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because the demographic profiles are synchronized, it seems unlikely that investors in these countries will be net buyers of capital when aging Americans begin to sell. If anything, this figure suggests that international linkages among developed countries are likely to amplify life cycle effects in the United States.

What about developing countries? Demographers project that their old-age dependency ratios will also rise, but expect the increase to occur roughly 50 years later than in the industrialized world. Since their demographic profiles differ from the developed world's, perhaps aging boomers in the latter can sell to younger boomers in the former. But will they have the means to buy? Capital tends to be scarce in developing countries, and unless they can grow rich in the next 25 years, it seems unlikely that they will be in a position to become net lenders to the developed world.

Other Considerations

The looming crunch might be slightly eased under several scenarios. For example, educated baby boomers may choose to stay in their careers longer, working past the traditional age of retirement; they need not sell their assets if they earn steady paychecks. In addition, the period over which the Baby Boom generation is expected to retire spans about 30 years. Capital markets might have time to adjust to the gradual decline in supply of funds for capital investment. For example, if Gen-Xers, Yers, and Zers were to anticipate further cuts in Social Security benefits, they might save a higher fraction of their incomes, and this would compensate for the fact that there are relatively few of them. Despite such possibilities, the surging old-age dependency ratio remains a significant generational challenge, not just for Social Security, but perhaps for private retirement plans as well, in ways we are just beginning to explore.

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Subjective Value at Risk

by Glyn Holton

Editor's Note: *The following article originally appeared in the August 1997 issue of* Financial Engineering News *and is reprinted with permission.*

Value-at-Risk (VaR) is becoming somewhat of a revolution. Around the globe, organizations are racing to implement the new technology. Pundits propose extending VaR to other risks, including credit risk and operational risk [1]. Some even suppose that all the risks of an organization should be summarized with a single risk measure [2].

It is the nature of revolutions that there be a backlash. One has begun. Critics suggest that VaR may be ineffective for assessing risks other than market risks [3]—or that it fails even with market risk [4]. Others have noted disturbing inconsistencies between risk estimates produced by different implementations of VaR [5].

If the VaR revolution is to succeed, it must be tempered by such concerns. After all, VaR is only a tool. All tools have limitations. For example, a hammer can drive nails, but it cannot drive screws. Saying that the hammer is limited is different from saying it is flawed.

To understand the limits of VaR, we need to explore what it means to "quantify" risk. Let's start by defining risk. Risk is exposure to uncertainty. Accordingly, risk has two components: (1) uncertainty; and (2) exposure to that uncertainty.

A synonym for uncertainty is ignorance. We face risk because we are ignorant about the future—after all, if we were omniscient, there would be no risk. Because ignorance is a personal experience, risk is necessarily subjective. When we put a number on risk, that number says as much about us—how little we know—as it says about the world around us.

Suppose you are in a casino. A man rolls a die behind a screen. If the result is a 6, you are going to lose $100. Behind the screen, the man sees the result of the die toss, but you have not yet seen it. In this example, the outcome is certain. It has already been determined. Uncertainty exists only in your head—but the risk is real until you see the die.

Let's try to quantify your risk in this example. To characterize the risk, we need to describe the uncertainty as well as your exposure to that uncertainty. Obviously, your exposure is $100. That is the amount you stand to lose. But what is your uncertainty— what is the probability that you will lose $100?

If you say it is one chance in six, I am sorry. You are wrong. I forgot to mention that the die is 10-sided. This illustrates an important point. Whenever we try to quantify risk, we are describing our own understanding of a situation. Often, there will be aspects

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of a situation that we are simply unaware of. It is one thing to not know the answer to a question. It is another matter to not even know the question exists.

Returning to our casino example, we still don't know your probability of losing $100. It is not one in ten. After all, the man throwing the die may be cheating. We are aware of the possibility, but it is difficult to place a number on that risk.

Would it help if I told you the man is unshaven and smells of whiskey? Maybe your opinion would change if I told you instead that he is a kindly grandfather wearing a boy scout cap. Changing the description may sway some peoples' opinions. It may not sway others'. Risk is subjective.

So what does this mean if we want to measure the financial risks of an organization? To find out, let's look at how risks are quantified. It is a four-step process:

- Define the risk to be measured
- Agree on a model for that risk
- Specify a risk measure that is compatible with that model
- Estimate the value of that measure implied by the model.

For example, the process might be as follows:

- Risk: market risk of a specified portfolio
- Risk model: market variables are assumed to be jointly normally distributed with specified volatilities and correlations
- Risk measure: one-day 90% VaR
- Risk estimate: achieved with Monte Carol simulation using 5,000 quasi-randomly generated scenarios.

It is the second step of the process that is pivotal. It is at this point that we take the subjective notion risk and describe it in an objective manner. However, a group of individuals may agree on a model, but retain their own subjective opinions about the risk. In this sense, the model does not make risk an objective notion, it merely makes the measure of risk an objective notion.

Let's continue with the example of market risk. Suppose a trading operation has implemented the above VaR system. One day a trader takes on a sizable long position in the Japanese yen, exceeding her risk limit. She knows the markets and is aware of a combination of market factors—perhaps central banks are intervening in the markets—that are going to drive the yen up in the short-term. She considers the position appropriate.

Her risk manager disagrees. He doesn't know about central bank intervention—and he doesn't care. All he knows is that the trader has exceeded her limit, and he calls her on it.

Reviewing the VaR number that indicates her limit violation, the trader retorts: "The model is wrong. I know the markets. I know what the central banks are doing. I'm on the phone with FX professionals all day long. This VaR model is just a bunch of formulas. It doesn't know the yen is going up, but I do. There is zero risk in my long position because any other market position, under these circumstances, would be ridiculous."

Who is right, and who is wrong? The trader knows the markets. It's her job. By the same token, what is the point in having a risk manager who is going to be overruled by every trader with a market view?

Some might perceive that the answer is to build a better VaR model— one that somehow captures the trader's intuitive understanding of central bank intervention. Others may cling to the existing VaR model, claiming that efficient markets and no-arbitrage conditions ensure its ultimate validity.

In fact, neither approach can possibly work. They both make a supposition that there is a "right" model—if only we can identify it. Markets, however, are too complex and ever-changing for any model to fully describe. Selecting a model is a subjective process.

Our FX trader and risk manager have a legitimate difference of opinion. To resolve such a situation, we have to get beyond the simplistic notion that one is right and the other is wrong. I so doing, we must challenge the idea that every risk has a number—that there is a "right" model that will find that number, and other models are "wrong." We must embrace the notion that risk is subjective.

We cannot manage market risk by having a risk manager forming—and then enforcing—his own subjective opinions about the riskiness of a trader's position. This would be unfair to the trader, and it would reduce the risk manager to being, in effect, just another trader.

Instead, we implement an objective benchmark for risk in the form of a VaR model. It may assume that market variables are normally distributed despite some observers preferring the lognormal assumption. It may not capture market leptokurtosis. It probably won't understand "sticky" volatilities. This is not important.

If we have a perfect model, it would know everything there was to know about the markets. It would eliminate the need for traders. We could trade the portfolio based upon the model—and we would be foolish not to.

A VaR model, however, is limited because it is objective whereas risk taking is subjective. If we deny that subjectivity, we deny a role for human judgment. Rather than trade portfolios based upon a model, we rely upon traders because we believe they understand things the model cannot.

This leaves us with two—potentially inconsistent—market views: that of the model; and that of the traders.

The question is: How can we use the objective VaR model to manage the risk-taking process, but not place arbitrary—or even dangerous—restrictions upon the activities of traders?

The answer is risk limits. These represent explicit authority for traders to take positions that differ from the model's perception of the markets. Risk limits enable an organization to manage risk by limiting traders to taking positions within a specified range. The role of the VaR model is to objectively define what that range is. The trader's role is to select the optimal position within the range.

In this context, VaR is just a tool for delimiting a set of acceptable portfolios. We can call it a "risk measure" if we like, but we don't have to.

Like any tool, VaR has limitations. It will be useful for performing some tasks, but not others. For example, other possible applications of VaR

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include determining capital requirements, capital allocation, or performance-based compensation.

Each process entails risk assessment. Accordingly, each is subjective. If we wish to apply the objective tool VaR to any of these, we must first ask what role VaR is to play. In each case, some mechanism must be found that will enable VaR to support subjective human judgment—without replacing it. For market risk management, the answer was risk limits. For other possible applications, the question remains open.

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END NOTES

1. See the J.P. Morgan CreditMetrics Technical Document and "VaR in Operation" by Duncan Wilson, *Risk*, December 1995.
2. See "CIBC Gets Commercial," *Risk*, August 1996.
3. See "Modeling of Operations Risk," by M. Yone, et al., in the Financial Risk Management Discussion Group (March 1997).
4. See "The World According to Nassim Taleb," *Derivatives Strategy*, December/January 1997.
5. See "Value at Risk: Implementing a Risk Management Standard," by Chris Marshall and Michael Siegel, *Journal of Derivatives*, Spring 1997.

Applying Insurance Company Quantitative Techniques for Improved Capital Budgeting

by Tony Dardis and Andrew Berry

The insurance industry has always used sophisticated quantitative techniques for appraising capital investment. The same, however, cannot always be said of other industries. In a 1994 study, the Confederation of British Industry found that only about one quarter of manufacturing companies use quantitative methods to assess project risk, with the majority relying on subjective judgment. It is generally thought that manufacturers in the United States have similarly been slow to adopt quantitative techniques in appraising projects. So, could some of these insurance industry techniques be applied to help organizations in other fields? In particular, should consideration be given to the use of these techniques for appraisals of capital projects?

This article recognizes and acknowledges the work of both the U.K. Institute of Actuaries and the Society of Actuaries in this area, in particular the important paper authored by a working party set up by the U.K. Institute entitled "Capital Projects," published in the *British Actuarial Journal* (Volume 1, Part II, 1995, pages 155–300). Many of the definitions used in the introductory sections of what follows are taken directly from the Institute paper. We take the discussion somewhat further, however, in looking at some of the more state-of-the-art techniques currently in use today within the insurance industry. A similar SOA working party is in its formative stages in the United States.

We have defined a capital project in the same fashion as the Institute working party, that is, "any project where the investment has significant physical, social, or organizational consequences and is not merely to secure a transfer of ownership of an existing asset [such as portfolio investment]." This definition therefore includes such schemes as:

- Physical construction, such as building a factory, bridge, or road
- Starting a new business producing goods or services, or a new product line in an existing business
- Taking over and modernizing an existing business or physical asset
- Developing a new asset for an existing business
- Repairing or renewing an existing asset.

Current Capital Budgeting Techniques

Capital projects are most commonly evaluated using pay-back period, net present value, or internal rate of return. Again, using the Institute paper definitions:

- ***Pay-back Period Technique***: A project is accepted if the number of years of projected cash flow required to return the initial investment is less than a pre-set maximum cut-off period (no account taken of the time value of money).
- ***Internal Rate of Return***: Find the interest rate (IRR) that equates the present value of expected future cash flows with initial costs and accept the project if the IRR exceeds the opportunity cost of capital.
- ***Net Present Value***: Find the present value (NPV) of the expected future cash flows of a project discounted at the opportunity cost of capital and accept the project if the NPV is greater than zero.

IRR and NPV incorporate the time value of money through discounting to present values and try to incorporate the notion of risk through the use of the relevant discount rate. Risk in this context means that actual returns from the project (revenues less costs) may be

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