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Session 13TS
Introduction to Derivatives

Track: Investment/Pension

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Summary: Derivatives have been used extensively by banks, insurance companies, and hedge funds and famously misused by Proctor & Gamble, Barings Bank, Orange County and Long Term Capital Management. Derivatives come in many flavors, such as options, futures, and swaps, and they can be either an effective risk management tool or a dangerous stand-alone investment category.

This session provides a basic background on derivatives and discusses how derivatives can be used in insurance and pension investment portfolios, how they are valued, and how they can impact the long-term financial situation of a portfolio.

MS. CATHERINE E. EHRLICH: The investment world is very dynamic, as most of us know. New products are constantly being invented in different research areas on Wall Street, and, in no time, these products are being marketed to insurance company investment departments. Very often these new products just add a wrinkle to the last new thing or repackage certain fundamentals. There are certain common building blocks that are used to design these products. Even though most actuaries have not had specific practical experience with derivatives used by these products or have not had a chance to study them on a syllabus, the analytical framework that you need to understand these products and to value these products is at the fingertips of most actuaries. It's not that different than the analytical work that you're doing on the liability side of the balance sheet.

However, because investment professionals use different terminology, it is difficult to understand that the themes are very similar to what you're doing on the liability side. So, this session will give people a chance to sit back and learn the basics of derivatives—to understand the language the structures, and how these products are developed and packaged so that you can use them in a variety of ways. You

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Note: The chart(s) referred to in the text can be found at the end of the manuscript.

can either use them to help understand and communicate with your investment folk, who are often investing in these products or using them to structure the portfolio, or to understand how these different risks are being measured and priced by Wall Street. Oftentimes, the risks are very similar to those you quantify on the liability side.

Our faculty for this presentation is very distinguished. Speaking first will be Tom Struppeck. He's a Fellow of the Casualty Society and an ASA, and he works for Centre in New York in the actuarial research and modeling group. Prior to his transfer to New York, he was the lead actuary in the Zurich office in Switzerland. Tom's actuarial career started in Dallas at Republic Financial Services where he started as an actuarial student. Before becoming an actuary, Tom taught in the math department at Rutgers University and at the University of Texas at Austin. Tom's going to speak first, and he's going to go through the basics of derivatives.

Our second speaker is Raghu Ramachandran. He is the senior portfolio strategist and head quantitative analyst for Brown Brothers Harriman's Investment Advisory Services specializing in the insurance and bank markets. Prior to joining BBH & Company he was an analyst at Tillinghast Towers Perrin at the Texas Workers' Compensation Insurance Fund. Earlier in his career, he designed and built cash-flow testing models for FIC Insurance Group. He has written and spoken *on Financial Accounting Standard (FAS) 133*, dynamic financial analysis, credit derivatives, and a variety of investment topics for actuarial audiences as well. He received his B.S. degree in physics and a B.A. in astronomy from the University of Texas at Austin.

MR. THOMAS STRUPPECK: I'm going to introduce a great deal of terminology. I'm sorry to bombard you with so much terminology, but this is the language that's used.

The first term that I want to define is an *option*. The title of the session is "Introduction to Derivatives." There are many different kinds of derivatives. There are options and swaps, and forwards and futures, and combinations of these, such as options on swaps, which are called swaptions. For our purposes, we're going to stick with just the simplest of the derivatives in my view—the option. What an option gives you is the right, but not the obligation, to either buy or sell something at a fixed price at a fixed time. An option allows you to decide later on whether you want to enter into a transaction at terms you agree on today. The price gets set today. The time period gets set today. But whether you do it or not doesn't get determined today. That gets determined in the future. You have the option of doing it.

An option is the right (but not the obligation) to buy or sell a certain thing at a certain price at a certain time.

Each of these pieces in this definition has a term associated with it. The first one is the term *call option*. This option lets you buy. It lets you, the person who makes the decision, be the buyer. It's called a call option. If the decision-maker has the right to sell, then it would be called a *put option*. The thing that you're going to buy or sell is called the *underlying*. The underlying could be a hundred shares of stock in

XYZ Corporation, or perhaps it's a certain bond, or could be any variety of things. Whatever will be bought or sold is the underlying. The price is called the *strike price*. Finally, the time is called the *expiration date*.

I've described European options, as they're called, in which the time when the transaction takes place is a set point in time, like six months from today, for example. There are also American options, where you have the right to purchase or sell any time between now and when it expires. For the European option, it's on a set date, and for the American option, it's any time between now and then.

Now I'm going to take those five terms that we defined, and I'm going to fold them into our preliminary definition of an option. We'll get the actual definition here. A call option or, respectively, a put option, is the right (but not the obligation) to buy, or, respectively, sell, the underlying at the strike price on the expiry date. That's my definition of a European style option.

Option contracts have two parties. One party has the right to do the buying or the selling. He makes the decision. The other party has an obligation to enter into this transaction if the first party wants it to do so. When you've entered into an option contract, one party gets to decide, and the other party is subject to the whims of the first party. If he wants to buy the thing, odds are it's worth more than he's going to pay, and if you currently own it, and you're required to sell it to him, then it will be a bad thing if he wants to take it from you. Similarly, if he wants to sell you something at a pre-agreed price, more likely than not the market price will be lower than that, but he has the right to sell it to you at a pre-agreed price. If you're the party with the obligation, then you have a position that has negative value. We'll see that in a moment. The party that has the right to decide whether it's the right to sell or the right to buy, is said to be long. The other party, the party that has something done to them, is said to be short.

Let's look at the economic payoff of a long position in a call option. Figure 1 shows the value of the call option as a function of the value of the underlying. For the purposes of this graph, let's take an option that lets you buy a share of stock for $20. That's the strike price. If the share of stock is worth $20, and you have the right to buy it for $20, anyone can buy a share of stock for the market price. So that right isn't worth very much. That's why the function is value zero at the strike price. Having that right gives you no additional value. If the price is less than $20, you'd never buy something for more than the market price if you could avoid it. You certainly wouldn't choose to. If you're long on the call, and the market price is less than that strike price, you would just let the option expire at a worthless point. It's worth zero.

On the other side of the strike price are values where we would say the call is in the money, and here the call option has some value. For example, if you can buy the stock for $20, that's the strike price for your call option, and the market price is $25. Then you could exercise your option and buy the share of stock, paying out $20 now, immediately turn around and sell the share of stock for $25. You've made $5. That option is worth $5 because you could create $5 with it by using your right to buy at $20 and then selling at the market price of $25. Similarly, as the price of the stock increases dollar for dollar, the value of the call option increases dollar for dollar once it's in the money at the expiration date.

Figure 2 is an illustration of a long put. With a long put, you have the right to sell the stock at a fixed price, in this case, say, $20. If the stock is worthless, you'll buy it for $0 because it's worthless, and you will turn around and use your right to sell it for $20, and you'll immediately sell it. You will pocket $20. That's your maximum gain. On a long position on a put, there's a maximum gain. There's no maximum gain on a call option. That graph continued off forever, but here there's a maximum gain. As the price of the stock increases, the value of your put option decreases until the market price reaches the strike price, at which point your put option is worthless at expiration, analogous to the previous graph.

Figure 3 illustrates a short position. Remember, options have two parties. They're two-party contracts. The short position, or the short put, is the person who must buy the stock from you at the agreed price. He's the person with the obligation to buy it. The worst thing that can happen to him occurs when the stock price is at -$0. That's when he must buy a worthless share of stock from you for $20. He loses $20. The best thing that can happen for him is for the stock price to be at or above the strike, in which case nothing bad happens. On the long positions, the graph was entirely on the x-axis or above it.

A long position has a positive value provided there's any probability that the stock is above the strike price for a call. For a short call position, the graph is entirely on the x-axis or below it, and so a short position always has a negative value in expectation. In order to enter into a short position, someone would have to pay you something. You'll be paid money up front in order to get into this situation.

Figure 4 combines a long call and a short put with the same strike price. So the red line is the long call position. We saw that in the first graph. The purple line is the short put, which we saw on the third graph. If you have both of those in your portfolio, then your net position is this line that starts at -$20 and extends up. It has slope one. The net position is this entire line. So some have a function at zero. When one of them is positive or negative, the other one is zero. When you add them you just get the line. This has an interesting consequence. The long call and a short put is reflected by the straight line. That's the same thing as owning the underlying stock and owing somebody the present value of the strike price. This straight line that starts at -$20 is the same as owning a share of stock and owing somebody $20 as a function of the value of that share of stock.

If the stock is worthless, then you owe someone $20. So your net portfolio corresponds to a point with a value of -$20 because you've got to pay off your loan. As the stock gains value dollar for dollar, if it's worth $5, your portfolio is -$15. If it's worth $10, your portfolio is -$10; if it's worth $15, your portfolio is -$5.. Finally, if the stock's worth $20, and you owe $20, that's worth zero net.

Let's discuss the more favorable position. If the stock is worth $25, you have a $25 share of stock, you owe $20, and your net position is $5. So, this line that starts at -$20 and extends up is the value of a portfolio that consists of a $20 loan and owning a share of stock, being long one share of stock. Those two are the same, and this gives us a little formula for valuing calls, puts, shares, and the present value of the strike price, so we can relate them together. This is called "Put/Call Parity," and this essentially is proof of a derivation of put/call parity in this simple case.

FROM THE FLOOR: What was the original price of the stock, and where's your starting point for the value on that option?

MR. STRUPPECK: I'm glad you asked that question. The price of the stock is going to determine how much people will pay for the call option, and how much they'll pay for the put option. However, the price of the stock, when you enter into the transaction is not a factor in the value at the payoff time. The graphs depict the time when the option is ready to expire and we're going to settle up. It is the payoff. If you want to know how to value it when you purchased it, that's a more delicate question. I answer that on the next graph.

Here's the data that we need in order to try and price the call option. Today the stock price is $100. In one year, the stock price is either going to be $130 or it's going to be $80. This is called a binary model, because it has only two possibilities. The stock price cannot be $129 in this model. It's either $130 or $80. This is a simple model. Notice I don't tell you the probability of going up to $130 or down to $80. The interest rate is 0%, and we want to price a call option as the strike price of $105.

Here's our strategy. We're going to create a portfolio that will pay off exactly the value of this option. You might wonder, what is the value of this option? In a year, one of two things happens. Either the stock price is at $80, in which case the option, which gives you the right to buy for $105 something you can buy for $80 on the street, is worthless. In the other case, the stock price is at $130, in which case you can take your option, buy something for $105, immediately sell it for $130, and pocket $25. So the option payoff is either $25 or zero. I've made the interest rate zero so it's simpler. The present values are the same as future values. Now I'm going to illustrate a portfolio that we can buy that will pay off either $25 or zero.

It has to be worth $25 if the stock goes up, and it has to be worth exactly zero if the stock goes down. It is zero because zero is the maximum of zero and -$25. We're going to buy a certain amount of stock, and we're going to borrow some money. That'll be a short position in cash. At this point, we have two equations and two unknowns. We're going to borrow some number of shares of stock, and we will borrow some amount of money. Those are the two unknowns. The two equations correspond to the stock price going down, in which case the amount of stock at a price of $80 and the loan need to net to zero, or the stock price will go up. If the price goes up we want to sell the stock, pay off the loan, and have $25.

In this case, we should purchase one-half of a share of stock, and we should borrow $40. The price of the stock today is what determines the cost of the half share of stock we have to buy. It's $100 today and half a share costs $50, so we need to borrow $40. The net cost of the portfolio is $10, and that is precisely the value of the call option in this binary model. These binary models are actually used to price things, but in practice you use a binary model where you chop time in finer and finer increments, and the resulting multi-period model is valued using similar methods.

The second example uses similar data, but this time stock prices are tighter. In the future, it's only going to go up to $120 instead of $130, and if it goes down, it only goes to $90 instead of $80. We see the same strike price, $105. What's the value of this option? We will do the same thing, buy some stock, get an appropriate loan so that if a price goes down, it's zero, and solve the equations. If you do, you discover that the cost of this portfolio is only $5. The previous one was $10. And the reason is that the first stock price was much "wigglier" than this one. This one only wobbles a little bit. Price either goes up to $120 or down to $90. It's less volatile. Option traders speak of option prices in terms of the volatility. In fact, using the Black-Scholes formula, you can actually translate the price of an option into a corresponding volatility for the underlying. There's a huge amount of research that has been done on that.

The next topic is delta hedging. When we set up that replicating portfolio in the previous two examples, we bought some stock and we borrowed some money. We didn't have to worry about the stock price changing during the year because it was either going to jump up, or it was going to go down. There were two possibilities with nothing in between. In the real world, stock prices change all the time, or at least when the markets are open. If you've tried to set up one of these trades where you have some stock, and you've got some loans, and you try and keep your option balance, as prices change, you'll find you need to do some trades. The trades that you have to do create an instantaneously risk-free portfolio. You can't do this in practice, of course, but in principle you can do infinitely many little, tiny trades, and you can track the value of the option perfectly with this replicating portfolio. It tracks it exactly. There's no tracking error. There's no risk. It is an exact match. In the real world that's harder to achieve.

Volatility is hard to capture. The two options had different prices, the $5 option and the $10 option. That's a measure of the "wigglyness" of the price of the underlying, or how volatile the price of the underlying is. In Black-Scholes, there's a one-to-one correspondence between volatility of the underlying, and the price of the option. Because of this, from the market price of an option we can deduce the volatility of the underlying (under the Black-Scholes model).

We will go through a very short dictionary, which relates together insurance terminology and the corresponding option language. Many reinsurance transactions can be viewed as option transactions in some generalized sense. The attachment point in an excess cover corresponds to the strike price. If you have an excess cover that attaches at $1 million per loss, and you have a loss of less than $1 million, the cover expires worthless, just like an option. If you have a loss of more than $1 million, the excess cover will pay the difference, just like an option.

The limit corresponds to the upper strike for a spread. In the property and casualty

(P&C) world, we put limits on our policies where we'll pay out up to $2 million in excess of a $1 million loss. In this example, we'll pay the layer from $1 million to $3 million. The limit corresponds to an upper strike price for a spread. Or, if you want to think of it another way, you bought one option to cede out losses above $1 million, but then you're short an option to have them ceded back to you if a loss gets above $3 million. You're long one, and short another, but they have different strike prices.

The technique of duration matching, which is on the exams for managing bond portfolios, is analogous to delta hedging. You're matching first derivatives in some sense. Convexity matching, which is really matching the second derivative, corresponds to something called gamma hedging that I haven't talked about.

MR. RAMACHANDRAN: Tom spoke about options as a theoretical exercise. I'm going to talk about how, as a money manager, we use options in managing a portfolio. I'm going to cover three examples -- portfolio insurance, covered call, and zero-cost collar.

Portfolio insurance is very simple. You own a stock, and you buy a put, as shown in Figure 5. As the stock price moves, the value of the stock moves one to one with the change in stock price. Then, if you buy a put, you have a wedge-shaped line. In this example, we add the cost of the option. It's the price you pay to purchase that put, and the end result is a portfolio that is the sum of the two lines, as shown in Figure 5.

Basically, you're buying insurance on the value of your stock going below the strike price. So, if the stock goes below the strike price, then your portfolio doesn't drop below a specified value. If you have a stock that experienced a lot of appreciation during the year, and you want to lock that in, you'd buy portfolio insurance to limit your downside so it doesn't go below the current level. The advantage of this is that you know how much you're going to lose. The amount is limited, and you can lock in your gains on the upside. The disadvantage is the cost. One of the biggest reasons people don't use this more often is that stocks that appreciate a lot have a higher volatility associated with them. As Tom mentioned, the cost of an option is dependent on its volatility. Sometimes it's not economical to buy, and it also lowers your appreciation going forward.

All through this exercise I'm going to pick on Cox Communications because, when I went down to our derivatives group, that was the one that was lying on the desk. It's also nice analytically, since it doesn't pay dividends. Dividends complicate calculations a bit. The current price of a share in April was $44.50. If we want to limit the loss to 10%, the strike price would be $40.05. Our time horizon will be a year from last April. The put option expires April 2002, and this option costs $4.14.

The first column of Table 1 shows the price of the stock, which could be any value. The value of the put, if the stock is above $40.05, is zero because you're not going to pay for something that you can get cheaper on the market. If you add the stock and put value, you get a portfolio value, which is in the third column. As the price of the stock goes down, the value of your portfolio doesn't drop below $40.05.

You've hedged the value of your portfolio to lose 10%. This, unfortunately, came with a cost of $4.14. The hedged value of your portfolio actually has a lower limit of $35.91. If you're looking at a portfolio strictly from a surplus viewpoint, this is nice because the $4.14 doesn't show up in your surplus statement, and the downside for my portfolio is limited to $40.05. In a total return sense you have to look at it as the cost for that year, so your lower limit is $35.91.

One thing you notice is if the stock doesn't move at all, and if you hadn't gotten into this derivative transaction, you wouldn't have lost anything. You wouldn't have gained anything, but you wouldn't have lost anything. However, because you had to pay the $4.14, if nothing happens to your stock, you're down 9% overall in your return on your portfolio. The nice side is, of course, you never go below 19.3%, which is the whole point of the insurance. You're also impacted on your upside. If you hadn't bought the derivative, for instance, and if the stock had gone to $54.20, your unhedged portfolio would have returned 21.8%, but your hedged portfolio would only return 12.5%. This is not expected because you're buying this to limit the downside, and it's going to hurt your upside as well.

Table 2 shows the same situation, except now the time horizon is two years — April of 2003. An option that expires in 2003 costs $5.86, and that's in part because you have a longer timeframe. A longer timeframe involves more uncertainty, and uncertainty involves more price. As the stock price goes down, the put value goes up, so the portfolio value is again limited to $4.05, but now the cost is higher. Note that even though the cost is higher on an annualized basis, if nothing happens, the return is -6.8%, which is less than the –9.3% that it was for a one-year option.

FROM THE FLOOR: Let's go back to one of the points you just made, which was that a $5.86 call is greater than the $4.14 because it's a longer period. Shouldn't the price on the stock ultimately converge -- or be expected to converge in some sense? You're going to have less over the long term. Go out 20 years. It should be unlikely that the stock's going to be below your price of $44.50. There should be forces in the economy that cause the average company to go up over time, such as productivity and things like that.

MR. RAMACHANDRAN: You're right, if everything works right. I could show you examples of companies where that hasn't happened, like Xerox or something. You don't know if it's going to be a Xerox or if it's going to be a GE, and if you don't know, people are going to charge you for it. Can you can guarantee that Jeffrey Immelt is going to produce exactly like Jack Welch, (and more than likely he is). If you can't guarantee it, there's an uncertainty, and you pay for that.

FROM THE FLOOR: Theoretically, if the time horizon is infinite, then the option would be worthless, since it could never be exercised. Wouldn't that set a limit on the value of an option for a long time horizon?

MR. STRUPPECK: If the option is European, meaning it can only be exercised on the strike date, on the expiry date, then you are completely correct. If it had an infinite time horizon, it would be worthless. An incredibly long-dated option like that would probably be American style. So, it could be exercised any time you wanted. It's a very interesting question.

FROM THE FLOOR: What happens is if it's an American style option?

MR. STRUPPECK: As the time horizon goes to infinity, the value of the option converges to the market price of the stock today, assuming that the strike is today's market price. An option that is at the money with an infinite time horizon that's American style on nondividend paying stock will have the current market price as its price. It is the share of stock because as soon as you wanted the stock, you just cash it in. It's the same as owning the stock.

MR. RAMACHANDRAN: The second example is covered call writing. You own a stock, and you sell a call on it, and then you invest the premiums that you get for it. In Figure 6, you have the stock, you sell a call, and you're short a call. You get a premium for that. Somebody pays you to sell them this call, and then you invest that premium. Looking at just the portfolio, as the price of the stock goes up, you're capped on the top. This is the reverse of what we had before which is when you had a floor at the bottom. Now you have a ceiling at the top. The use for this is to reduce concentration. One example of this is if you have received a lot of options, and you're an executive in a company. You can't really sell your stock without causing adverse effects and reporting. You can write a covered call program on this and then invest it to diversify out of a concentrated position in a security.

You can also use this to generate income. If you write with the strike price far enough out of the money, so that there's a low probability it will be called, then you're generating income on a stock that isn't paying dividends, for instance. Many technology companies used to do that, at least a year or two ago. It's also a way to get out of a concentrated position in an organized fashion with a little bit more control than having to sell it. It helps you build a diversified portfolio, and you're also selling your stock, if you had to sell the stock, at a premium over what it is today, because the strike price is set higher than the current stock price.

There are disadvantages. It limits your appreciation potential, and although the downside is limited, or it's somewhat limited, there still is a downside.

We can look at an example of this using Cox Communications as shown in Table 3. Using a current price of $44.50, we set a strike price at $55 or 123% expiring in 2002. You get $3.61 for this, and you're going to invest it in a one-year Treasury that returns 5%. The value of the stock, shown in the left column, goes up and down. As the value goes up, your call kicks in, so you have negative value on the call, and then you generate $3.79, which is the $3.61 accumulated at 5%. The hedged value of your portfolio is the sum of the stock price, the call value, and the call income. This is exactly the opposite of what we had before. If your stock doesn't move, you automatically get an 8.5% return. That's more than the return on the Treasury, which is 5%, in part because you're getting $3.79 on the $44.50 without doing anything.

There is, of course, a downside. As the stock price goes up, your return is capped at 32.1%, in this case. You'll notice on the downside the hedged portfolio is better than the unhedged portfolio in every case, but you still have an unlimited downside. As it keeps going down, the hedged portfolio will still keep going down. There's no floor as there is in portfolio insurance.

If we show this example in Table 4, using a two-year time horizon, the option premium is higher, as you would expect. Now you're investing in a two-year Treasury, so you would invest the premium at 6.25% annualized over two years as opposed to 5%. The math is still the same. You get a higher call income and similar returns. Now you notice it's the reverse. Previously, the maximum return you got was capped at 32.1%. Now it's 21.7% on an annualized basis over two years.

The final example is a zero-cost collar. This is basically putting the two things together — the call and the put— as shown in Figure 7. You own a stock; you decide on a downside limit, such as 10%. You buy puts to limit the downside, which is like the portfolio insurance shown earlier. Then you sell calls to cover the cost of the insurance, which is the covered call option. So, in this example, you have the stock (Cox), you buy the put at $40.05, and that costs you something ($4.14). So you sell enough calls to make up for the cost of the put. The call premium has to equal the put price, and, in the end, you get a collar. It's called a collar because you're limited on the downside and on the upside. So, it limits your exposure.

The advantage of it is you know the upside, and you know the downside. You still retain ownership of the stock in the interim. The stock moves within a defined range that you determine. It hedges all sorts of risks: systematic risk or market risk, common factor risk (which is industry risk), and the specific risk of the particular security.

There are also disadvantages. It doesn't diversify your risk like a covered call writing program, and you're limited on your appreciation. You also have some price risk in that you still move within that band that you defined.

An example is shown in Table 5. Using Cox again, you want to limit your losses to 10%. The strike price of the put will again be $40.05. As before, this is going to cost you $4.14. What you want to do is find a price on a call that you can sell to get $4.14 in call premium. The strike price for that call happens to be at $52.97, or 119% of current price. So, if we buy a put and sell a call, the net cost is zero. In Table 5, we again show the stock price. The value of the call kicks in as the stock price goes up. The value of the put kicks in as the stock price goes down. The hedged value is capped at $40.05 on the bottom, and $52.97 at the top. You're limited on the downside and the upside on your return, and there's the payoff.

The one thing I should point out is that you don't have to buy a zero-cost collar. The reason you buy the zero-cost collar is to offset the cost of the puts. If you are willing to take on some of that cost, you can put some money into the collar along with it, and the calculations work out similarly.

You do have to pay a little bit more attention to these. It's not so simple, since you usually you don't buy European collars. It's a little bit more complicated because most of the options are American options, at least the ones you find on the market, and so you have to be able to manage the timing of when you think the call might be exercised and roll that option forward.

Table 6 shows a two-year example. You want to limit your downside to $40.05. The cost is $5.86. The price of a two-year call with a strike price of $57.54 or 129% is $5.86. The table shows the math that illustrates this example.

FROM THE FLOOR: How widely available are these? Presumably you can find any of these options on GE, GM, IBM. You also mentioned some technology stocks. Are these available on everything that is listed? And for any strike price?

MR. RAMACHANDRAN: They're not available on everything that's listed, but for most of the shares that an insurance company would be buying, they are probably available. It depends on the depth and liquidity of the market. Of course, there's more to option pricing than just the strike price. There's liquidity and volatility. Obviously, a less liquid stock would have a higher price than an equivalent stock with more liquidity, all else being equal.

MR. STRUPPECK: Also, the exchange-traded options will tend to have strike prices that are spaced by $5 or $2.50 or whatever. In this example, to get the zero-cost collar, I think you needed a somewhat exotic 129% of current price or something. You might not find one that matched to the penny so you'd have some net cost. The put strike price had to be $40.05. You might find a $40 option in the market, but probably not a $40.05 option.

Figure 1
Option Payoffs
Long Call

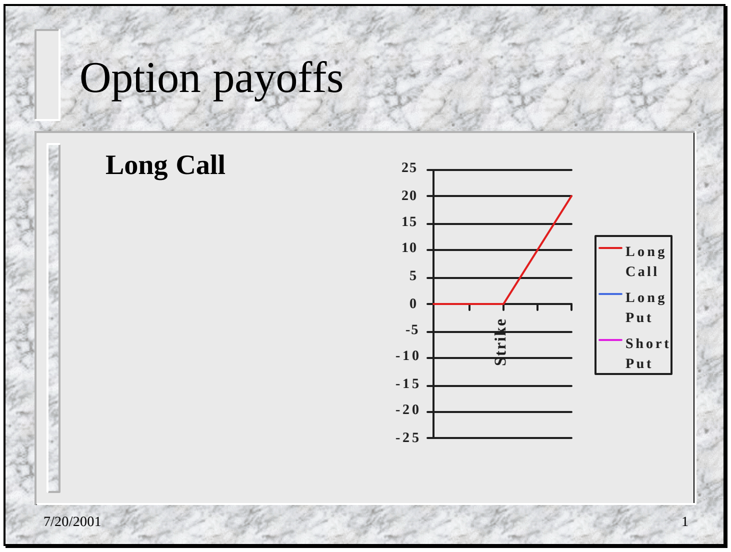

Figure 2
Option payoffs

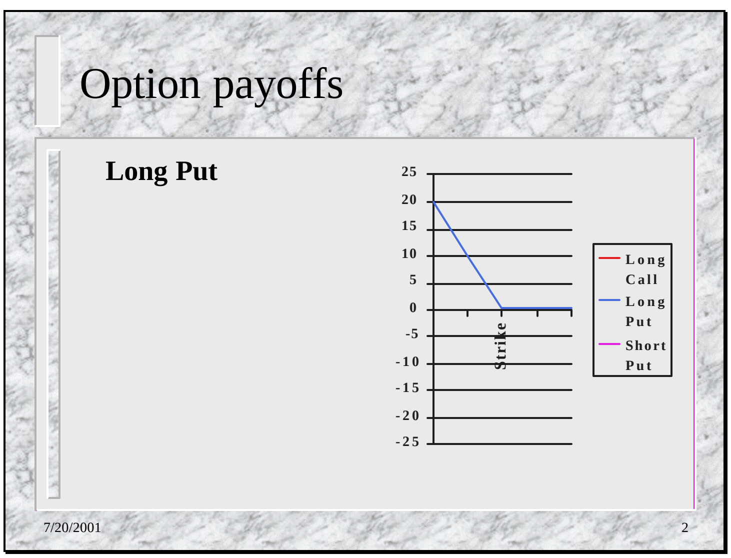

Figure 3
Option payoffs
Short Put

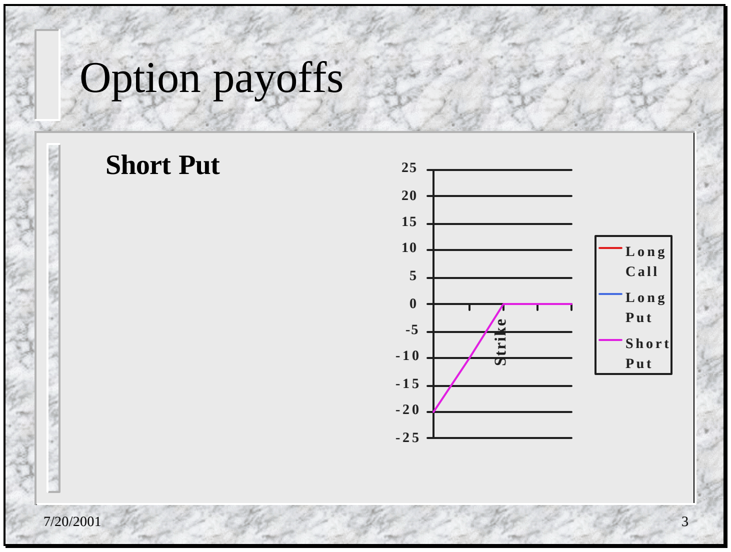

Figure 4
Option Payoffs
Long Call + Short Put

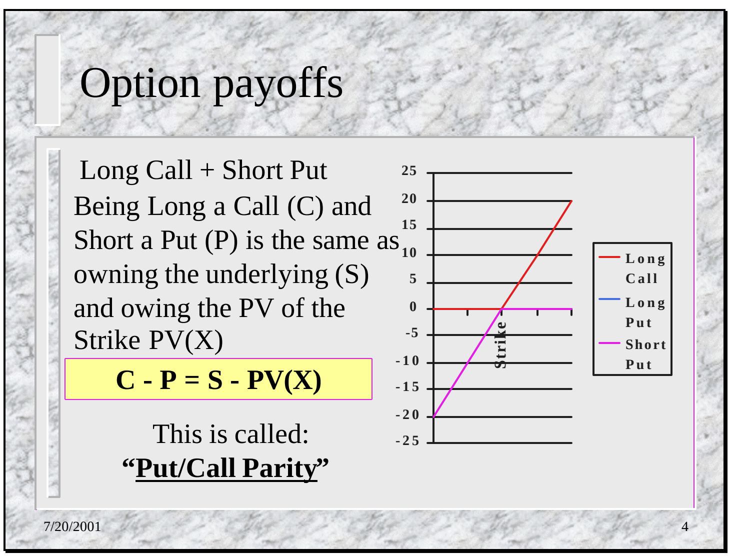

Figure 5
Portfolio Insurance

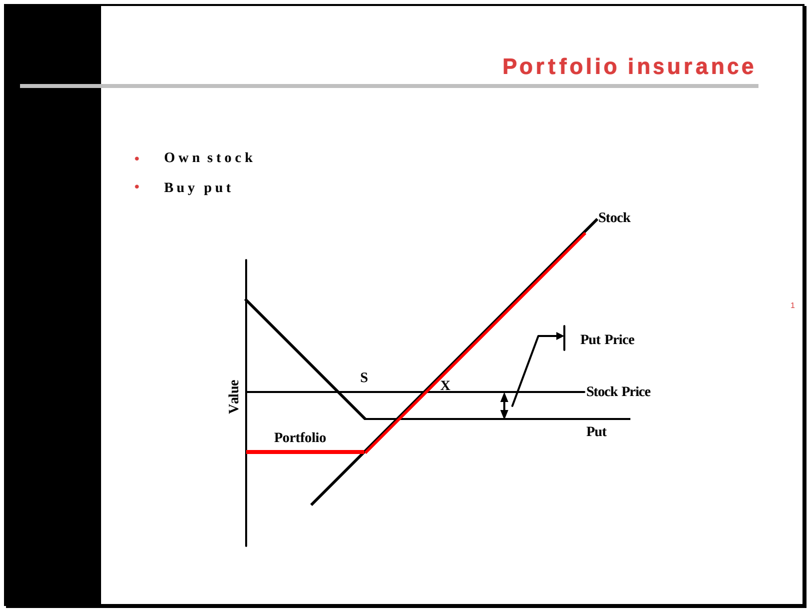

Table 1
Portfolio Insurance
One Year Horizon

Portfolio insurance

Stock Price	Put Value	Portfolio Value	Put Cost	Hedged Value	Unhedged Return	Hedged Return
$ 54.20	$ -	$ 54.20	$ (4.14)	$ 50.06	21.8%	12.5%
$ 52.26	$ -	$ 52.26	$ (4.14)	$ 48.12	17.4%	8.1%
$ 50.32	$ -	$ 50.32	$ (4.14)	$ 46.18	13.1%	3.8%
$ 48.38	$ -	$ 48.38	$ (4.14)	$ 44.24	8.7%	-0.6%
$ 46.44	$ -	$ 46.44	$ (4.14)	$ 42.30	4.4%	-4.9%
$ 44.50	$ -	$ 44.50	$ (4.14)	$ 40.36	0.0%	-9.3%
$ 42.56	$ -	$ 42.56	$ (4.14)	$ 38.42	-4.4%	-13.7%
$ 40.05	$ -	$ 40.05	$ (4.14)	$ 35.91	-10.0%	-19.3%
$ 38.68	$ 1.37	$ 40.05	$ (4.14)	$ 35.91	-13.1%	-19.3%
$ 36.74	$ 3.31	$ 40.05	$ (4.14)	$ 35.91	-17.4%	-19.3%
$ 34.80	$ 5.25	$ 40.05	$ (4.14)	$ 35.91	-21.8%	-19.3%
$ 32.86	$ 7.19	$ 40.05	$ (4.14)	$ 35.91	-26.2%	-19.3%
$ 30.92	$ 9.13	$ 40.05	$ (4.14)	$ 35.91	-30.5%	-19.3%
$ 28.98	$ 11.07	$ 40.05	$ (4.14)	$ 35.91	-34.9%	-19.3%
$ 27.04	$ 13.01	$ 40.05	$ (4.14)	$ 35.91	-39.2%	-19.3%
$ 25.10	$ 14.95	$ 40.05	$ (4.14)	$ 35.91	-43.6%	-19.3%
$ 23.16	$ 16.89	$ 40.05	$ (4.14)	$ 35.91	-48.0%	-19.3%

Table 2
Portfolio Insurance
Two Year Time Horizon

Portfolio insurance

Stock Price	Put Value	Portfolio Value	Put Cost	Hedged Value	Unhedged Return	Hedged Return
$ 54.20	$ -	$ 54.20	$ (5.86)	$ 48.34	10.4%	4.2%
$ 52.26	$ -	$ 52.26	$ (5.86)	$ 46.40	8.4%	2.1%
$ 50.32	$ -	$ 50.32	$ (5.86)	$ 44.46	6.3%	0.0%
$ 48.38	$ -	$ 48.38	$ (5.86)	$ 42.52	4.3%	-2.3%
$ 46.44	$ -	$ 46.44	$ (5.86)	$ 40.58	2.2%	-4.5%
$ 44.50	$ -	$ 44.50	$ (5.86)	$ 38.64	0.0%	-6.8%
$ 42.56	$ -	$ 42.56	$ (5.86)	$ 36.70	-2.2%	-9.2%
$ 40.05	$ -	$ 40.05	$ (5.86)	$ 34.19	-5.1%	-12.3%
$ 38.68	$ 1.37	$ 40.05	$ (5.86)	$ 34.19	-6.8%	-12.3%
$ 36.74	$ 3.31	$ 40.05	$ (5.86)	$ 34.19	-9.1%	-12.3%
$ 34.80	$ 5.25	$ 40.05	$ (5.86)	$ 34.19	-11.6%	-12.3%
$ 32.86	$ 7.19	$ 40.05	$ (5.86)	$ 34.19	-14.1%	-12.3%
$ 30.92	$ 9.13	$ 40.05	$ (5.86)	$ 34.19	-16.6%	-12.3%
$ 28.98	$ 11.07	$ 40.05	$ (5.86)	$ 34.19	-19.3%	-12.3%
$ 27.04	$ 13.01	$ 40.05	$ (5.86)	$ 34.19	-22.0%	-12.3%
$ 25.10	$ 14.95	$ 40.05	$ (5.86)	$ 34.19	-24.9%	-12.3%
$ 23.16	$ 16.89	$ 40.05	$ (5.86)	$ 34.19	-27.9%	-12.3%

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Figure 6
Covered Call Writing

Covered call writing

- Own a stock
- Sell a call
- Invest premium

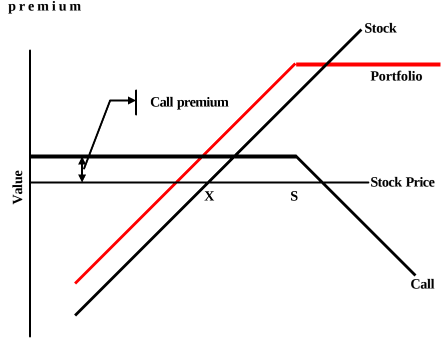

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Table 3
Covered Call Writing
One Year Time Horizon

Covered call writing

Stock Price	Call Value	Call Income	Hedged Value	Unhedged Return	Hedged Return
$ 65.50	$ (10.50)	$ 3.79	$ 58.79	47.2%	32.1%
$ 63.40	$ (8.40)	$ 3.79	$ 58.79	42.5%	32.1%
$ 61.30	$ (6.30)	$ 3.79	$ 58.79	37.8%	32.1%
$ 59.20	$ (4.20)	$ 3.79	$ 58.79	33.0%	32.1%
$ 57.10	$ (2.10)	$ 3.79	$ 58.79	28.3%	32.1%
$ 55.00	$ -	$ 3.79	$ 58.79	23.6%	32.1%
$ 52.90	$ -	$ 3.79	$ 56.69	18.9%	27.4%
$ 50.80	$ -	$ 3.79	$ 54.59	14.2%	22.7%
$ 48.70	$ -	$ 3.79	$ 52.49	9.4%	18.0%
$ 46.60	$ -	$ 3.79	$ 50.39	4.7%	13.2%
$ 44.50	$ -	$ 3.79	$ 48.29	0.0%	8.5%
$ 42.40	$ -	$ 3.79	$ 46.19	-4.7%	3.8%
$ 40.30	$ -	$ 3.79	$ 44.09	-9.4%	-0.9%
$ 38.20	$ -	$ 3.79	$ 41.99	-14.2%	-5.6%
$ 36.10	$ -	$ 3.79	$ 39.89	-18.9%	-10.4%
$ 34.00	$ -	$ 3.79	$ 37.79	-23.6%	-15.1%
$ 31.90	$ -	$ 3.79	$ 35.69	-28.3%	-19.8%

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Table 4
Covered Call Writing
Two Year Time Horizon

Covered call writing

Stock Price	Call Value	Call Income	Hedged Value	Unhedged Return	Hedged Return
$ 75.50	$ (15.50)	$ 5.95	$ 65.95	30.3%	21.7%
$ 72.40	$ (12.40)	$ 5.95	$ 65.95	27.6%	21.7%
$ 69.30	$ (9.30)	$ 5.95	$ 65.95	24.8%	21.7%
$ 66.20	$ (6.20)	$ 5.95	$ 65.95	22.0%	21.7%
$ 63.10	$ (3.10)	$ 5.95	$ 65.95	19.1%	21.7%
$ 60.00	$ -	$ 5.95	$ 65.95	16.1%	21.7%
$ 56.90	$ -	$ 5.95	$ 62.85	13.1%	18.8%
$ 53.80	$ -	$ 5.95	$ 59.75	10.0%	15.9%
$ 50.70	$ -	$ 5.95	$ 56.65	6.7%	12.8%
$ 47.60	$ -	$ 5.95	$ 53.55	3.4%	9.7%
$ 44.50	$ -	$ 5.95	$ 50.45	0.0%	6.5%
$ 41.40	$ -	$ 5.95	$ 47.35	-3.5%	3.2%
$ 38.30	$ -	$ 5.95	$ 44.25	-7.2%	-0.3%
$ 35.20	$ -	$ 5.95	$ 41.15	-11.1%	-3.8%
$ 32.10	$ -	$ 5.95	$ 38.05	-15.1%	-7.5%
$ 29.00	$ -	$ 5.95	$ 34.95	-19.3%	-11.4%
$ 25.90	$ -	$ 5.95	$ 31.85	-23.7%	-15.4%

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Figure 7
Zero Cost Collar

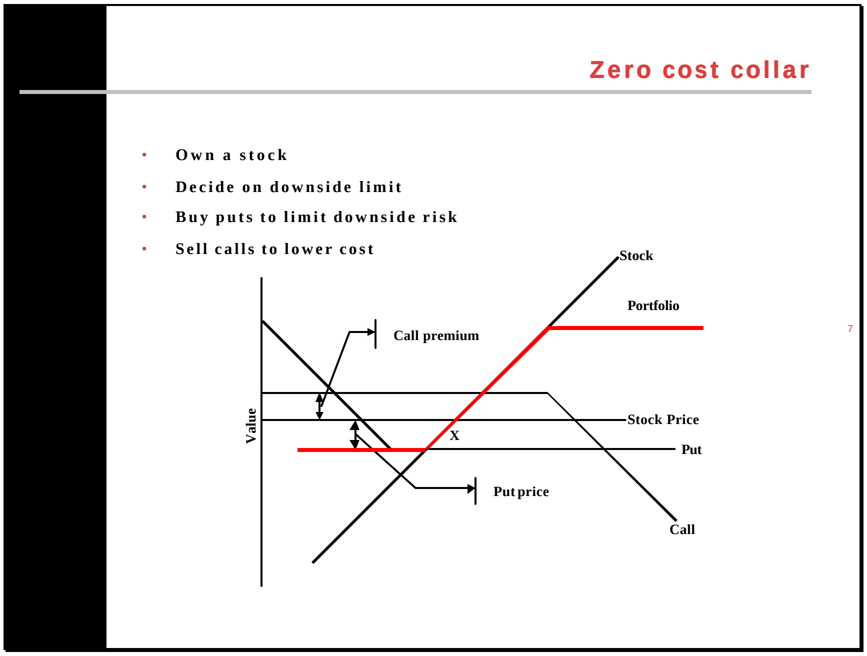

Table 5
Zero Cost Collar
One Year Time Horizon

Zero cost collar

Stock Price	Call Value	Put Value	Hedged Value	Unhedged Return	Hedged Return
$ 58.13	$ (5.16)	$ -	$ 52.97	30.6%	19.0%
$ 56.84	$ (3.87)	$ -	$ 52.97	27.7%	19.0%
$ 55.55	$ (2.58)	$ -	$ 52.97	24.8%	19.0%
$ 54.26	$ (1.29)	$ -	$ 52.97	21.9%	19.0%
$ 52.97	$ -	$ -	$ 52.97	19.0%	19.0%
$ 51.68	$ -	$ -	$ 51.68	16.1%	16.1%
$ 50.26	$ -	$ -	$ 50.26	12.9%	12.9%
$ 48.82	$ -	$ -	$ 48.82	9.7%	9.7%
$ 47.38	$ -	$ -	$ 47.38	6.5%	6.5%
$ 45.94	$ -	$ -	$ 45.94	3.2%	3.2%
$ 44.50	$ -	$ -	$ 44.50	0.0%	0.0%
$ 43.06	$ -	$ -	$ 43.06	-3.2%	-3.2%
$ 41.63	$ -	$ -	$ 41.63	-6.4%	-6.4%
$ 40.05	$ -	$ -	$ 40.05	-10.0%	-10.0%
$ 38.76	$ -	$ 1.29	$ 40.05	-12.9%	-10.0%
$ 37.32	$ -	$ 2.73	$ 40.05	-16.1%	-10.0%
$ 35.88	$ -	$ 4.17	$ 40.05	-19.4%	-10.0%

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Table 6
Zero Cost Collar
Two Year Time Horizon

Zero cost collar

Stock Price	Call Value	Put Value	Hedged Value	Unhedged Return	Hedged Return
$ 63.93	$ (6.39)	$ -	$ 57.54	19.9%	13.7%
$ 61.99	$ (4.45)	$ -	$ 57.54	18.0%	13.7%
$ 60.05	$ (2.51)	$ -	$ 57.54	16.2%	13.7%
$ 57.54	$ -	$ -	$ 57.54	13.7%	13.7%
$ 56.17	$ -	$ -	$ 56.17	12.3%	12.3%
$ 54.23	$ -	$ -	$ 54.23	10.4%	10.4%
$ 52.29	$ -	$ -	$ 52.29	8.4%	8.4%
$ 50.35	$ -	$ -	$ 50.35	6.4%	6.4%
$ 48.41	$ -	$ -	$ 48.41	4.3%	4.3%
$ 46.47	$ -	$ -	$ 46.47	2.2%	2.2%
$ 44.50	$ -	$ -	$ 44.50	0.0%	0.0%
$ 42.56	$ -	$ -	$ 42.56	-2.2%	-2.2%
$ 40.05	$ -	$ -	$ 40.05	-5.1%	-5.1%
$ 38.68	$ -	$ 1.37	$ 40.05	-6.8%	-5.1%
$ 36.74	$ -	$ 3.31	$ 40.05	-9.1%	-5.1%
$ 34.80	$ -	$ 5.25	$ 40.05	-11.6%	-5.1%
$ 32.86	$ -	$ 7.19	$ 40.05	-14.1%	-5.1%

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