

Uncertainty and Consumer Behavior

EE311

This material is adapted from the original lecture note prepared by Prof. Chayunt.

Topics to be Discussed

- Definitions of Risk
- Describing Risk
- Preferences Toward Risk
- Reducing Risk

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.



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.



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 an event X_i is denoted by $P(X_i)$
- It measures 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



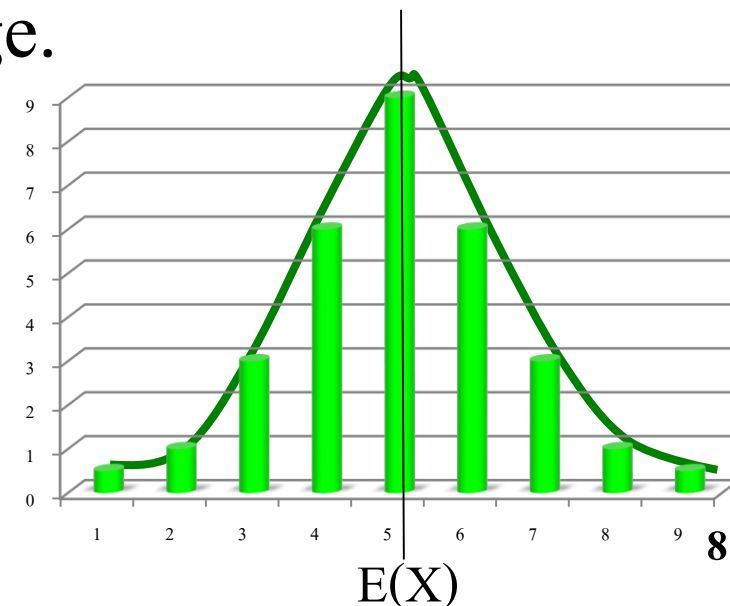
Describing Risk

- **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.

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

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

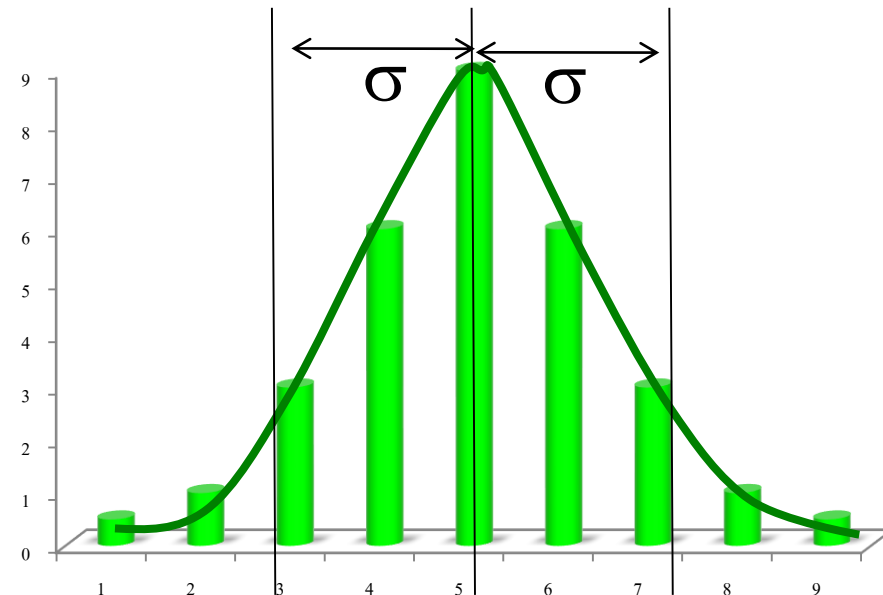
$$X = 50$$

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
Job 1: Commission	.5	5	.5	25
Job 2: office position	.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
Job 2: office position	.5	10	.5	20
Job 3: Direct sales	.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:

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

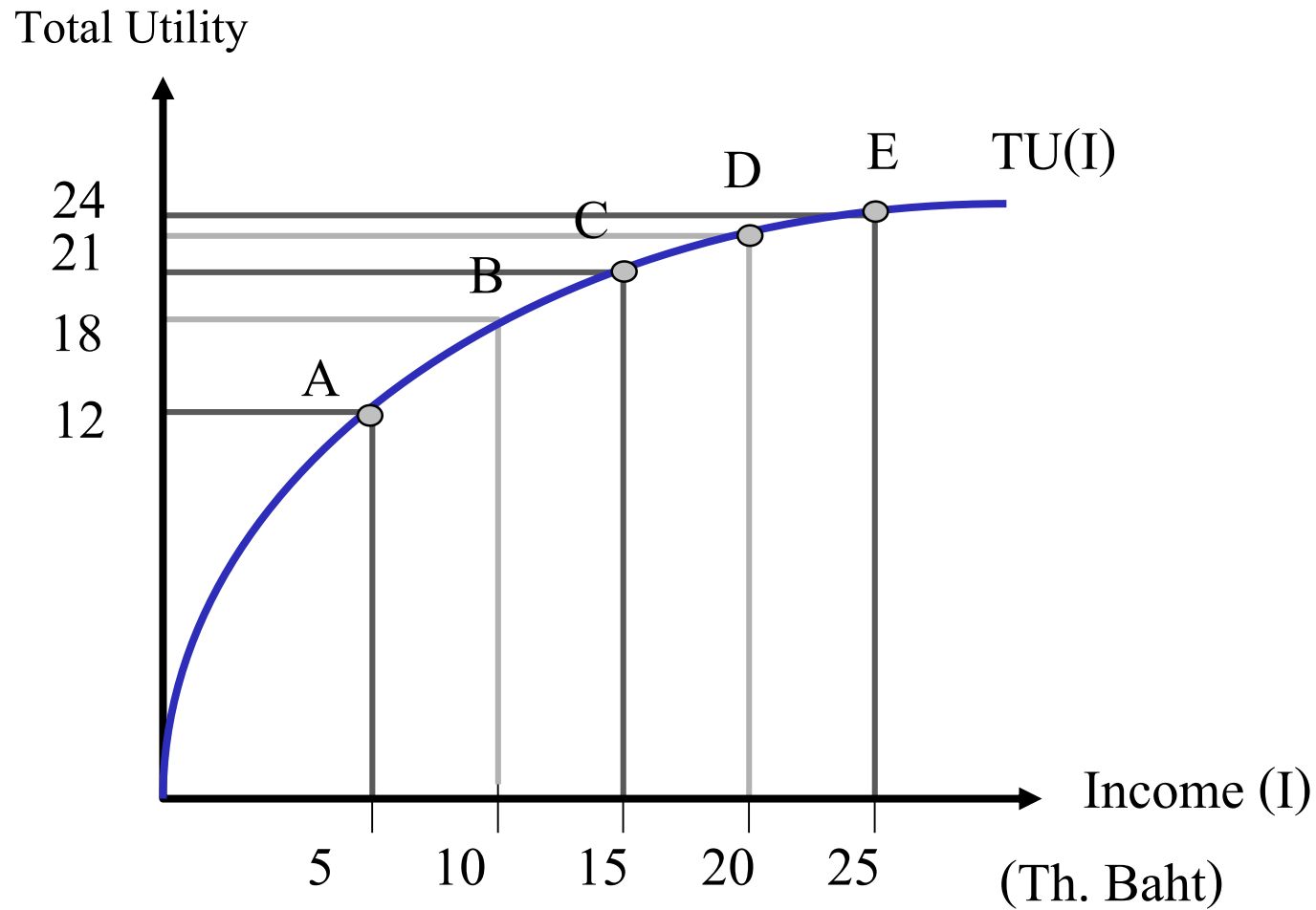
- EU of new job is 18 which is less than the current utility of 21 and therefore less preferred.

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

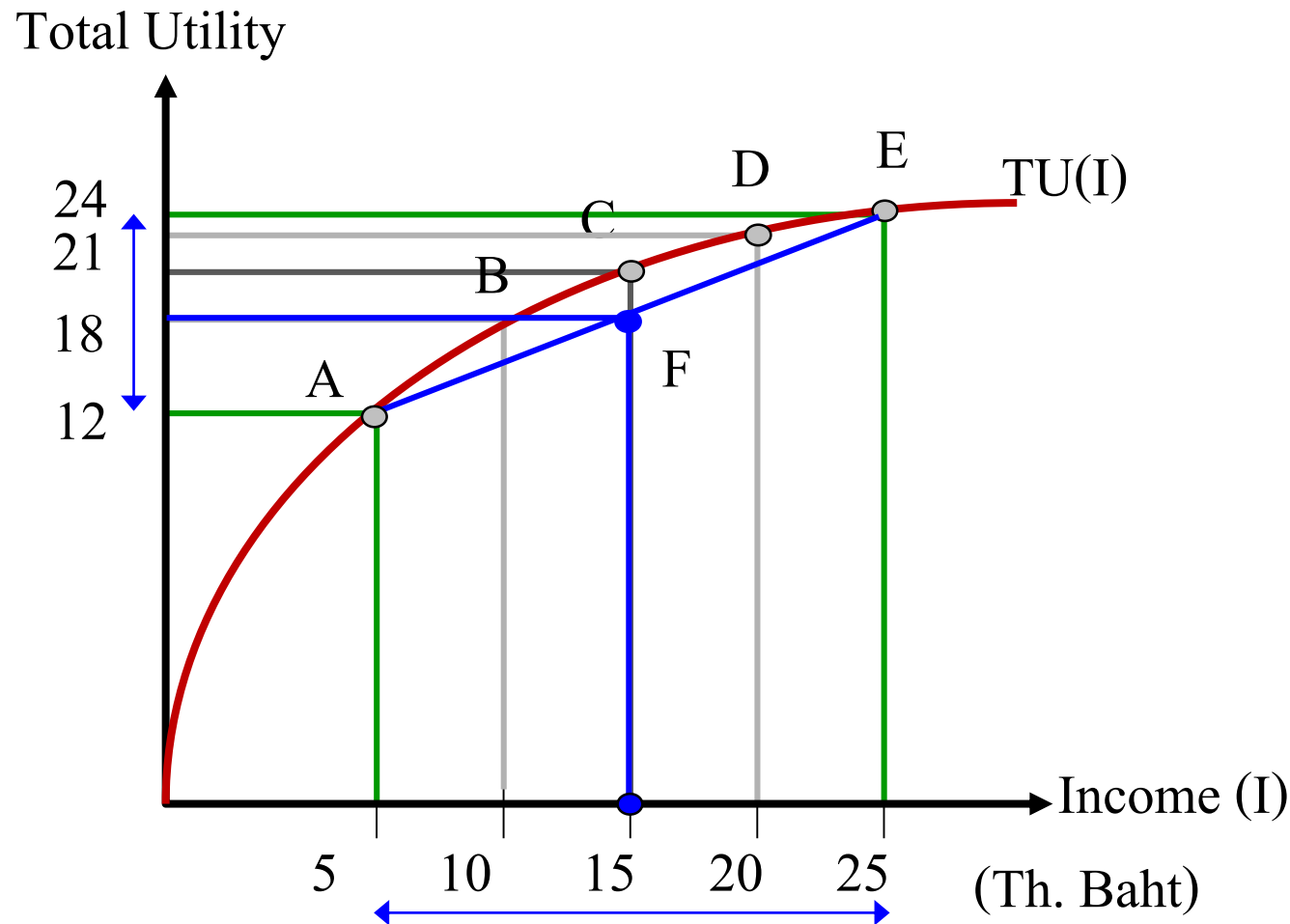


Types of preferences toward risk

- **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.

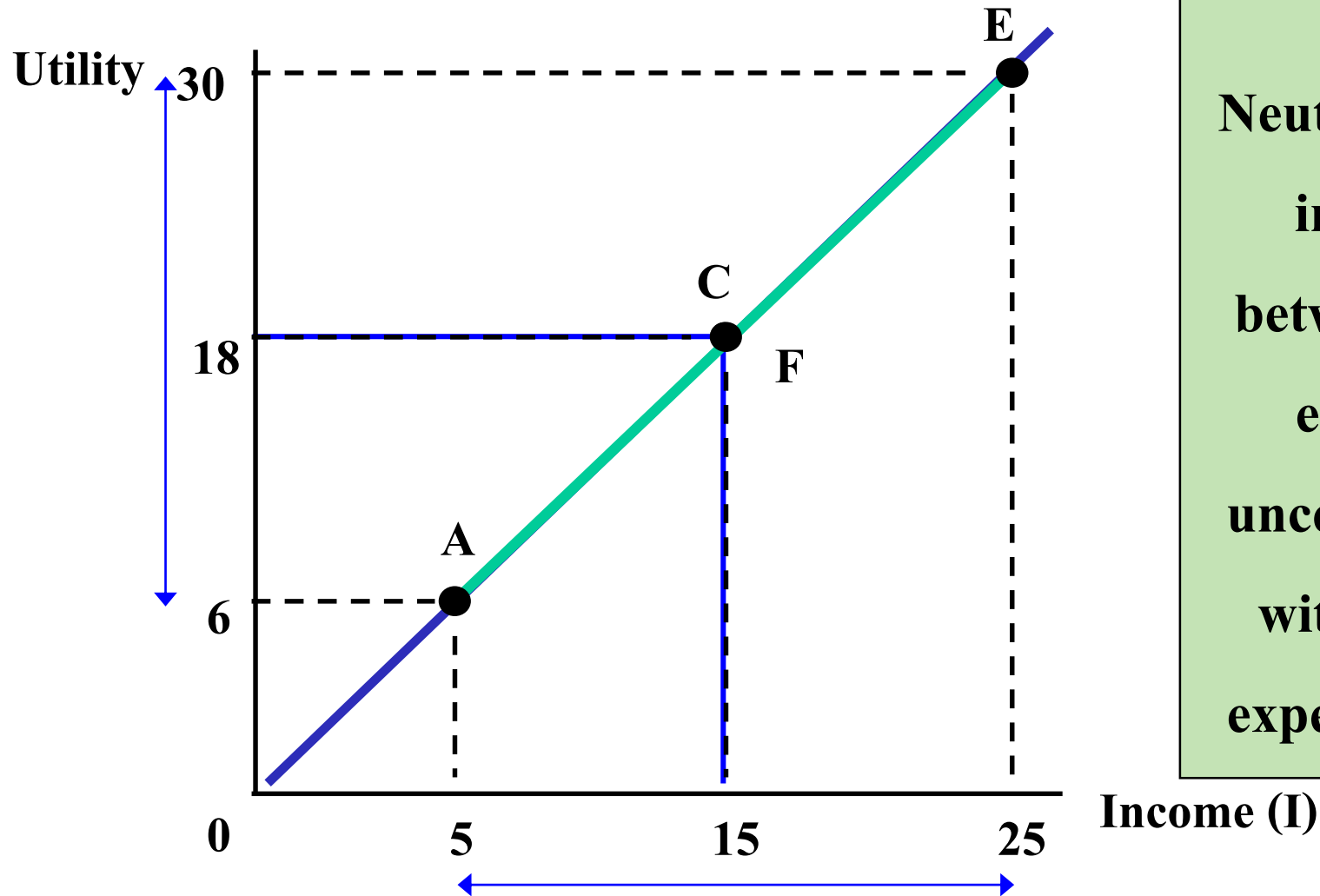


Risk Neutral

- **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

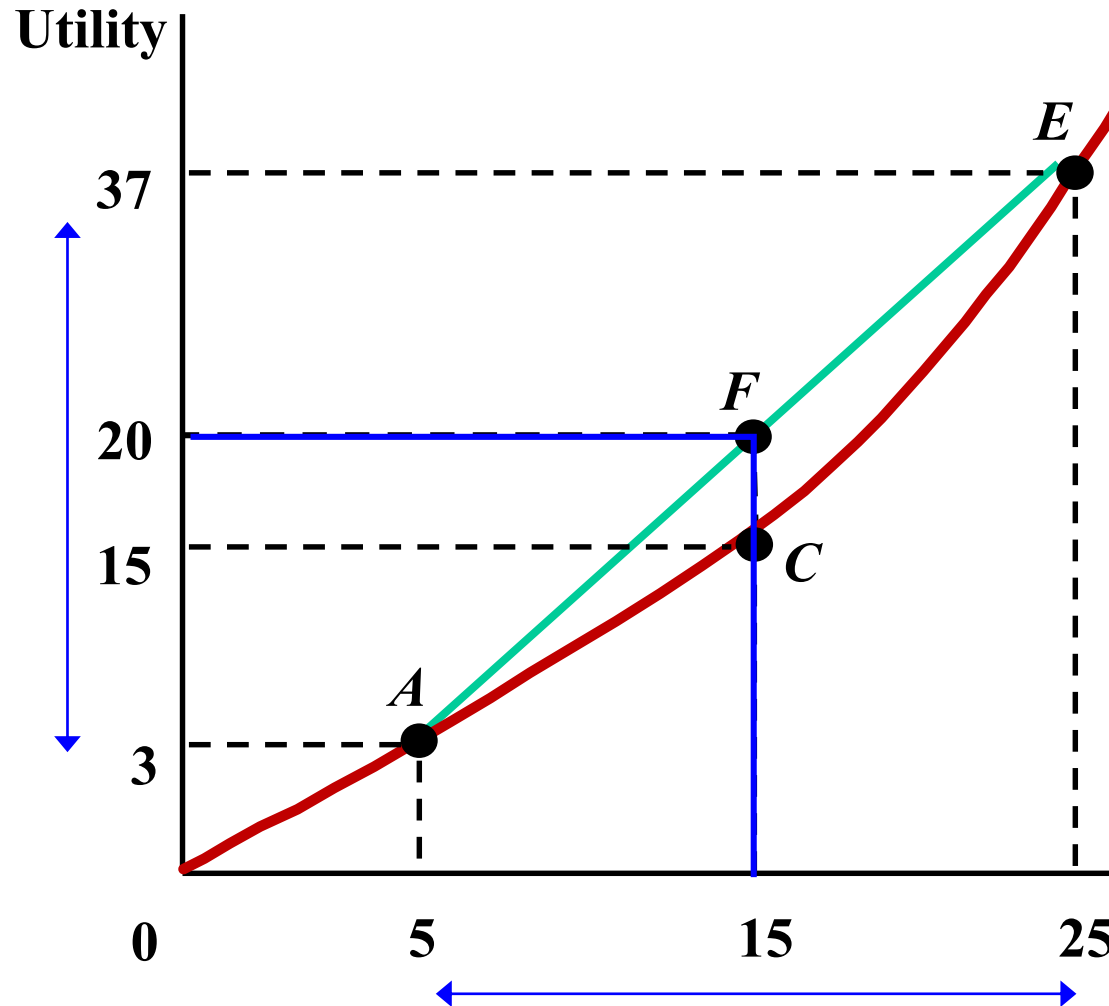
- Expected value for risky option is the same as utility for certain outcome
- $E(I) = (0.5)(\text{฿}5,000) + (0.5)(\text{฿}25,000)$
 $= \text{฿}15,000$
 $E(u) = (0.5)(6) + (0.5)(30) = 18$
- This is the same as the certain income of $\text{฿}15,000$ with utility = 18

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



**A risk loving person
prefers uncertain
income with the same
expected income as a
certain income at ฿
15,000**

Income (I)



Risk Loving

- Expected income of uncertain job

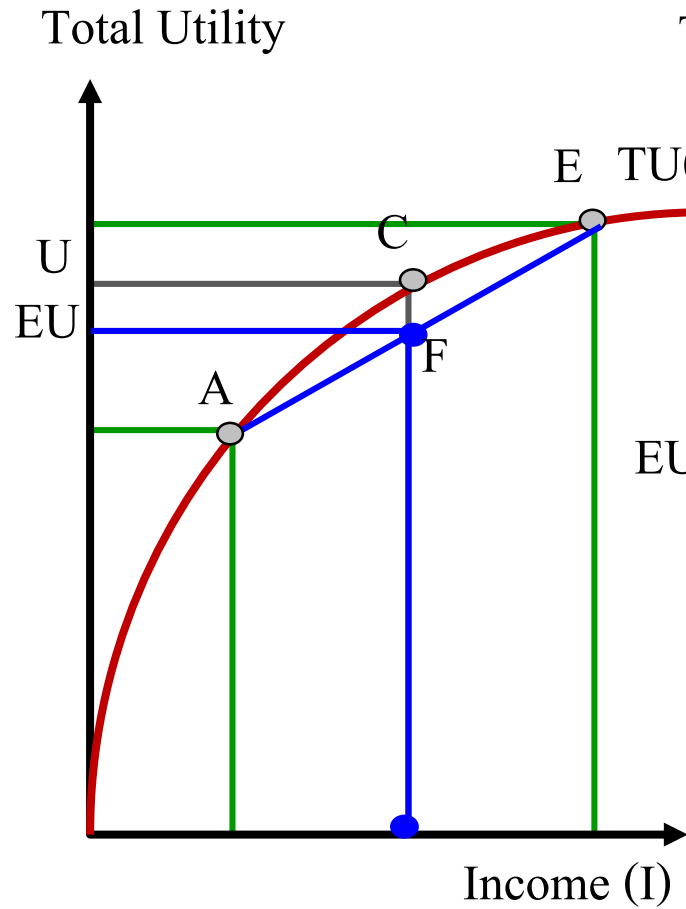
$$\begin{aligned} E(I) &= (0.5)(\text{฿}5,000) + (0.5)(\text{฿}25,000) \\ &= \text{฿}15,000 \end{aligned}$$

$$E(u) = (0.5)(3) + (0.5)(37) = 20 - \text{Point F}$$

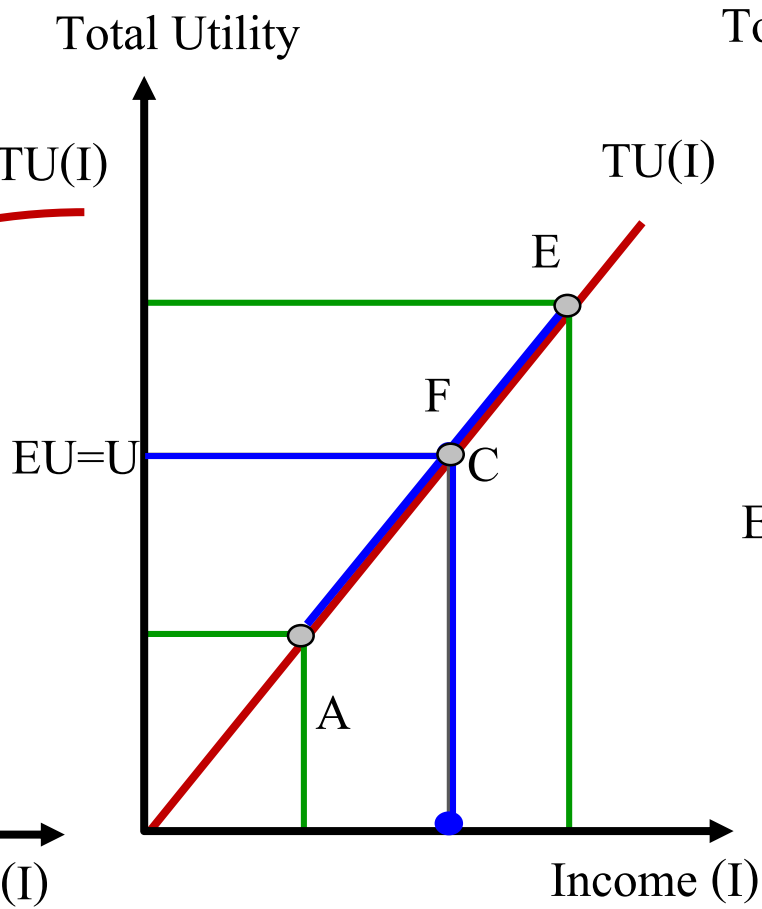
- Certain income job give ฿15,000 with utility 15 – point C
- He would prefer uncertain job.



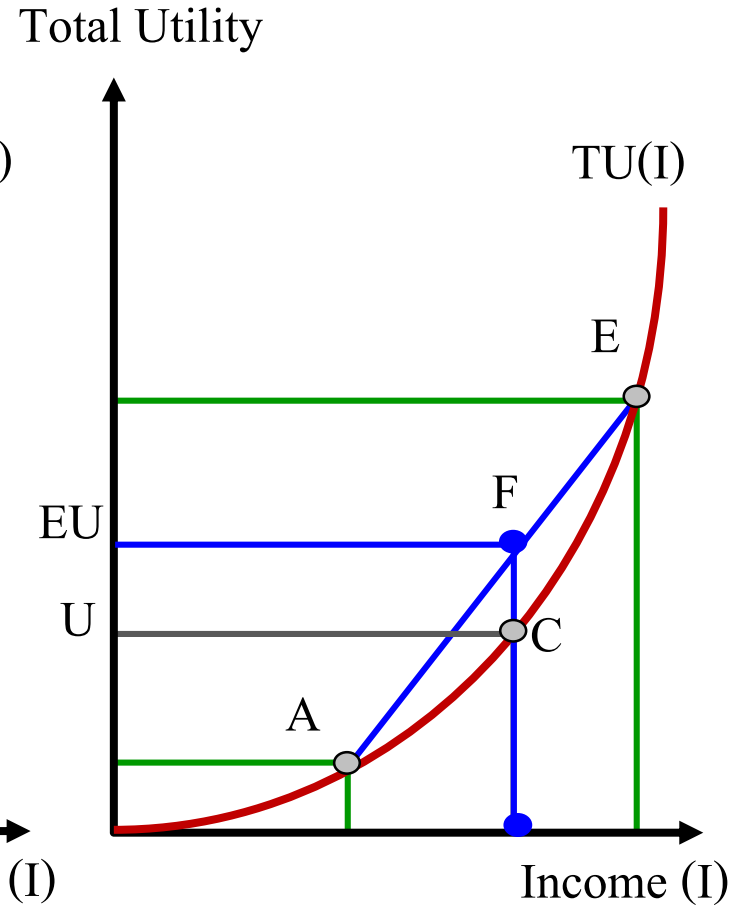
Summary



Risk averse



Risk neutral



Risk loving

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

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.



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




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

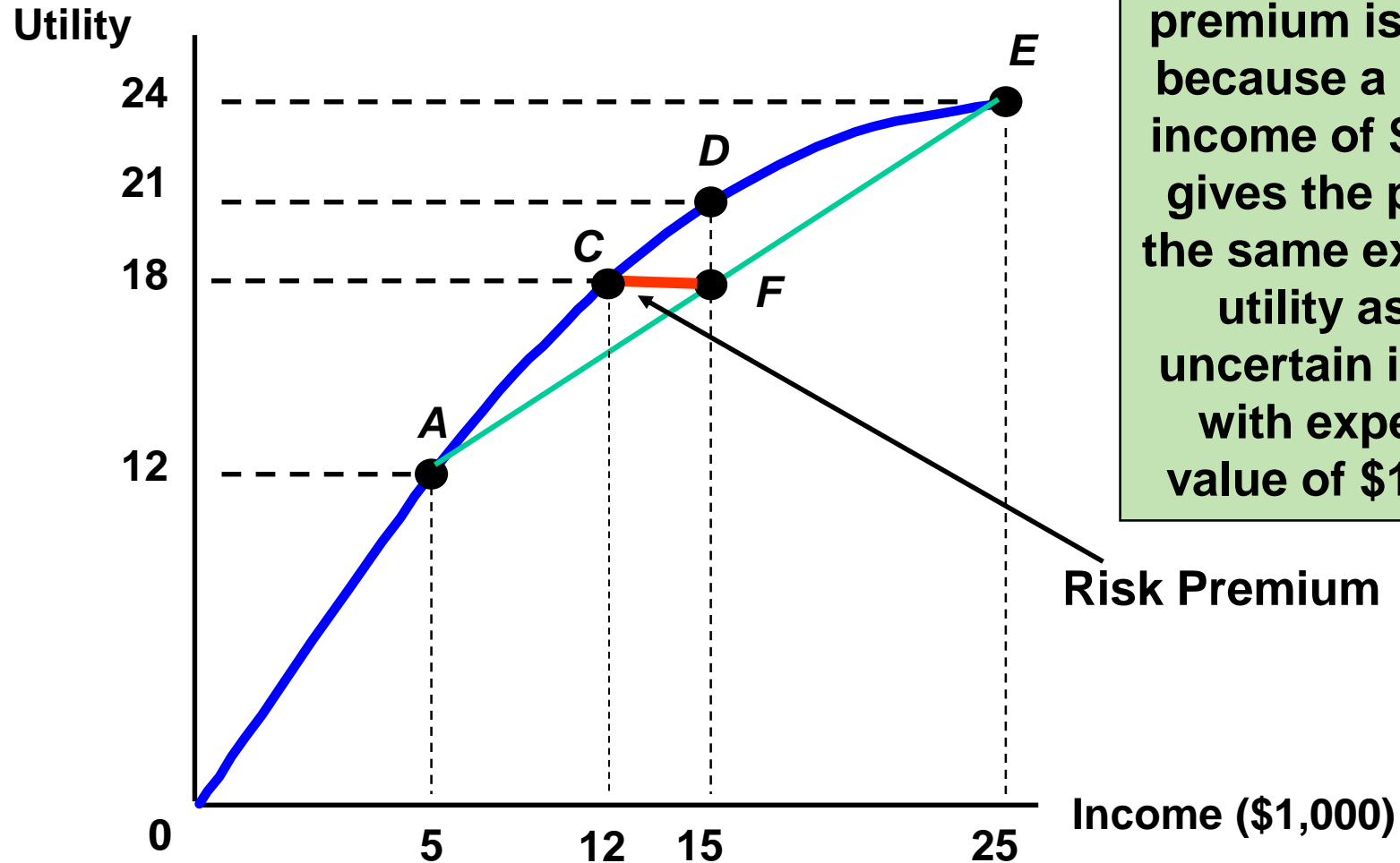
- **Speculative risk** may generate gains or losses and consumers are willing to pay for insurance premium to avoid risk.
- **Risk Premium:**
- The maximum amount of money that a risk-averse person would pay to make risky option becomes certain option with the same total utility.



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



Here, the risk premium is \$3,000 because a certain income of \$12,000 gives the person the same expected utility as the uncertain income with expected value of \$15,000.

Risk Premium



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

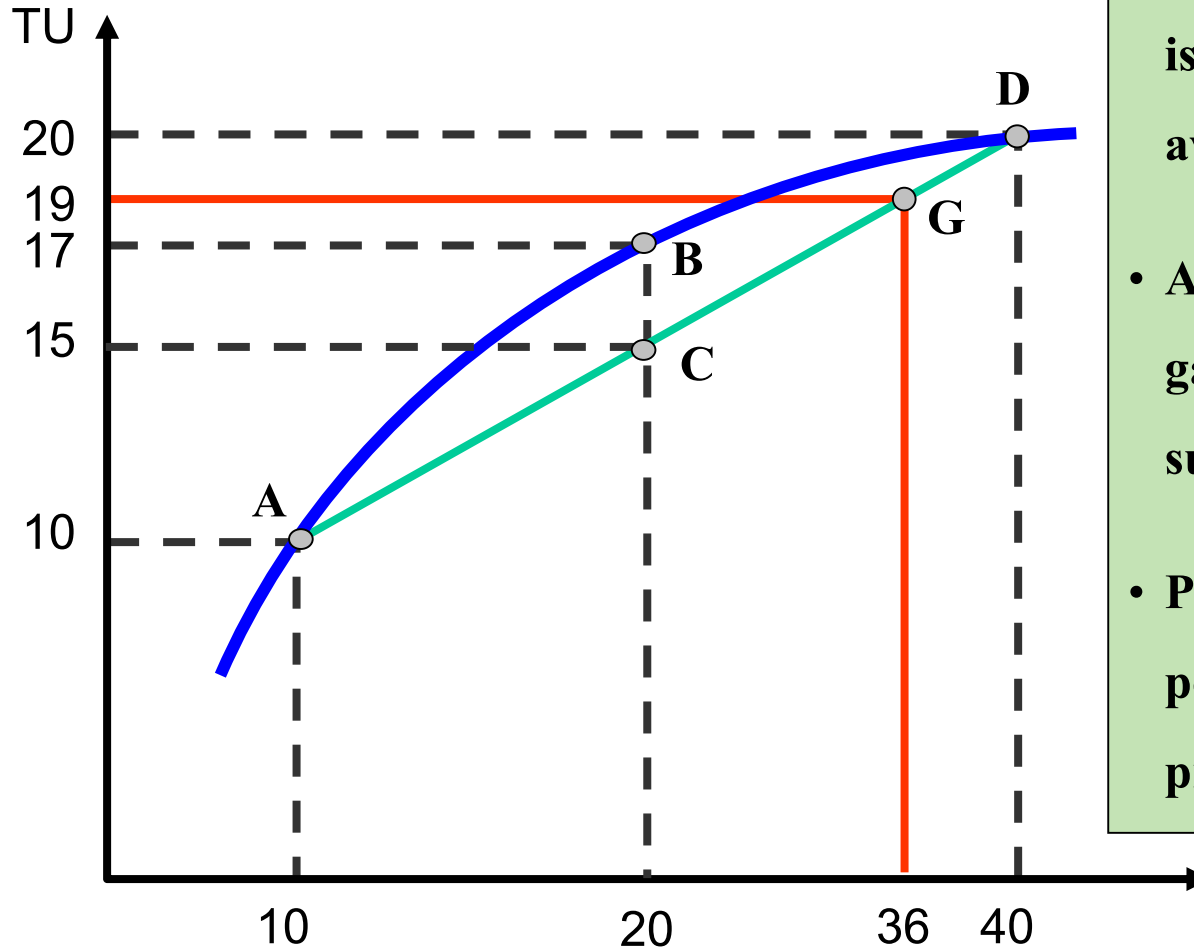
Reducing Risk – The Stock Market

- 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.