




Uncertainty and Consumer Behavior  
EE311

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Topics to be Discussed

- Definitions of Risk
- Describing Risk
- Preferences Toward Risk
- Reducing Risk
- The Demand for Risky Assets


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Definition of Risk

- Risk is a possibility of suffering harm or loss or danger.
  - Risk of loss from the stock market.
  - Risk of fire.
  - Risk of failing this course.
  - Risk of business loss.

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Types of risk

- **Pure Risk:** A category of risk in which loss is the only possible outcome; there is no beneficial result. Pure risk is related to events that are beyond the risk-taker's control and, therefore, a person cannot consciously take on pure risk.
- **Speculative Risk:** A category of risk that, when undertaken, results in an uncertain degree of gain or loss. All speculative risks are made as conscious choices.

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## Describing Risk

- To measure risk we must know:
  - All of the possible outcomes.
  - The probability or likelihood that each outcome will occur (its probability).
- Interpreting Probability
  - Objective Interpretation
    - Based on the observed frequency of past events
  - Subjective Interpretation
    - Based on perception that an outcome will occur
    - Based on judgment or experience

## Probability

- The probability for and event  $X_i$  is denoted by  $P(X_i)$
- It measure the frequency of the event

$$P(X_i) = \frac{n}{N}$$

$n$  = number of outcomes that  $X_i$  occurs

$N$  = total number of outcomes

## Probability

- The value of probability must be between 0 and 1
  - $P(X_i) = 0$  means definitely not going to occur
  - $P(X_i) = 1$  means definitely going to occur
- $\sum P(X_i) = 1$  the summation of all mutually exclusive events must equal to one. For example
  - Total sum of probability of getting “Head” and “Tail” is one

## Describing Risk

- Expected Value
  - The weighted average of the payoffs or values resulting from all possible outcomes.
- Expected value measures the central tendency; the payoff or value expected on average.

$$E(X) = \sum_{i=1}^N P(X_i) X_i$$

## Expected Value – An Example

- Investment in offshore drilling exploration:
- Two outcomes are possible
  - Success – the stock price is \$40/share
  - Failure – the stock price is \$20/share
- Objective Probability
  - Probability (Pr) of success = 0.25 and the probability of failure = 0.75
- $E(X) = .25(\$40) + .75(\$20) = \$25/\text{share}$

## Law of large numbers

- In a repeated independent trials with the same probability, as the numbers of trials increase the predicted probability will become closer and closer to the true probability.
  - We cannot predict the exact outcome.
  - But we can predict the average likelihood of the outcome.

## Application: Fair Bet

- A bet that causes the expected outcome of the gambling equals to zero.
- Example: a gambling promises to pay ₪100 if you guess the right face of a coin. What should be a fair bet?
- Let the fair bet be  $X$  and the coin is fair.

$$E(X) = 0.5(100 - X) + 0.5(-X) = 0$$

$$50 - 0.5X - 0.5X = 0$$

$$X = 50$$

We should not bet more than ₪50.

## Standard deviation

- It is used to measure the variability of events from the expected value.
- Larger standard deviation means more variability and larger risk.
- Formula

$$\sigma = \sqrt{\sum P(X_i) [X_i - E(X)]^2}$$

### Standard deviation – Example 1

- The first job is based entirely on commission.  
There are two equally likely outcomes in the first job--฿5,000 if the economy is bad but ฿25,000 if it is good.
- The second is a office position. It pays ฿10,000 if the economy is bad, but ฿20,000 if it is good.

### Standard deviation – Example 1

Unit: Th. Baht

	Bad Economy		Good Economy	
	Prob.	Income	Prob.	Income
<b>Job 1: Commission</b>	.5	5	.5	25
<b>Job 2: office position</b>	.5	10	.5	20

### Standard deviation – Example 1

- Both jobs have the same expected income  

$$E_1(X) = (0.5)(5) + (0.5)(25) = 15$$

$$E_2(X) = (0.5)(10) + (0.5)(20) = 15$$
- Standard deviation  

$$\sigma_1 = \sqrt{(0.5)(5-15)^2 + (0.5)(25-15)^2} = \sqrt{100} = 10$$

$$\sigma_2 = \sqrt{(0.5)(10-15)^2 + (0.5)(20-15)^2} = \sqrt{25} = 5$$
- Job 1 is riskier than Job 2. If you do not like risk, you should take Job 2

### Standard deviation – Example 2

- How should we choose if Job 3 has a higher risk and expected income than Job 2

Unit: Th. Baht

	Bad Economy		Good Economy	
	Prob.	Income	Prob.	Income
<b>Job 2: office position</b>	.5	10	.5	20
<b>Job 3: Direct sales</b>	.5	5.2	.5	25.2

## Standard deviation – Example 2

$$E_2(X) = (0.5)(10) + (0.5)(20) = 15$$

$$E_3(X) = (0.5)(5.2) + (0.5)(25.2) = 15.2$$

The expected income of Job 3 is higher than that of Job 2

- Standard deviation

$$\sigma_2 = \sqrt{(0.5)(10 - 15)^2 + (0.5)(20 - 15)^2} = \sqrt{25} = 5$$

$$\sigma_3 = \sqrt{(0.5)(5.2 - 15.2)^2 + (0.5)(25.2 - 15.2)^2} = \sqrt{100} = 10$$

- Not possible to answer with given tools and need to know about the consumer preferences toward risk



## Preferences Toward Risk

- Can expand evaluation of risky alternative by considering utility that is obtained by risk
  - A consumer gets utility from income
  - Payoff measured in terms of utility
- Example: A person is earning \$15,000 and receiving 21 units of utility from the job.
- She is considering a new, but risky job
  - 0.50 chance of \$5,000
  - 0.50 chance of \$25,000



## Preferences Toward Risk - Example

- Utility at \$5,000 is 12
- Utility at \$25,000 is 24
- Must compare utility from the risky job with current utility of 21
- To evaluate the new job, we must calculate the **expected utility** of the risky job



## Preferences Toward Risk

- The **expected utility** of the risky option is the sum of the utilities associated with all her possible incomes weighted by the probability that each income will occur.

$$\begin{aligned} EU &= (\text{Prob. of Utility 1}) * (\text{Utility 1}) \\ &+ (\text{Prob. of Utility 2}) * (\text{Utility 2}) \end{aligned}$$

$$EU(I) = \sum_{i=1}^K P(I_i) TU(I_i)$$



## Preferences Toward Risk – Example

- The expected is:

$$\begin{aligned} EU &= (1/2)U(\$5,000) + (1/2)U(\$25,000) \\ &= 0.5(12) + 0.5(24) \\ &= 18 \end{aligned}$$

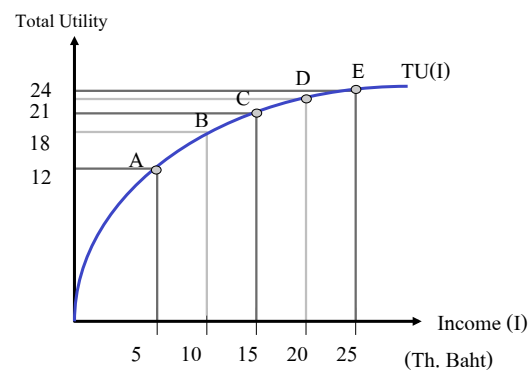
- EU of new job is 18 which is less than the current utility of 21 and therefore less preferred.

## Preferences Toward Risk

- Assume that consumer gets utility solely from income

Income (I)	Total Utility TU(I)	Marginal Utility MU(I)
5	12	-
10	18	6/5
15	21	3/5
20	23	2/5
25	24	1/5

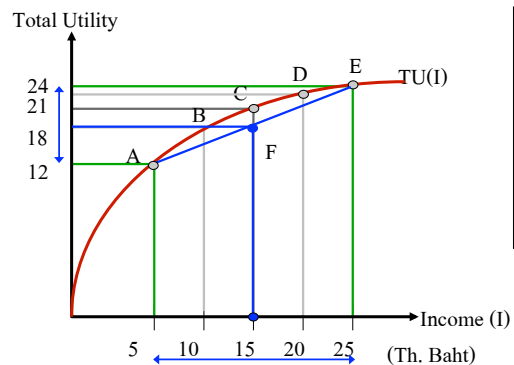
## Example



## Types of preferences toward risk

- Risk Averse:** A person is risk averse if they show a preference toward a certain income over an uncertain income with the same expected value.
- A risk averse person values losses (reducing utility) more than gain.
- The total utility curve is concave or marginal utility is decreasing.

## Risk Averse Utility Function



A risk averse person prefer a certain income of ฿15,000 (C) to an uncertain expected income (F) = ฿15,000

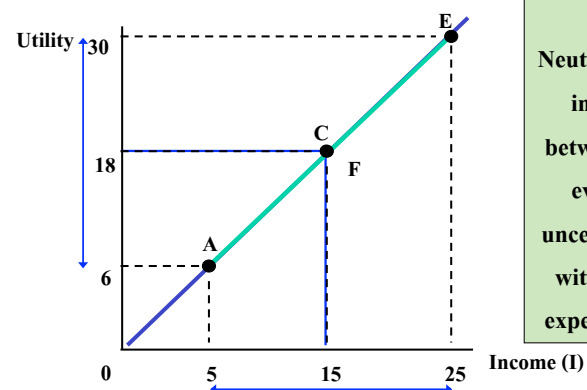
## Risk Averse

- The certain income job earns ฿15,000 with utility = 21
  - Point C on the total utility curve
- The risky job gives equal expected income = ฿15,000, but gives expected utility = 18
  - Point F on the cord that connect points A and E
- Note: This person may take risk if the expected utility of the uncertain alternative is higher.

## Risk Neutral

- **Risk neutral:** a person is said to be **risk neutral** if they show no preference between a certain income, and an uncertain income with the same expected value.
- the marginal utility of income is constant.

## Risk Neutral



A risk Neutral person is indifferent between certain events and uncertain events with the same expected income

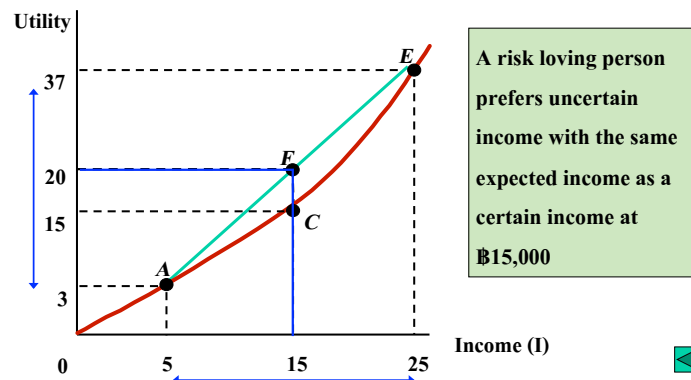
## Risk Neutral

- Expected value for risky option is the same as utility for certain outcome
- $E(I) = (0.5)(\text{₱}5,000) + (0.5)(\text{₱}25,000)$   
 $= \text{₱}15,000$   
 $E(u) = (0.5)(6) + (0.5)(30) = 18$
- This is the same as the certain income of  $\text{₱}15,000$  with utility = 18

## Risk Loving

- **Risk loving:** A person is said to be risk loving if they show a preference toward an uncertain income over a certain income with the same expected value.
  - Example: Gambling, Bungee Jumping
- The total utility is convex or marginal utility is rising

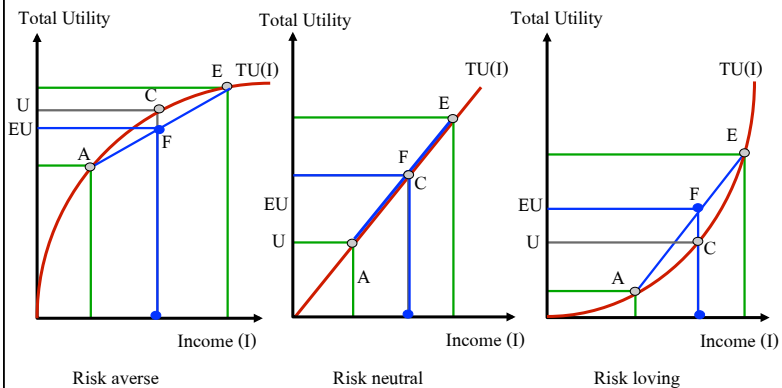
## Risk Loving



## Risk Loving

- Expected income of uncertain job  
 $E(I) = (0.5)(\text{₱}5,000) + (0.5)(\text{₱}25,000)$   
 $= \text{₱}15,000$   
 $E(u) = (0.5)(3) + (0.5)(37) = 20$  – Point F
- Certain income job give  $\text{₱}15,000$  with utility 15 – point C
- He would prefer uncertain job.

## Summary



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## Reducing Risk

- Consumers are generally risk averse and therefore want to reduce risk
- Three ways consumers attempt to reduce risk are:
  - Obtaining more information
  - Diversification
  - Insurance

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## Reducing Risk – Insurance

- Risk averse are willing to pay to avoid pure risk.
- If the cost of insurance equals the expected loss, risk averse people will buy enough insurance to recover fully from a potential financial loss.

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## Pure risk and Insurance

Insurance	Accident (Pr = .1)	No Accident (Pr = .9)	E(I)
No	40,000	50,000	49,000
Yes	40,000	50,000	
Insurance premium = (0.1)10,000	-1,000	-1,000	
Compensation	10,000	0	
Net	49,000	49,000	49,000

Sure income

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## The Law of Large Numbers and insurance



- Insurance companies know that although single events are random and largely unpredictable, the average outcome of many similar events can be predicted.
- When insurance companies sell many policies, they face relatively little risk.

## Reducing Risk



- Insurance company can ensure that total premiums paid will equal total money paid out.
- Companies set the premiums so money received will be enough to pay *expected* losses plus operating costs and profits.

## Systemic Risk and Insurance



- **Systemic risk** is the risk of collapse of an entire system or entire market, as opposed to risk associated with any one individual entity, group or component of a system.
- Human may not know accurate probability of and it can affect the whole group; can't diversify risk .
  - Tsunami, flooding, financial meltdown, terrorist attack
- Governments have had to create insurance for these types of events
  - Ex: National Flood Insurance Program

## Speculative risk and Insurance



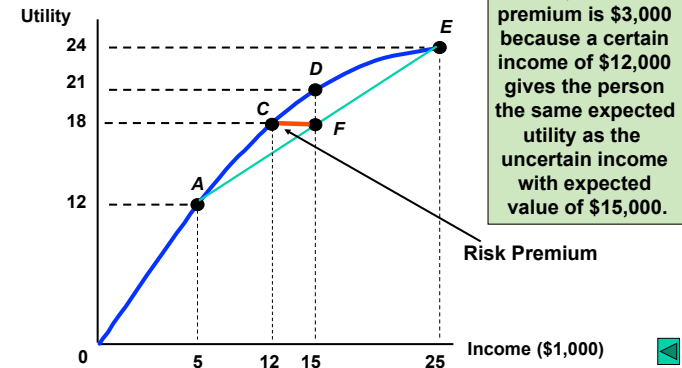
- **Speculative risk** may generate gains or losses and consumers are willing to pay for insurance premium to avoid risk.
- **Insurance Premium:**
- The maximum amount of money that a risk-averse person would pay to make risky option becomes certain option with the same total utility.

## Risk Premium – Example

- From the previous example

- A person has a .5 probability of earning \$25,000 and a .5 probability of earning \$5,000
- The expected income is \$15,000 with expected utility of 18.

## Risk Premium – Example



## Risk Premium – Example

- Point F shows the risky scenario – the utility of 18 can also be obtained with certain income of \$12,000
- \$12,000 is called risk-free equivalent income.
- This person would be willing to pay up to \$3,000 (15,000 – 12,000) to avoid the risk of uncertain income.
- Can show this graphically by drawing a straight line between the two points – line CF

## Reducing Risk

- Diversification
  - Reducing risk by allocating resources to a variety of activities whose outcomes are not closely related.
  - “Don’t put all eggs in one basket.”
- Example:
  - Suppose a firm has a choice of selling air conditioners, heaters, or both.
  - The probability of it being hot or cold is 0.5.
  - How does a firm decide what to sell?

## Income from Sales of Appliances

	Hot Weather	Cold Weather
Air conditioner sales	\$30,000	\$12,000
Heater sales	12,000	30,000

## Diversification – Example

- If the firm sells only heaters or air conditioners their income will be either \$12,000 or \$30,000.
- Their expected income would be:
  - $1/2(\$12,000) + 1/2(\$30,000) = \$21,000$

## Diversification – Example

- If the firm divides their time evenly between appliances their air conditioning and heating sales would be half their original values.
- If it were hot, their expected income would be \$15,000 from air conditioners and \$6,000 from heaters, or \$21,000.
- If it were cold, their expected income would be \$6,000 from air conditioners and \$15,000 from heaters, or \$21,000.

## Diversification – Example

- With diversification, expected income is \$21,000 with no risk.
- Better off diversifying to minimize risk
- Firms can reduce risk by diversifying among a variety of activities that are not closely related

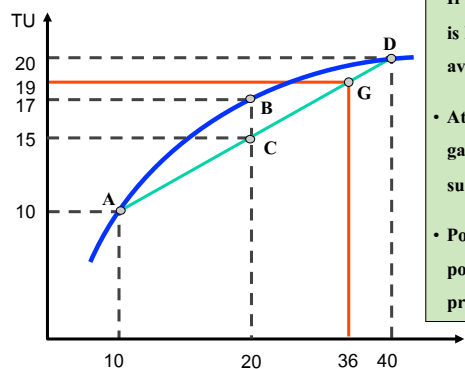
## Reducing Risk – The Stock Market

- If invest all money in one stock, then take on a lot of risk
  - If that stock loses value, you lose all your investment value
- Can spread risk out by investing in many different stocks or investments
  - Ex: Mutual funds

## Gambling

- Why do people take unfair bets?
  - Risk lovers.
  - Compulsion to gambling.
- How do we explain non-compulsive gambling by people who exhibit risk-averse behavior?
  - For entertainment
    - They insure their houses because there is no enjoyable about bearing risk of theft or fire.
    - They bet on horse races because they get enough pleasure from the game.

## Non-compulsive Gambling



- If the probability of winning is high enough even a risk averse person may gamble.
- At G the expected utility of gambling is higher than a sure income at B.
- Point G may be the result of poor judgment on the probability of winning.

## The Demand for Risky Assets

- The higher the return, the greater the risk.
- Investors will choose lower return investments in order to reduce risk
- A risk-averse investor must balance risk relative to return
  - Must study the trade-off between return and risk

### Trade-offs: Risk and Returns: Example

- An investor is choosing between T-bills – riskless and Stocks – risky
- Investor can choose only T-bills, only stocks, or some combination of both
- $R_f$  = risk free return on T-bill
  - Expected return equals actual return on a riskless asset
- $R_m$  = the expected return on stocks
- Assume  $R_m > R_f$  or no risk averse investor would buy the stocks

### Trade-offs: Risk and Returns: Example

- How do we determine the allocation of funds between the two choices
  - $b$  = fraction of funds placed in stocks
  - $(1-b)$  = fraction of funds placed in T-bills
- Expected return on portfolio is weighted average of expected return on the two assets

$$R_P = bR_m + (1 - b)R_f$$

### Trade-offs: Risk and Returns: Example

- Assume,  $R_m = 12\%$ ,  $R_f = 4\%$ , and  $b = 1/2$

$$R_P = bR_m + (1 - b)R_f$$
$$R_P = (1/2)(12\%) + (1 - 1/2)(4\%)$$
$$R_P = 8\%$$

### Trade-offs: Risk and Returns: Example

- How risky is the portfolio?
  - As stated before, one measure of risk is standard deviation
  - Standard deviation of the risky asset,  $\sigma_m$
  - Standard deviation of risky portfolio,  $\sigma_p$
  - Can show that:

$$\sigma_p = b\sigma_m$$

### Trade-offs: Risk and Returns: Example

- We still need to figure out how the allocation between the investment choices
- A type of budget line can be constructed describing the trade-off between risk and expected return

$$R_p = bR_m + (1 - b)R_f$$
$$R_p = R_f + \frac{(R_m - R_f)}{\sigma_m} \sigma_p$$

- Expected return on the portfolio,  $R_p$  increases as the standard deviation,  $\sigma_p$  of that return increases

### Trade-offs: Risk and Returns: Example

- The slope of the line is called the **price of risk**
  - Tells how much extra risk an investor must incur to enjoy a higher expected return

$$\text{Slope} = (R_m - R_f) / \sigma_m$$

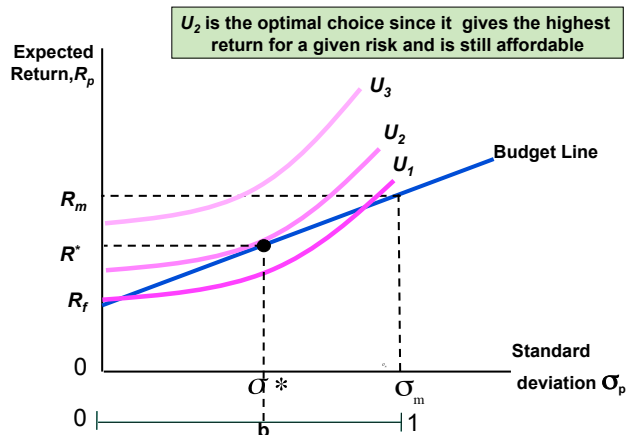
### Choosing Between Risk & Return

- If all funds are invested in T-bills ( $b=0$ ), expected return is  $R_f$
- If all funds are invested in stocks ( $b=1$ ), expected return is  $R_m$  but with standard deviation of  $\sigma_m$
- Funds may be invested between the assets with expected return between  $R_f$  and  $R_m$ , with standard deviation between  $\sigma_m$  and 0

### Choosing Between Risk & Return

- We can draw indifference curves showing combinations of risk and return that leave an investor equally satisfied
- Comparing the pay-offs and risk between the two investment choices and the preferences of the investor, the optimal portfolio choice can be determined
- Investor wants to maximize utility within the “affordable” options

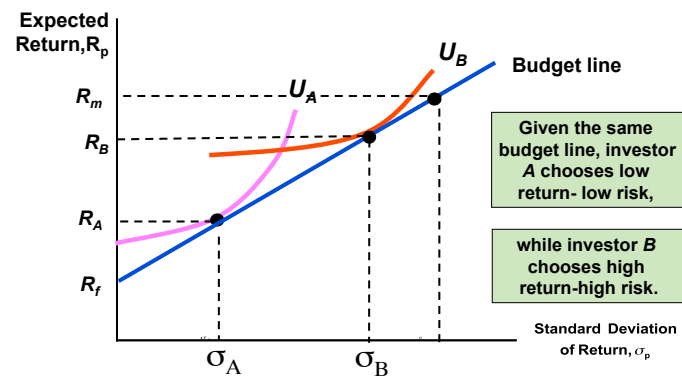
## Choosing Between Risk & Return



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## The Choices of Two Different Investors



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## Choosing Between Risk & Return

- Different investors have different attitudes toward risk
- If we consider a very risk averse investor (A)
  - Portfolio will contain mostly T-bills and less in stock with return slightly larger than  $R_f$
- If we consider a riskier investor (B)
  - Portfolio will contain mostly stock and less T-bills with a higher return  $R_b$  but with higher standard deviation

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