Finance 4335 (Risk Management) Course Overview

by James R. Garven*

April 29, 2024

Abstract

This course provides a comprehensive approach to risk management by integrating concepts, tools, and techniques from finance and related fields such as economics and the decision sciences. The course emphasizes identifying, evaluating, pricing, and managing risk from both personal and corporate perspectives. Key topics include understanding and measuring risk attitudes, comparing and pricing risks, assessing the impact of risk on stakeholder incentives and corporate value, and devising effective risk management strategies for individuals and organizations.

Part 1: Finance 4335 introduces students to the expected utility hypothesis and how rational decision-makers should make choices under conditions of risk based on their risk preferences. Special cases of expected utility (mean-variance theory and stochastic dominance) are also considered, as are risk measures other than variance, such as skewness and kurtosis.

I. **Part 1**

A. The foundational principle upon which Finance 4335, Part 1 is based is that decision-makers vary in terms of their risk-bearing preferences. While our primary focus in Finance 4335 is on modeling risk-averse behavior (where decision-makers dislike risk but are willing to bear risk if properly compensated), we also consider risk neutrality (where decision-makers care only about expected wealth and are indifferent about risk) and risk-seeking behavior (where decision-makers not only prefer to bear risk but are willing to expend resources for the opportunity to do so).

B. Regardless of whether one is risk averse, risk neutral, or risk loving, the foundation for decision-making under conditions of risk and uncertainty is expected utility. Given a choice among various risky alternatives, one selects the choice that yields the highest utility ranking.

1. <u>If one is risk averse</u>, then the expected value of wealth ($E(W)$) exceeds the certainty equivalent of wealth (W_{CE}), and the difference between $E(W)$ and W_{CE} is equal to the risk premium λ. Here are some practical implications - under risk aversion, insurance buyers may find actuarially unfair insurance premiums to be financially attractive. If a bettor is risk averse, he or she will not be willing to pay more than the certainty equivalent of wealth for a bet on a sporting event or a game of chance such as rolling dice or tossing a coin.

*James R. Garven is the Frank S. Groner Memorial Chair in Finance and Professor of Finance & Insurance at Baylor University (Address: Foster 320.39, One Bear Place #98004, Waco, TX 76798, telephone: 254-307-1317, e-mail: James_Garven@baylor.edu).

2. If one is risk neutral, then $E(W) = W_{CE}$ and $\lambda = 0$; risk is inconsequential and all you care about is maximizing the expected value of wealth.

3. If one is risk loving, then $E(W) < W_{CE}$ and $\lambda < 0$; i.e., such a person is willing to pay for the opportunity to (on average) lose money. This is because risk is, by definition, a "*sought-after*" attribute for someone with risk loving preferences.

C. We discuss different methods for calculating λ for risk averse decision-makers.

1. The initial method considered requires 1) calculating expected utility $E(U(W)$, 2) setting expected utility equal to the certainty-equivalent of wealth; i.e., $E(U(W)) = U(W_{CE})$, 3) solving the $E(U(W)) = U(W_{CE})$ equation for W_{CE}, and 4) determining λ by calculating the difference between $E(W)$ and W_{CE}. For example, suppose the decision-maker has $U(W) = \sqrt{W}$, $E(W) = \$110$, and $E(U(W)) = 10$. Then $W_{CE} = 100$, and $\lambda = E(W) - W_{CE} = \$110 - \$100 = \$10$.

2. An alternative method for calculating λ involves evaluating the Arrow-Pratt coefficient $(R_A(W) = -U''/U')$ at the expected value of wealth and multiplying it by half of the variance of wealth. Suppose the variance of wealth $\sigma_W^2 = 4{,}400$. Then for $U(W) = \sqrt{W}$, $R_A(W) = .5/W$ and $\lambda \cong .5\sigma_W^2 R_A(E(W)) = .5(4,400)(.5/\$110) = \$10$.

   a. The Arrow-Pratt method provides important intuitive insights into the determinants of risk premiums. We find that risk premiums depend on two factors: 1) the magnitude of the risk itself (as indicated by variance), and 2) the degree to which the decision-maker is risk averse (as indicated by the Arrow-Pratt coefficient). For example, suppose $U(W) = \ln W$. Then $R_A(W) = 1/W$ and $\lambda \cong .5\sigma_W^2 R_A(E(W)) = .5(4,400)(1/\$110) = \$20$. Thus, the logarithmic decision-maker is *twice* as risk averse than the square root decision-maker.

D. We consider "special cases" of expected utility; specifically, the mean-variance and the stochastic dominance models. If we impose various restrictive assumptions upon expected utility, then these models emerge as "special cases".

1. As long as the various restrictive assumptions required by these models apply, we can be confident that if risk X "dominates" risk Y, then the expected utility for X is greater than the expected utility for Y; a result which applies to *all arbitrarily risk averse decision-makers.*

2. Of these two models, the mean-variance model is more restrictive than stochastic dominance. Indeed, the mean-variance model is *not* an appropriate method for risk evaluation under a variety of circumstances. For example, if one risk has a *higher mean and variance* than another risk, then we need further information about the decision-maker's utility function to determine which risk is preferred; just knowing

the mean and variance is *not sufficient* in such a case.

3. The mean-variance model implicitly assumes that *risks* are *symmetrically distributed* and have *"thin" tails*; examples of such distributions include the binomial distribution in the discrete setting and the normal distribution in the continuous setting. However, if the underlying distribution is skewed or fat-tailed, then it is *not appropriate* to rank-order risks based on the mean-variance framework because variance only partially captures risk.
   a. To illustrate this, we consider a numerical example (see pp. 6-8 of the Decision Making Under Risk and Uncertainty (Part 3) lecture note) in which a positively skewed risk with a lower mean and a higher variance has higher expected utility than a symmetrically distributed risk with a higher mean and lower variance.
4. The stochastic dominance model is more flexible than the mean-variance model in cases such as the example presented in I.A.3.a. above because the stochastic dominance model properly accommodates broader risk attributes such as skewness and kurtosis.

Part 2: Building on the foundation of Part 1, we consider behavioral economics, insurance economics (e.g., the Bernoulli Principle, Mossin's theorem, and Arrow's theorem) and asymmetric information (e.g., moral hazard and adverse selection). We also compare and contrast risk implications of insurance economics (with its emphasis on idiosyncratic risks) vis-a-vis portfolio/capital market theory (which emphasizes systematic risk).

II. **Part 2**

A. Behavioral Economics: Expected utility (the primary topic covered during Part 1 of Finance 4335) is based on the principle of rationality in decision-making under risk and uncertainty, whereas behavioral economics identifies how emotions and cognitive biases can also influence decision-making. Key concepts include:

1. Loss aversion: "Loss aversion" causes decision-makers to feel more pain and regret from losing \$100 than satisfaction from gaining \$100.
2. Framing: "Framing" refers to how information is presented to individuals, which can significantly influence and alter their decisions and judgments.
3. How Framing interacts with emotions and cognitive biases:
   a. Loss Aversion and Framing - Framing accentuates loss aversion by emphasizing losses rather than gains, impacting decision-making processes such as medical choices based on survival versus mortality rates.
   b. Confirmation Bias and Framing - Framing can reinforce confirmation bias by presenting information that aligns with preexisting beliefs, leading to uncritical

acceptance.

c. Overconfidence Bias and Framing - Framing affects overconfidence by either enhancing or diminishing self-assurance based on whether successes or failures are highlighted.

d. Optimism Bias and Framing - Framing can amplify or mitigate optimism bias, with positive framing increasing unwarranted optimism and negative framing increasing unwarranted pessimism.

e. Availability Bias and Framing - Framing influences availability bias by overemphasizing the importance of recent or readily available information.

f. Hindsight Bias and Framing - Framing can impact hindsight bias by depicting outcomes as predictable, reinforcing the misconception that one 'knew it all along.'

g. Anchoring Bias and Framing - Framing establishes the initial reference point for decisions, significantly influencing how subsequent information is interpreted and judgments are made.

B. Insurance economics: After exploring behavioral economics, we return to studying risk management through the lens of expected utility. We examine how risk aversion motivates risk transfer to an insurer through insurance economics. Key topics include the Bernoulli principle, Mossin's theorem, and Arrow's theorem.

1. Bernoulli Principle – risk averters fully insure if insurance is actuarially fair.
2. Mossin's Theorem – risk averters partially insure if insurance is actuarially unfair.
3. Arrow's Theorem – Other things equal, if insurance is actuarially unfair, then the optimal partial insurance contract is the deductible contract.

C. Asymmetric information, moral hazard, and adverse selection

1. Asymmetric information occurs in a counterparty relationship, where one party has an informational advantage over the other.
2. The two types of problems that arise when there is asymmetric information include (1) moral hazard, which is a problem of *hidden action* that occurs *after* a counterparty relationship has been formed (e.g., between a firm and its manager), and (2) adverse selection, which is a problem of *hidden information* that occurs *prior to* to the formation of a counterparty relationship (e.g., between a prospective buyer and seller).

D. Portfolio Theory

1. A mean-variance-efficient set of portfolios lies along the northwest perimeter of the feasible set of portfolios, where σ_p is the variable on the X axis and $E(r_p)$ is the variable on the Y axis.

2. Optimal exposure to risk is positively related to the Sharpe Ratio and risk tolerance; inversely related to market volatility.

E. Capital Market Theory

1. From the portfolio theory, it follows that expected utility-maximizing investors will (depending on their level of risk tolerance) either lend or borrow at the riskless rate of interest r_f against the (tangent) market portfolio M.

2. Thus, the mean-variance efficient set of portfolios in a world with riskless lending and borrowing is the locus of points that lie along the *Capital Market Line*, the equation for which is $E(r_p) = r_f + \frac{E(r_M) - r_f}{\sigma_M}\sigma_p$.

3. The *Security Market Line*, also known as the Capital Asset Pricing Model or CAPM, follows as a logical consequence of the Capital Market Line. Its equation is $E(r_i) = r_f + \beta_i[E(r_M) - r_f]$, where $\beta_i = \sigma_{iM}/\sigma_M^2$ indicates (on a relative scale) how risky asset i is compared with M.

4. Thus, the expected return on a risky asset i is equal to the expected return on a riskless asset r_f, plus a risk premium that is proportional to the excess expected net return of the market above the expected return on a riskless asset; that is, $E(r_m)-r_f$; the proportionality factor is β_i. The CAPM implies that only "systematic risk " (that is, covariance) is priced. "Unsystematic" risk (idiosyncratic or unique) is inconsequential since investors fully diversify unsystematic risk away by holding combinations of the riskless asset and the market portfolio.

5. The fact that corporations actively manage unique and systematic risks contradicts the notion that only systematic risk matters. For example, US firms paid nearly $300 billion in commercial property-liability insurance premiums in 2019.[1] To put this in context, the total dividends paid by US non-financial corporations in 2022 were $1,329 billion.[2] Thus, it appears that the management of unique firm-specific risks is important after all. We will explore reasons for this in the third (and concluding) part of Finance 4335.

Part 3: Derivatives such as futures, forwards, and options contracts are important risk management tools that are priced via well-known "arbitrage-free" methods. Corporate limited liability exposes investors to firm-specific risks and contributes to the demand for risk management. Credit risk must be managed because of the default potential of the firm's secured and unsecured liabilities. Risk management adds value by, among other things, facilitating optimal investment strategies by mitigating agency problems and reducing various frictional costs related to factors such as tax asymmetries and financial distress.

[1] See Chapter 7, page 65 of the 2021 Insurance Fact Book.

[2] See "Dividends paid: Domestic corporate business: Nonfinancial".

III. **Part 3**

A. Risk Management using Financial Derivatives

1. Derivatives such as futures/forwards and options are widely used for the purpose of managing financial risks.
2. Limited liability creates option-like payoffs for corporate stakeholders, which implies that firm-specific risks affect corporate value.

B. Pricing of Financial Derivatives

1. Pricing of Futures/Forwards - we show that the "arbitrage-free" price of a forward contract that expires T periods from today is $K = Se^{rT}$, where S corresponds to the current market value of the underlying asset. If this equality does not hold, e.g., if $K > Se^{rT}$, then one can earn positive profits with zero net investment and zero risk by selling forward and buying the replicating portfolio. Similarly, if $K < Se^{rT}$, then one can earn positive profits with zero net investment and zero risk by buying forward and selling the replicating portfolio.[3]
2. Similar arguments apply to the pricing of options; specifically, the replicating portfolio for a call option is a margined investment in the underlying, whereas the replicating portfolio for a put option represents a combination of a short position in the underlying along with the purchase of a bond.
3. Approaches to pricing options in both the discrete-time and continuous-time cases include delta hedging, replicating portfolio, and risk neutral valuation approaches.
4. The arbitrage-free call option price according to the discrete-time "binomial" model (also known as the Cox-Ross-Rubinstein, or CRR model) is $C = SB_1 - Ke^{-rT}B_2$, and the arbitrage-free call option price according to the continuous-time model (also known as the Black-Scholes-Merton, or BSM model) is $C = SN\left(d_1\right) - Ke^{-rT}N\left(d_2\right)$.
5. Prices for otherwise identical (same underlying asset, same exercise price, same time to expiration) put options in both settings (discrete-time and continuous-time) are obtained by applying the put-call parity equation. Consequently, $P = Ke^{-rT}(1 - B_2) - S(1 - B_1)$ under the CRR model and $P = Ke^{-rT}N(-d_2) - SN(-d_1)$ under the BSM model.
6. For a given time to expiration (T, where $T = n\delta t$), as the number of time-steps (n) and the length of each time-step (δt) become arbitrarily large and small, respectively, the CRR call and put model prices converge to the BSM call and put model prices (thanks to the Central Limit Theorem).

[3]See pp. 10-14 of the Derivatives Theory, part 1 lecture note for further details on arbitrage-free pricing of forward contracts.

C. Credit Risk

1. Under limited liability, the value of the corporation's equity corresponds to a call option on the value of its assets, with an exercise price equal to the promised debt payment.
2. Under limited liability, debt issued by the corporation is risky for investors because promised payments on the debt are subject to the risk of default. Therefore, the value of risky debt is equal to the value of safe debt minus the value of the (put) option to default.
3. In the Credit Risk Class Problem, we show how to apply option pricing principles to value the option to default as well as determine the credit risk premium that investors demand from companies that issue risky debt.

D. Corporate risk management

1. Important determinants of corporate risk management policies considered in Finance 4335 include:
   a. Tax asymmetries (in the form of progressive marginal tax rates and incomplete tax-loss offsets) motivate firms to employ various corporate risk management strategies that increase after-tax rates of return to shareholders by lowering the expected value of taxes.
   b. Corporate risk management creates value by facilitating optimal investment; e.g., we show how coordinating corporate financing and risk management decisions mitigate the so-called underinvestment problem (where, in the absence of risk management, it may sometimes be "rational" to reject a positive net present value project). The dynamic interaction between financial and risk management policies also determines whether the firm may be inclined to engage in risk-shifting behaviors. These agency problems derive from incentive conflicts between corporate owners and creditors caused by corporate limited liability. Furthermore, because of adverse selection in equity markets, risk management ensures the company has the cash available to fund value-enhancing investments that might otherwise be foregone.
   c. The design of the managerial compensation contract is an important corporate risk management determinant; e.g., see pp. 27-38 of the "Why is Risk Costly to Firms?" lecture note.