Real Option Analysis: The Profession's Next Cutting-Edge Tool

by Glenn Kautt, CFP

With the advent of stochastic financial planning models, planners now have tools to help forecast the probability of certain outcomes. Yet, many important decisions cannot be made using the available forecasting tools. A new type of planning tool is being developed to analyze information for these types of decisions. It employs a methodology called “real option analysis,” which provides a framework for making informed decisions about problems that could not be readily solved in the past. This article explores this cutting-edge planning tool. It explains what a real option analysis includes and shows readers how to think of decisions in a real option framework. Finally, it suggests when real option analysis may be appropriate.

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In the recent past, the efficacy of advanced planning tools using a stochastic process has been hotly debated.[1] To properly frame the debate from a technical standpoint, consider that a discussion about using advanced planning tools is like a discussion about surgical equipment. Everyone in the operating room, including the patient, wants to use the most advanced equipment available, assuming the equipment and tools have been tested and will produce the desired medical results. Clearly, each surgical procedure requires certain tools and equipment. For every operation, some equipment is highly desirable but may be optional, some equipment is better than others and some equipment is unnecessary.

In a similar fashion, when developing comprehensive financial plans for clients, planners may wish to employ certain analytical tools and processes and not others, based on their skills and the specific needs and objectives of each client. Sometimes planners need the most advanced analytical tools to provide counsel for clients and sometimes no analytical tools are necessary. For the majority of client situations, we assume financial planners, like surgeons, want the most advanced and powerful tools available to them. If this assumption is valid, then it’s important to continue to seek out or develop those tools. It is with that goal in mind that this paper was written. Just as with other professions, we must seek out or develop these tools even before the majority of financial planners understand or employ them. One such tool is real option analysis. Real option analysis has had a significant impact on decision making in other industries. At this time, however, real option analysis has not been applied in the financial planning profession because the program tools are just now being developed in a way that could be useful for financial planners. This article looks at this newly applicable planning tool in four areas:

- What is real option analysis?
- How can planners think of decisions in a real option framework?
- What examples of using this framework illustrate how to make more informed strategic decisions?
- When is real option analysis appropriate?

A subsequent article will provide a more in-depth look at the technical and mathematical details of real option analysis and serve as a primer for those who wish to employ this powerful tool.

Real Choices

Just what is a real option and what is real option analysis? To find out, we need to review the fundamental way of making a financial decision that involves future costs and benefits: the net present value (NPV) analysis. The NPV calculation is straightforward: future benefits are discounted to the present, from which all present and future costs of the option to invest in the opportunity, discounted to the present, are subtracted, yielding the NPV. The difference between a simple net present value analysis and an option analysis centers on the uncertainty of future prices (benefits) of the underlying security. This can be expressed in a simplified formula as

Present value of option =

present value of known benefits –

present value of costs +

present value of uncertain benefits

due to future unknowns –

option execution costs

The addition of the NPV of uncertain costs and benefits lies at the heart of real option analysis.

Many readers will have heard about financial options and the options markets. A real option is different from a financial option.[2] While this paper is not about financial options, it is necessary to describe the fundamental characteristics of financial options.[3] A financial option is an instrument whose value is affected by six factors:

1. **The price of the underlying security (stock price),** which represents the present value of cash flow expected from the investment opportunity in the stock.
2. **The exercise price,** which represents the present value of all the costs to execute the option.
3. **Uncertainty,** which is the unpredictability in future cash flows due to one or more factors, such as stock price volatility, taxes and dividends. Practically, this is represented by the standard deviation of the future stock price logarithmic returns in the standard options pricing model.
4. **Time to expiration** of the option.
5. **Dividends** paid.
6. **The risk-free interest rate.**

As mentioned earlier, the option price is determined by uncertain factors. To the extent we can model or calculate that uncertainty, we can calculate the option's actual price.

As the name implies, a real option is the right or privilege to take an action with a financial consequence having to do with real assets or property. There is a cost to obtain the option, which is either an upfront cost to obtain the option or the cost to exercise it. There is an element of uncertainty about the future liability or value of the asset, which is why the option exists: to assure a specific benefit (such as price) or somehow limit a future liability.

For example, many years ago the Disney Corporation bought options on thousands of acres of land in Florida before developing Walt Disney World. As market conditions made the land more valuable, Disney exercised its option to purchase portions of the property at the option price. It continued to hold options on additional property and as the land increased in value, it paid the previously agreed upon (much lower than market) option price. Obviously, real options are exercised only when the necessary conditions are met.

Let's compare financial and real options. Table 1 delineates the major differences. Here are a couple of important terms. The "American" financial option can be exercised at any time during the option period. The "European" option can be exercised only at the end of a specified holding period. From a timing standpoint, real options may resemble either American or European, depending on the situation.

TABLE 1

Financial Options Versus Real Options

Financial Options	Real Options
Short maturity, usually in months.	Longer maturity, usually in years.
Underlying variable driving its value is equity price or price of a financial asset.	Underlying variables are cash flows, which in turn are driven by market, personal and unknown factors.
Cannot control option value by manipulating stock prices.	Can increase option value by personal decisions.
Values are usually small.	Values can be quite large.
Competitive or market effects are irrelevant to its value and pricing.	Outside factors drive the value.
Have been around and traded for more than four decades.	A recent development in corporate finance, but not currently used in personal financial planning.
Usually solved using closed form partial differential equations and simulation/variance reduction techniques for exotic options.	Usually solved using closed form equations and binomial lattices with simulation of the underlying variables.
Marketable and traded security with comparables and pricing information.	Not traded and proprietary in nature, with no market comparables.
Business and personal assumptions and actions have no bearing on valuation.	Personal actions and assumptions drive the value.

From Real Options Analysis by Johnathan Mun, Ph.D. John Wiley Publishing, New York, NY. 2002.

The Real Deal

Let's take an abbreviated look at the real option analysis process. It combines mathematical elements with which every CFP practitioner is familiar, as well as some new stochastic twists.

Identifying the option situation(s). Screening for a potential real option situation or opportunity is the first step. Usually, this is quite obvious, but thinking in terms of a real option may give the planner more ways to view the problem.

Base case (deterministic) NPV analysis. A discounted cash flow model is built, using assumptions that approach the conditions of the situation but do not take into account the uncertainty of the future. This would yield an NPV that is the value of the option if, and only if, all the values of each variable in the option situation were known. Since they aren't known, the base case is useful only in following calculations.

Stochastic simulation. Because the deterministic NPV model produces only one number, there is usually little or no confidence in its accuracy. But using the NPV analysis, we can change each of the input variables and note the change in the resulting outcome. By varying each input, we can see the effect on the resulting NPV. A graphical representation can be created, which is often called a "tornado diagram" due to its shape. It displays the most sensitive input variables first, in descending order of magnitude of impact. Armed with this information, the planner can decide which key variables are highly uncertain in the future and which aren't—that is, changing them won't affect the outcome much. The critical inputs are candidates for further stochastic simulation and analysis for correlation effects.

Real option problem framing. Because the option situation was identified in step 1, the problem can now be framed as a "selection," "expansion," "contraction," "switching" or other type of option action. For most financial planning situations, it will be a selection or switching option.

Real option modeling and analysis. At this point, depending on the kind of option, the math may be quite simple or it may get tricky. The selection option will require only a straightforward stochastic simulation of the critical variables. For other real option situations using stochastic simulation, the resulting outcomes are used to develop the implied volatility of the value of those underlying critical variables noted in the aforementioned tornado diagram. After selecting each potential option, the option analysis is applied, which may employ one or more open-form or closed-form approximations, binomial lattice calculations, partial differential equations, multinomial branch models or stochastic simulations.

Portfolio/resource optimization. This is a discretionary step in the analysis, but it is highly desirable when considering a portfolio of different assets and options. This step allows the financial planner to assist the client in effectively allocating resources across multiple assets in a diversified portfolio to maximize wealth with a minimization of risk.

What's Real and What's Not?

To understand and use real option analysis, we must be able to frame the situation to see if it contains the elements of a real option situation. If it does, it may be possible to use a real option analysis to examine the outcomes. Here are a number of examples of situations. Test yourself to see if you can recognize whether a real option exists.

The purchase of an extended warranty on a new car. The purchaser of the new car is offered a contract warranting major components of the car for a five-year period over the original warranty period. Real option? This contract gives the purchaser the right to buy repair services at a specific price (no or very low cost) for a period of time in the future. The purchaser limits a potential liability (cost) by paying for the option up front. The future value of the option is uncertain but is somehow related to vehicle operation. This is a real option situation, albeit one where calculation of the future uncertainties is very difficult or impossible for the average consumer because of the lack of data.

Converting to a Roth IRA. A client has a regular before-tax IRA account. She's heard about some law that allows for the conversion to a Roth IRA. Did this new law create a real option? Some sort of choice exists, but will a conversion limit liability in the future or set a price? Having a Roth IRA means there will not be a forced withdrawal of capital from the IRA due to the required minimum distribution provisions of the federal tax code. In this case, the conversion privilege is not purchased, per se. Rather, the price of conversion is paid in taxes up front. In this case, the option to convert has a price, may limit a future liability and is of uncertain value based on potential future tax law changes. This is a real option situation examined in detail later in this paper.

The purchase of long-term care insurance. Real option? The contract gives purchasers the right to receive a benefit if they need specific types of personal or medical care. It limits a possible (and uncertain) future liability based on the provisions of the contract and exists for a specific period of time. The value of the insurance is linked to the purchaser's health. The purchase of long-term care insurance is a real option situation. Again, this may be difficult for the planner to calculate without significant actuarial data on long-term care events.

Deemed sale to reduce capital gains. The client has heard about some new tax law that will reduce capital gains taxes in the future—something about a "deemed sale." The couple's financial planner explains that the deemed sale provision of a tax law passed in 2001 allows for the phantom (deemed) sale of existing securities as of January 1, 2001. If they pay any taxes due from the sale, any future gain during the next five years will be taxed at a rate of 18 percent rather than 20 percent.

Real option? The investor pays a tax if the deemed sale has any gain. Furthermore, their original basis will be changed, so they may have an increase or a decrease in basis of the investment. Well, the cost element is there. How about limiting risk or creating some benefit? There is a possibility of a lower gain on any growth in the asset value. We've limited a potential future liability. This is a real option situation.

Spendthrift trust or stretch IRA? Your client wants to leave all of her IRA assets to her three children by a previous marriage. Her current husband agrees and signs a "waiver of beneficiary rights" clause on the IRA application. But she also informs you that she's not sure if one of her children could handle the considerable amount of money that would be inherited when she passes away. She's heard about something called a "stretch" IRA and she wonders if this concept would apply to her and her kids. She also wonders if this would help the child who can't manage money.

Is this some sort of real option? She has the choice to give the money to her children directly or place it in trust for one or more of the children based on her assessment of their financial acumen. If she gifts the money directly to her children, they can exercise the provisions of the stretch IRA tax code and stretch the distribution of the IRA over their remaining lifetimes, which effectively keeps a great deal of the assets sheltered for a very long time. If she makes the beneficiary a spendthrift trust for one child, that child may not be able to stretch the withdrawals. We have no upfront "cost" to change the beneficiary designation, but there is a significant cost at her death: immediate taxes and an after-tax account versus a deferral of taxes with tax-free investment returns for potentially half a century. This is not a real option situation, as there is no way to guarantee limiting a future liability.

The decision to refinance a mortgage. Homeowners have the flexibility to refinance their fixed or variable rate mortgages at any time when the prevailing market interest rates are sufficiently low. The cost of refinancing is the closing fee plus other contractual fees. The benefit is the amount saved from making a lower payment each month. Besides the hard financial costs and benefits to the homeowner is the cost of a process that may be too time consuming or too much of a hassle. The ability to refinance is clearly a real option situation—one where the costs and benefits can be accurately forecast—and one many homeowners have analyzed and executed.

Let's summarize what we've learned so far:

- Many situations contain the elements necessary for option analysis.
- If a situation contains the proper elements, then real option analysis may help with the decision making.
- The decision continues to have uncertainty that unfolds over time. If everything is certain, then the decision is simple: If benefits outweigh the costs, just do it. It is because the future is filled with uncertainty that decisions are not cut and dried.
- Knowledge of the uncertainty as it unfolds must bring with it value the decision maker can capture, or downside risks the decision maker can hedge or avoid. Otherwise, uncertainties are worthless and a detailed real option analysis is unnecessary.
- There must be flexibility in making mid-course corrections on decisions over time. Otherwise, the decision maker cannot profitably navigate through the maze of uncertainty.
- The decision maker must be able to efficiently execute the relevant options to maximize wealth and minimize risks to take advantage of flexibility and uncertainty as they evolve through time. Otherwise, all future options are useless.
- The elements include owning or having a right to do something in the future (the option), which gives the holder of the option a real benefit or limits a liability (the same as receiving a benefit).
- The option may or may not have a time limit on its exercise.
- There is a cost for the option, either at purchase or exercise.
- The ultimate value of the option is uncertain and is based on known and unknown variables.
- The ultimate value of the option may be more or less than the original cost. Usually, the real value of the option is not readily apparent or simple to calculate because it is based on uncertainties that are difficult to ascertain or calculate.

Real Option Examples

If the true price of a real option is not readily apparent, the value of real option analysis is to determine that exact price. How do we do that? Assume, for the moment, that you can see into the future and you can predict with perfect accuracy the outcome of the situation your client faces. If this were the case, how is the option analysis conducted? Say your client wants to purchase life insurance. She can purchase either term or a cash-value policy.

For level term insurance, the annual cost is typically low for a set number of years, then increases dramatically. For cash-value insurance, the client has the choice of whole life, with a stated rate of interest; universal, with a changing rate of interest; or variable life, whose death benefit varies as returns from investments in the equity markets vary. All the cash-value policies require different premiums for the same death benefit.

Is this a real option situation? The client needs insurance. The cost of the various policies is known, but the net present value of the purchase is unknown unless we know the date of death of the insured. The purchase itself is not the option. The option lies in the choice of what type to purchase. Another real option situation is the ability to switch to a different insurance program sometime in the future, allowing the client to capture the program that provides the highest upside potential when the uncertainty in interest rates and the equity markets become known.

Which policy will have the most value to the client? This question is immediately answered if we know when the client will pass away. In this example, assume she will die in a scant ten years. Assume she can buy a ten-year level term policy for $300 a year, versus a whole life policy with the same benefit for $1,500 annually. Let’s frame the insurance decision in real option terms. Based on the date the death benefit will be paid, we calculate the present value (PV) of the future benefit by discounting it to the day of purchase. The present value cost also can be calculated. For a term policy, we simply discount the scheduled premium payments. For a cash-value policy, we perform the same discounting because we know the stream of payments, even in the face of varying interest rates and premium requirements to keep the policy in force.

Let’s look at this idealized option situation using some typical numbers, shown in Table 2.

TABLE 2

Idealized Option Situation

	Term Life	Whole Life
PV Benefit	$83,000	$83,000
PV Cost	$2,200	$9,000
PV Benefit	$81,800	$72,000

In this highly idealized example, the best option—the policy with the highest net benefit—wins. Right about now, though, you are probably saying, “This isn’t going anywhere because the actual variables of longevity and market performance are too hard to figure. I’m faced daily with these sorts of questions and I don’t see what value this sort of analysis has in the real world!” Actually, it is extremely valuable—if we somehow peer into the future and get the numerical data we need to perform the NPV analysis. Can we actually see into the future? Of course not. But we have methods to help more accurately predict the uncertain parts of the future, sometimes with a high degree of accuracy.

Consider a situation first proposed by insurance consultant Glenn Daily.[4] His example involves the conversion from a regular to a Roth IRA in a simple but illustrative case. Many planners have performed Roth conversion analyses, including this author. Daily did an excellent job of framing the issue in terms of a real option analysis but stopped short of the mathematics. Unfortunately, there is no commercially available software that includes a provision for either tax or investment return uncertainties. As a result, this author turned to a modeling tool, Crystal Ball Pro 2000. [5]

Here are the assumptions, chosen for convenience:

- The regular IRA has a $100,000 balance and the client has made no nondeductible contributions. The client also has at least $34,000 in investments outside the IRA.
- The client expects to let the money grow for 20 years until retirement. At that point, it will be withdrawn in equal installments over the following 20 years at the beginning of each year.
- The planner and client expect to get an eight percent annual pre-tax return inside the IRA. The planner and

client expect to get a six percent annual after-tax return on investments outside the IRA. The effective 25 percent tax rate reflects a blend of ordinary and tax-exempt income and realized and unrealized capital gains.
- The marginal tax rate for income generated by a Roth IRA conversion is 34 percent. The conversion occurs in one year and the tax is paid upon conversion.
- The client expects a marginal tax rate in retirement of 32 percent.

Once we have framed the analysis in real option terms, we can apply the stochastic process to develop a range of outcomes and a probable value. Remember, the first step in a real option analysis is to look at the net present value. Using the standard deterministic format, what is the value of conversion? Table 3 shows the calculations, assuming we know all the variables.

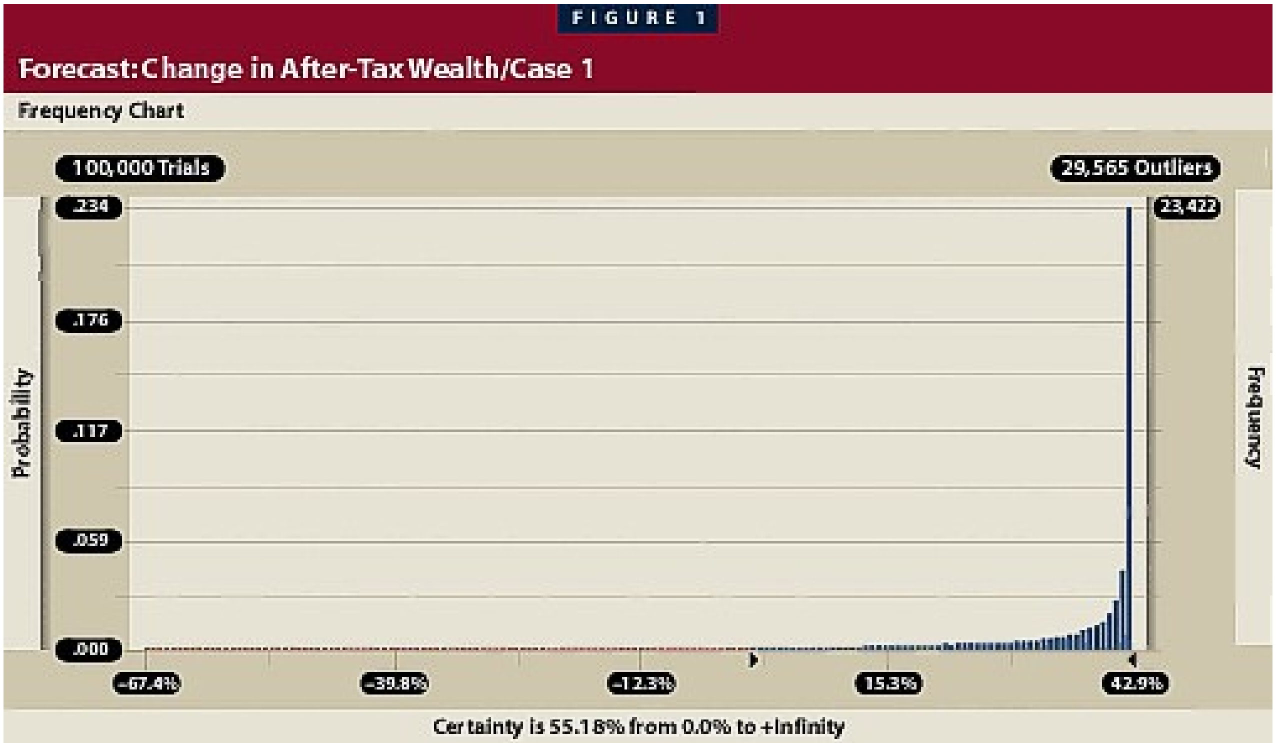
TABLE 3

IRA to Roth IRA: Conversion Analysis

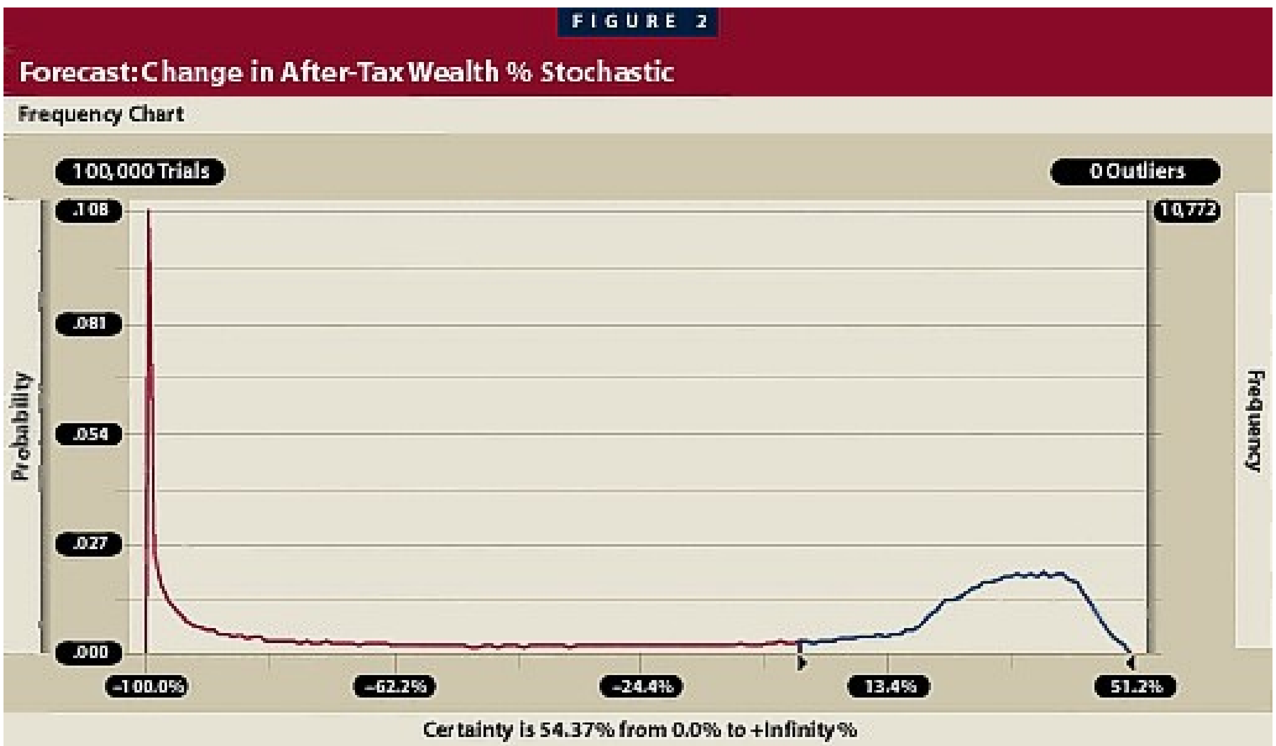
		Expected Value
Assumptions	Amount in IRA	$100,000.00
	Amount outside IRA	$34,000.00
	Years until retirement	20
	Years during retirement	20
	Assumed pre-tax investment return	8.00%
	Blended after-tax investment return	6.27%
	Marginal tax rate at retirement	32%
Calculations	**Convert to Roth IRA**	
	Value of IRA at retirement	$466,095.71
	Value of outside assets at retirement	$ —
	Annuitized payments from Roth IRA	$43,956.37
	Yearly tax due on Roth IRA payment	$ —
	Annuitized payments from outside assets	$ —
	Yearly tax due on outside asset payments	$ —
	Yearly after-tax income at retirement:	$43,956.37
	No Convert Option	
	Value of IRA at retirement	$466,095.71
	Value of outside assets at retirement	$114,734.10
	Annuitized payments from IRA	$43,956.37
	Yearly tax due on IRA payment	$13,186.91
	Annuitized payments from outside assets	$9,620.22
	Yearly tax due on outside asset payments	$ —
	Yearly after-tax income at retirement:	$40,389.68
	Final Answer	
	Yearly value of conversion:	$3,566.69

The deterministic analysis looks positive now, but is it really? In reality, we know that the rate of return will not remain exactly at eight percent each and every year of our model. Further, even if it did, we are not sure what will happen with tax rates. As a result, our analysis contains two significant variables—tax rates and investment return—that will affect the value of the option. After applying the stochastic process to those variables, the outcome looks quite different.

In this case, let’s first assume only the investment return changes, using a volatility term of 14.3 percent standard deviation on normally distributed returns for the life of the portfolio. Figure 1 shows us the range of outcomes after applying a Latin Hypercube simulation.



We then apply the same stochastic process for taxes. The outcome changes again. This is shown in Figure 2.



The outcome in Figure 2 is positive only 54.4 percent of the time. Most people will not convert knowing they have only a 54 percent chance of gaining value. This financial planner would not recommend they convert, given the facts of this case. It is clear that real option analysis puts a value on the uncertainty of the future and gives more information on which to make an informed decision.

When You're Hot, You're Hot

Real option analysis is a powerful tool when information is available for the calculations. Is it always appropriate to use it? No. In many instances, quantitative analysis is not necessary or viable. Often, a real option situation does not exist. Clearly, opportunities to use this analysis depend on the situation and whether enough appropriate and accurate information is available. As with any tool that attempts to forecast the future, the ultimate outcomes depend on the input assumptions. Obtaining relevant and accurate data has always been the goal (and the bane) of financial planners.

In every stochastic process, a critical input is the expected "behavior" of the future events. Technically speaking, this is the expected distribution of future events, known as the probability function.[6] For real option analysis, usually one of the most difficult pieces of input data to obtain is the estimated volatility of future events. Fortunately, there are mathematical solutions that can calculate implied volatilities based on the range of possible outcomes and a few key assumptions. If the planner can develop the implied volatilities, he or she then can run a stochastic analysis to determine the range and probability of outcomes.

Can the planner develop implied volatilities in every situation? That is unlikely because data is not always available to give the planner any idea of the range of likelihood of any outcome. For example, when considering a warranty for your new car purchase, you will not be given all the necessary repair history information on which to base the analysis—nor is that information easy to obtain.

As a result, the planner must look to first frame the problem to see if there is a real option situation, then look to see what data is available or can be developed to analyze the problem. If data can be developed, the planner possesses a powerful new tool for financial decision making. That process will be discussed in the author's next paper on this subject.

Endnotes

1. See comments by Andrew Gluck in his June 2002 column in *Financial Advisor Magazine*. Also see John Ameriks, Robert Veres and Mark J. Warshawsky, "Making Retirement Income Last a Lifetime," *Journal of Financial Planning*, December 2001. David Nawrocki, "The Problems with Monte Carlo Simulation," *Journal of Financial Planning*, November 2001. Several rebuttals have surfaced to this article, such as the critical response by Ren Curry, Ph.D., "The Problem with the Problems with Monte Carlo," at www.MonteCarloSimulations.org. Also see Richard Wagner, "Integral Finance: A Framework for the 21st Century Profession," *Journal of Financial Planning*, July 2002.
2. The financial option is described by the generalized Black-Scholes formula, as modified by Robert Merton:

$$Call = Se^{(b-r)T}\Phi\left(\frac{\ln(S/X)+(b+\sigma^2/2)T}{\sigma\sqrt{T}}\right) - Xe^{-rT}\Phi\left(\frac{\ln(S/X)+(b-\sigma^2/2)T}{\sigma\sqrt{T}}\right)$$

$$Put = Xe^{-rT}\Phi\left(\left[\frac{\ln(S/X)+(b-\sigma^2/2)T}{\sigma\sqrt{T}}\right]\right) - Se^{(b-r)T}\Phi\left(-\left[\frac{\ln(S/X)+(b+\sigma^2/2)T}{\sigma\sqrt{T}}\right]\right)$$

The general formula can be used in a wide variety of circumstances, where:

$b = 0$: Futures options model

$b = r - q$: Black-Scholes with dividend payment

$b = r$: Simple Black-Scholes formula

$b = r - r^*$: Foreign currency options model

Definitions of Variables

- S present value of future cash flows ($)
- X implementation cost ($)
- r risk-free rate (%)
- T time to expiration (years)
- σ volatility (%)
- Φ cumulative standard-normal distribution
- b carrying cost (%)
- q continuous dividend payout (%)

The original formula calculates the theoretical option value based on no transaction costs, taxes or dividend payout. Mertons's elegant modification incorporates dividends and carrying costs, which reduces the value of the option by the present value of the foregone dividend stream.

3. For an in-depth text on options and option pricing, see John C. Hull's comprehensive textbook: *Options, Futures and Other Derivatives Fourth Edition*, New York, NY: Prentice-Hall Inc., 2000.
4. Glenn S. Daily, "Should You Convert to a Roth IRA? A Real Options Perspective," www.glenndaily.com/documents/rothira.pdf., 2001.
5. All calculations performed on Crystal Ball Pro 2000, Decisioneering Inc., 1515 Arapahoe St., Suite 1311, Denver, CO 80202. (800) 289-2550, www.crystalball.com.
6. For an explanation of the normal distribution and the stochastic process, see: Kautt, Glenn and Lynn Hopewell, "Modeling the Future," *Journal of Financial Planning*, October 2000; and Glenn Kautt and Fred Wieland, "Modeling the Future: the Full Monte, the Latin Hypercube and Other Curiosities," *Journal of Financial Planning*, December 2001.