Richard Roll predicted central Florida weather better than published meteorological forecasts.

What people may not realize, however, is that market prices can yield predictions not only about the timing or direction of future events, but also about the markets' degree of *certainty* about events transpiring as predicted. Is the market offering equal chances of good or bad times, or is it clearly predicting an anemic recovery? While the picture of two old stockjobbers standing around lamenting that the "markets are nervous" is a cliché, the increasing depth and sophistication of financial markets over the past 25 years allow economists to make this notion of market certainty—or as economists refer to it, *un*certainty—more precise. More specifically, the tremendous growth in options—contracts that give a party the right but not the obligation to buy (or sell) at a given price—make it possible to extract more detailed information from market prices. This *Commentary* explores the information extractable from option prices and considers how policymakers might use this information.

Options Markets

A typical options contract offers a person a payment based on the value of an underlying good, security, or index (called the underlying) at a future date (the expiration date). A *call* option is an option to buy the underlying at the expiration date for a certain price, called the strike price. A *put* option is an option to sell the underlying at the expiration date at the strike price. Table 1 illustrates the payoffs to the holder of a call or put option on a stock with the strike price of $55.[1] Unlike holders of the underlying stock, option holders exercise their option only when it is in their interest, so their loss is limited to the price paid for the option. The call option lets you gain from stock appreciation without losing if stocks fall. The put lets you gain from falling stock prices without losing if stocks rise.

Uncovering Uncertainty

How can options tell us about the markets' view of uncertainty? To see how, we need to be more precise about what we mean by uncertainty. For this, it pays to draw an analogy to gambling. Consider a simple dice game where you pay some price to play and get $1 if a six turns up. The price of playing the game is determined by a group of "investors." To make things interesting, the die may

We're used to hearing analysts make predictions about where the economy is headed based on changes in the prices people are paying for stocks, futures, or other assets. Now, recent research is showing how we can analyze the prices of sophisticated new investment products, like options, to also gauge the probability assigned by the markets to possible future events. In short, we can calculate how likely market participants feel it is that an event will take place in the future.

be crooked, so you don't know the odds. The investors don't know whether the die is crooked either, but they have spent a long time thinking about this particular game with this particular die.

In this hypothetical game, one can tell much about the probabilities of the die's crookedness from the price the investors set for playing the game. If the price is 17 cents (or about $1 divided by six), you might conclude that the die is probably fair. If, on the other hand, the price is 60 cents, you might conclude that the probability a six will turn up is much higher, probably greater than half.

The price of playing will equal the chance that a six will turn up (on average, of course). However, if you had a lot of investors offering different prices for other numbers, you could also get the odds on any other number turning up, which in turn would provide you with a measure of the uncertainty in this

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"market." That is, you get what is called the *probability distribution* for the set of all numbers on the die. This is not just some summary of the odds—the mean or the variance or what have you—but rather the chances for each separate event (each number of the die turning up, in this case). This is important because most summary measures, such as means, leave important information out.

Can you do the same thing for the stock market, for example, find the odds that the Dow Jones Industrial Average will go up by 5, 10, or 13 points in one day? Using options, the answer is yes. The key in the dice example was having a simple contract that paid off only if a six came up. Options can be combined in ways that allow an investor to isolate risks associated with particular events in the same way. Next, I show how a combination of long and short positions in the options markets (that is, offers to buy or sell a contract) can extract information related to a single event in the future.

To isolate risks in the stock market, all that is needed is to construct a portfolio that has a payoff of $1 if the price of the underlying stock is a single arbitrary price (say $55) at the expiration date. This portfolio would hold two call options that the owner has purchased, one with a strike price of $54 and one with a strike price of $56, and two calls that the owner has sold (referred to as *write calls*), each with a strike price of $55. As shown in table 2, this portfolio pays $1 if the underlying price is $55 on the expiration date. Using options at different strike prices, you can construct a portfolio that incorporates the information about where the stock price is likely to be on the expiration date. (That is, you get the *probability distribution* of stock prices on a given day.) Incidentally, you can do the same thing with a comparable portfolio of put options.[2]

Indeed, this distribution contains far more information than just a single number that measures the degree of uncertainty, such as the variance from statistics theory. To continue our analogy with the crooked dice, suppose that two dice were thrown in a game of craps. Numbers such as those adding up to seven, eleven, or two are of special importance, so it could be helpful to know the probability associated with

TABLE 1: PAYOFF TO OPTIONS: STRIKE PRICE OF $55

Price at expiration	Futures contract (that costs $55)	Call option	Put option
50	–5	0	5
51	–4	0	4
52	–3	0	3
53	–2	0	2
54	–1	0	1
55	0	0	0
56	1	1	0
57	2	2	0
58	3	3	0
59	4	4	0
60	5	5	0

TABLE 2: A PORTFOLIO THAT PAYS $1 AT SELECTED EXPIRATION PRICE (HERE $55)

	Holdings			
	Buy 1	Write 2	Buy 1	
Strike price	$54	$55	$56	
Price at expiration	Payoff of each call			Total payoff of portfolio
50	0	0	0	0
51	0	0	0	0
52	0	0	0	0
53	0	0	0	0
54	0	0	0	0
55	1	0	0	1
56	2	–2	0	0
57	3	–4	1	0
58	4	–6	2	0

specific numbers. In the same way, there are times when investors or policymakers need to know the market assessment of the probability of specific events. For example, a construction firm whose break-even point is at a given interest rate may be interested in the probability that interest rates will be higher than this rate.

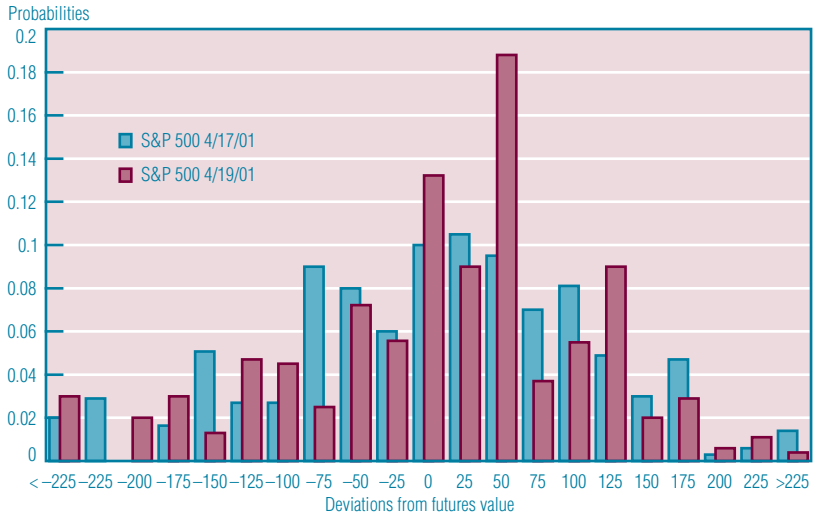
An Example

While financial engineers and corporate risk managers would obviously be interested in the distribution of prices, the distribution can also be of interest to others. For example, looking at how the distribution of stock prices changes after an action by the Federal Reserve's Federal Open Market Committee (FOMC) is much richer than statements such as "the markets fell as a result of the monetary policy announcement." Using options on the S&P 500, a policy announcement can be analyzed for its effect on the markets' assessment of future price changes. A priori, one could argue that an announcement causes more information to come to the market, so the FOMC announcement gives more certainty to investors. On the other hand, the FOMC announcement could indicate a change in policy, perhaps injecting more uncertainty into the market.

Note that there is always a problem with assuming that because an action occurred and market prices changed afterward, the markets must have reacted to that action. In other words, it may be difficult to sort out cause and effect. The most we can say with certainty is that the distribution of stock market outcomes changed shortly after a monetary announcement was made. However, the probability distribution will give an indication of how the markets forecast change following a policy announcement.

For example, on April 18, 2001, between regular meetings, the FOMC decided to

FIGURE 1: PROBABILITIES FOR CHANGES IN S&P 500



SOURCE: Author's calculations.

cut the overnight interest rate by 50 basis points. The statement issued with this action said: "The Committee continues to believe that against the background of its long-run goals of price stability and sustainable economic growth and of the information currently available, the risks are weighted mainly toward conditions that may generate economic weakness in the foreseeable future." Newspaper accounts the next day said the markets did not anticipate the amount of the cut and reacted strongly as a result. Equity markets gained in value: the Nasdaq the day after the cut was 9.8 percent above its price of the previous day, and the Dow Jones gained almost 5 percent. The general impression was that the equity markets responded to the announcement by increasing firms' expected earnings.

The FOMC's press release itself, however, hints that investors' reaction was in fact more complicated. The comment about the "rising uncertainty about the business outlook" suggests that the markets might have become less certain about future earnings. On the other hand, perhaps those earnings were uncertain because of uncertainty about FOMC actions. In light of the press release accompanying the action, it would be interesting to know whether equity-market uncertainty diminished or rose as a result of the policy action.

If we look at figure 1, we see the probabilities for various values of the S&P 500 as calculated from options for the June 2001 expiration date that was about two months away. These are calculated for the day before and the day following the interest rate announcement. The futures price for the index (for June delivery) rose about 5 percent, from 1195.5 to 1253.7, during these two days. On the horizontal axis is the value in points that the index may be expected to rise above the futures value, in 25-point increments. The probabilities are calculated for the event that on the June 21 expiration date, the index falls between the value of the horizontal axis and 25 points below it. Thus, the label "–25" corresponds to the event where, by June 21, the index falls between 50 and 25 points below the futures value, "25" corresponds to a rise between 0 and 25 points above the futures value, and so forth. The probabilities are calculated, approximately, around where investors expect, on average, the market to be for each day, so that a comparison between the two days can be made.

What these probabilities show is that the uncertainty surrounding the possible future values of the index did indeed diminish from the day before the action to the day afterward. In other words, the probability bars for April 19 are higher around the center of the distribution than are the corresponding bars for the earlier date, which are generally higher in the ends, indicating that on April 17, there was a greater belief that changes in the index might be extreme. Further, much of the probability on April 19 was assigned to the possibility that the market would advance normally and the index would gain between 25 and 50 points, as indicated by the long red bar at 50. Thus, the FOMC action was associated with a change in market beliefs, which became more concentrated around the futures contract value, that is, near the value that would give investors an average rate of return.

These results must be taken with a grain of salt. Measurement error can be quite large when working with option prices that are set by trades throughout the day. Even so, they provide some evidence that the FOMC action reduced market uncertainty, at least for the day following the announcement of a 50-basis-point decrease.

■ Conclusion

Investing, because it involves predicting the future, is inherently risky. Yet that means asset prices, the outcome of many traders doing their best to forecast the future, can give us information about the risk of today's economy. This can also tell us how policy or other events change that risk. Recent research has concentrated on reducing the error in calculating these market measurements of the distribution and with it their ability to forecast the future. This is a fruitful and active area of research that should give policymakers an additional piece of immediate information with which to evaluate the effects of their actions.

■ Footnotes

1. The payoffs shown in table 1 do not include several things that must be taken into account by a person buying the option. First, the expiration date is in the future, so the payoffs are paid at the expiration date. This means that the payoff must be discounted back to "current dollars" when evaluating the value of an options portfolio. Second, an investor, when calculating the possible profits from purchasing an option, must also subtract the price of the option from its expected benefits.

2. Call and put options may be American or European contracts. The holder of an American option can exercise it any time up to and including the expiration date. European options can be exercised only on the expiration date (see Cox and Rubinstein in the recommended reading). This *Commentary* assumes that the options are European options and that investors are risk neutral.

■ Recommended Reading

Cox, John, and Rubinstein, Mark. 1985. *Options Markets*. Englewood Cliffs, N.J.: Prentice-Hall.

Roll, Richard. 1984. "Orange Juice and Weather." *American Economic Review*, 74, pp. 861–80.

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