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Search Go

> Home
> Teaching
> Finance Essentials
> Suggested Books and Movies
> General Investment Information
> Research
> Miscellaneous Tools and Tips
> Personal

Ravi Shukla > Finance Essentials

Risk

Risk is one of those ideas that we understand intuitively, but often find it difficult to describe. Regardless, we understand that risk is something bad and is to be avoided, unless of course there are incentives to not avoid it. To understand risk, we need to understand the related concepts of randomness, variability and uncertainty.

Randomness refers to a situation where the outcome may take a value from a set of several possible outcomes. For example, when rolling a die (die is singular of dice), the possible outcomes are 1, 2, 3, 4, 5, and 6. The actual realized outcome from rolling the die may be any of these. If the die is fair, i.e., not loaded, each outcome is equally likely with the probability of 1/6. You can roll the die virually at this page of Random.org.

Randomness creates variability in the outcomes. For example, if we roll the die 10 times, we may observe the following outcomes: 2, 6, 4, 5, 3, 2, 6, 4, 4, 3. We can quantify variability by measures such as variance, standard deviation, and range.

Randomness and variability lead to risk if some of the possible outcomes are *undesirable*. Imagine a game in which you roll a pair of dice. You win $5 if both the dice show the same numbers (4 and 4, for example) and lose $1 if the dice show different numbers (3 and 5, for example). In this game unmatched dice results are undesirable as they create loss of wealth.

In finance, risk refers to the possibility of loss (PoL). When investing, we *fear* that we might lose some our principal or initial investment and earn a negative return. For example, if you buy shares of a stock for $100 per share, the risk is that the stock will be worth less than $100 in the future. If the stock price turns out to be $90, you'd lose $10 or 10% of your initial investment, and your return would be −10%. Consistent with this definition of undesirability, risk is defined as the probability of loss, i.e., Prob($r < 0$). While this definition of undesirability is fairly common, it is not universal by any means. Some people define undesirable outcome to mean the situation where the return is less than 4\%, the rate of return that could be earned on a bank account. Others define undesirable outcome as one where the return is less than 2\%, being the expected inflation rate. Keeping these alternative definitions of undesirability in mind, risk can be expressed as Prob($r < r^*$).

Some people may not care about the probability or likelihood of low return. Instead, they may be concerned about the maximum they can lose. This measure of risk is known as value at risk (VaR). Technically speaking, one can lose everything invested. If you buy a stock for $100 per share, the stock price may go down to $0, causing you to lose the entire investment, a return of −100%. To avoid getting this obvious answer in response to the serious question: How much can I lose?, we qualify the question by adding a probability associated with the rarity of the risky event(s). So, for example, we might want to know how much we can lose if an event that happens only 1\% of the time or less were to happen. The value at risk can be determined by first calculating the return associated with such an event and then coverting he return to the amount lost. The return is r^* such that Prob($r < r^*$)=1\%. Some reflection should convince you that VaR is the inverse of PoL: PoL measures the probability given a r^*, while VaR measures r^* given a probaility.

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