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

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 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 occures

N = total number of outcomes

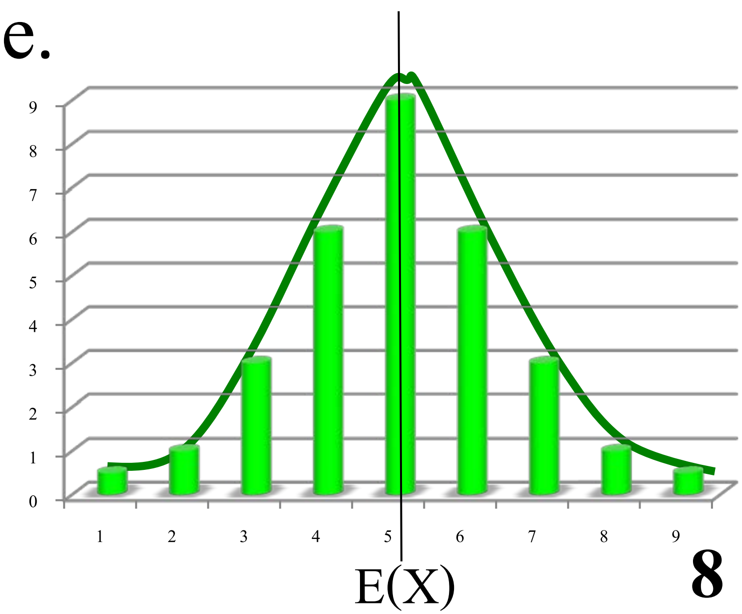
Probability

- 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
- $\Sigma P(X_i) = 1$ 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
- $E(X) = .25(\$40) + .75(\$20) = \$25$/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.

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

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

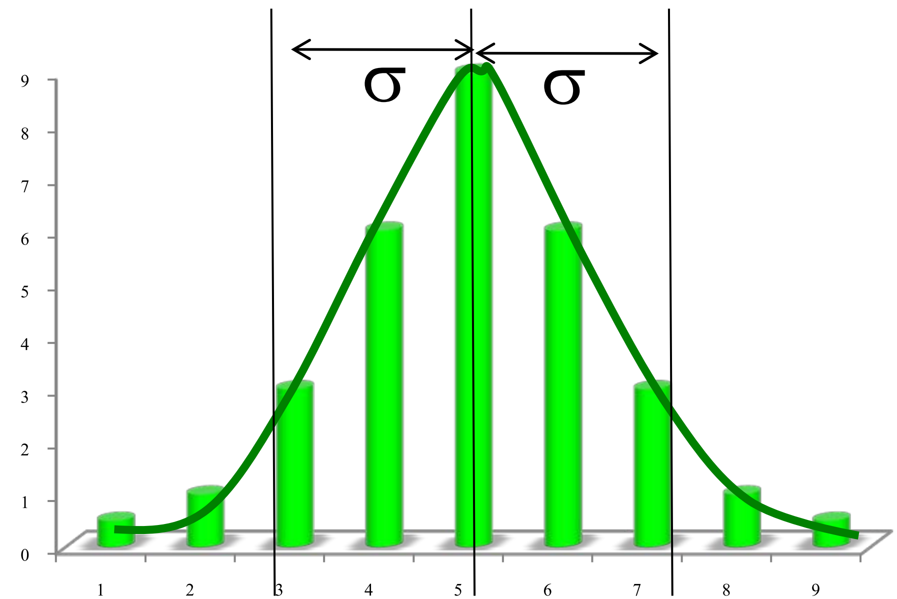
$$X = 50$$

We should not bet more that ฿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

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



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.

EU = (Prob. of Utility 1) *(Utility 1)

+ (Prob. of Utility 2)*(Utility 2)

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

Preferences Toward Risk – Example

- The expected is:

$$EU = (1/2)U(\$5{,}000) + (1/2)U(\$25{,}000)$$

$$= 0.5(12) + 0.5(24)$$

$$= 18$$

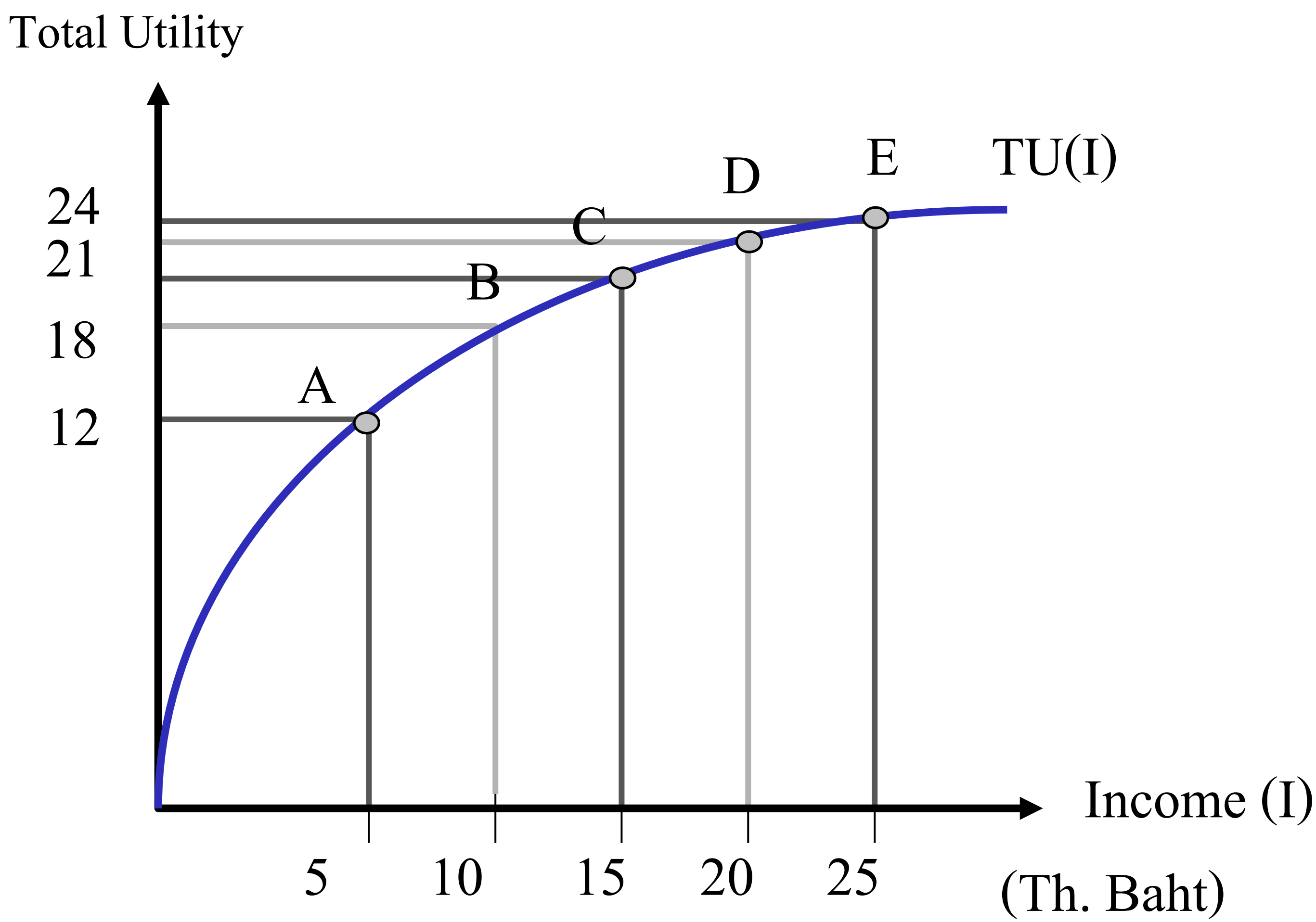
  – EU of new job is 18 which is less than the current utility of 21 and therefore less preferred.

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

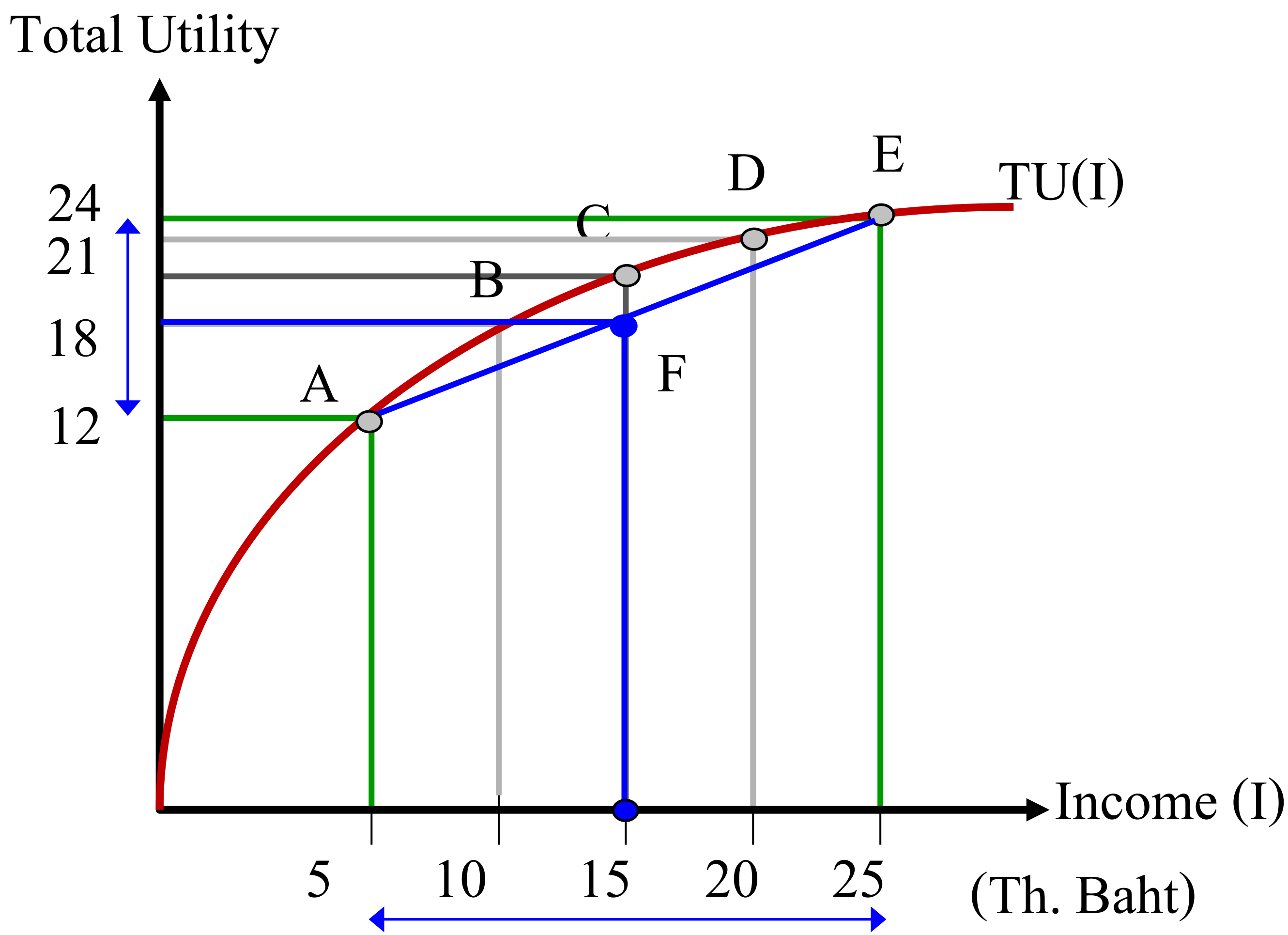
Example


Total Utility
24
21
18
12
A
B
C
D
E
TU(I)
Income (I)
5
10
15
20
25
(Th. Baht)

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 cure is concave or marginal utility is decreasing.

Risk Averse Utility Function



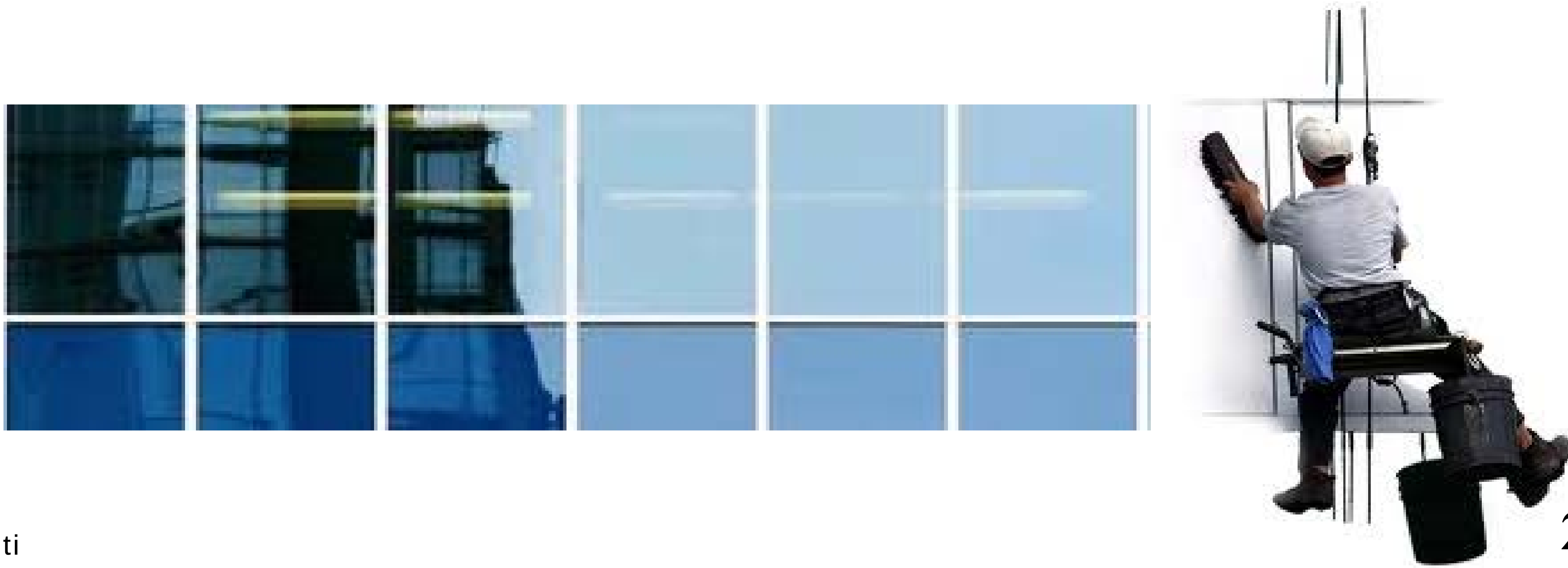
A risk averse person prefer a certain income of ฿15,000 (C) to an uncertain expected income (F) = ฿15,000

Risk Averse

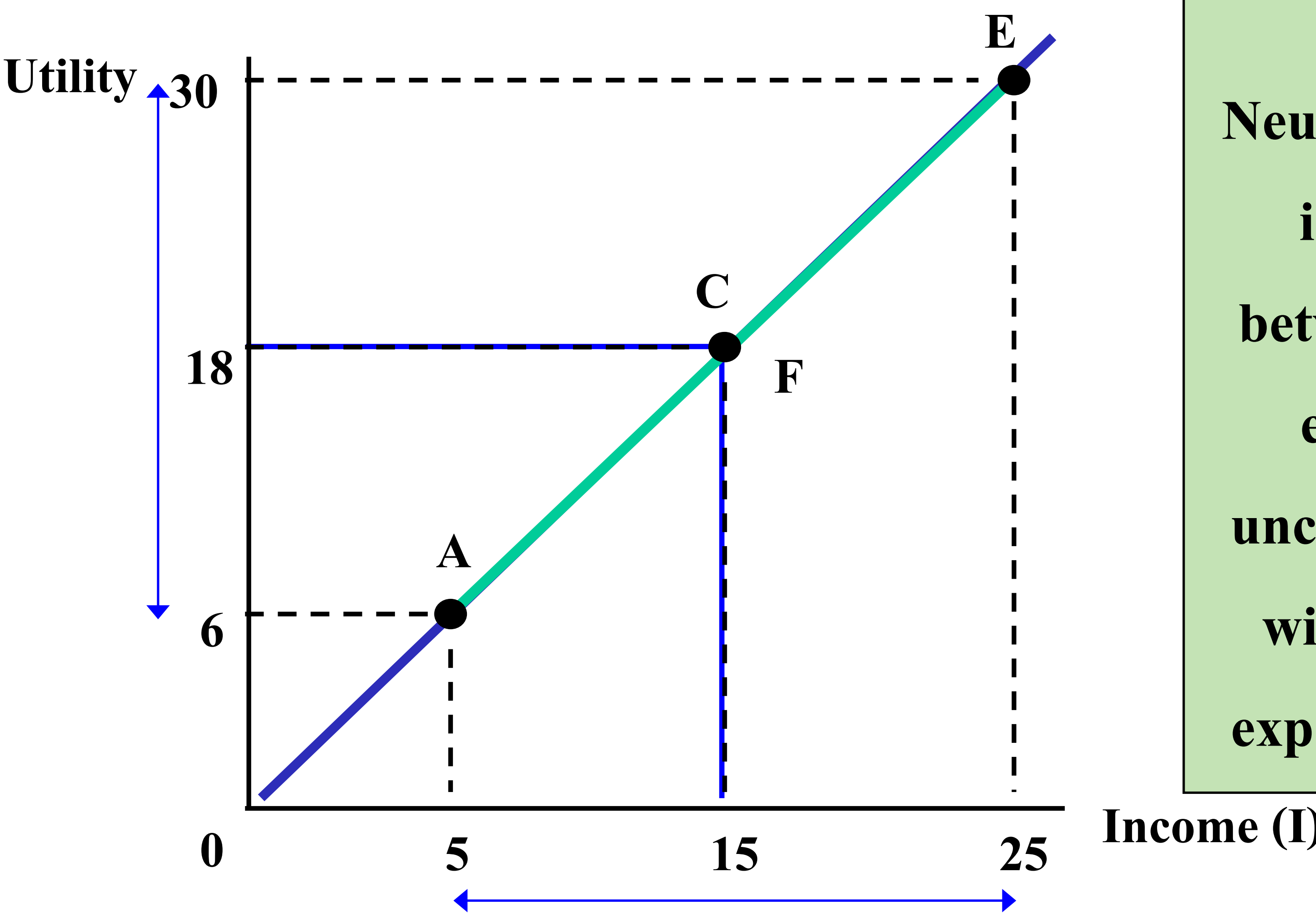
- The certain income job earns ฿15,000 with utility = 21
  - Point C on the total utility curve
- The risky job gives equal expected income = ฿15,000, but gives expected utility = 18
  - Point F on the cord that connect points A and E
- Note: This person may take risk if the expected utility of the uncertain 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)(฿5,000) + (0.5)(฿25,000)

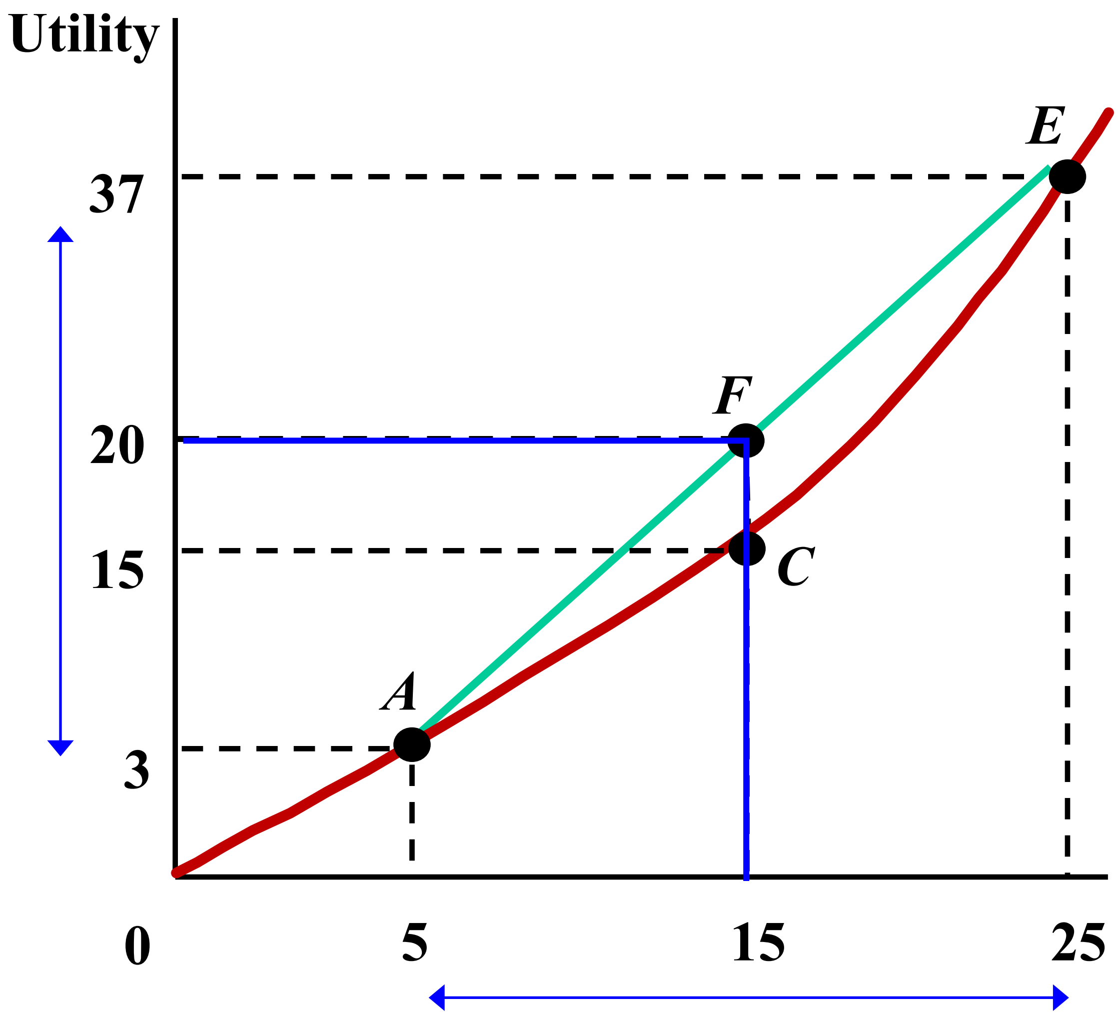
  = ฿15,000

  E(u) = (0.5)(6) + (0.5)(30) = 18
- This is the same as the certain income of ฿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

Risk Loving

- Expected income of uncertain job

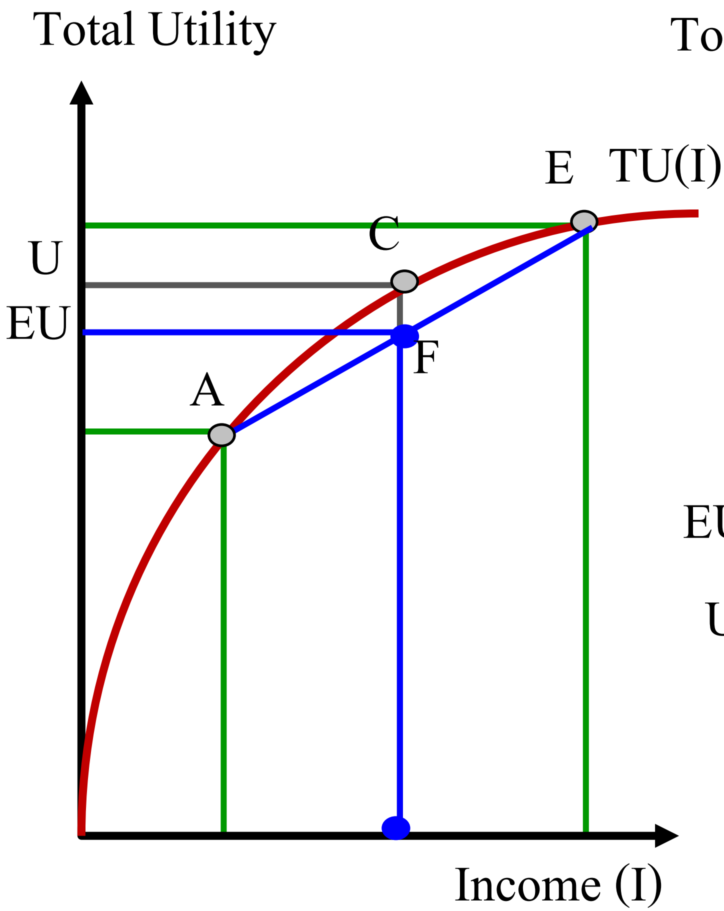
$$E(I) = (0.5)(฿5,000) + (0.5)(฿25,000)$$

$$= ฿15,000$$

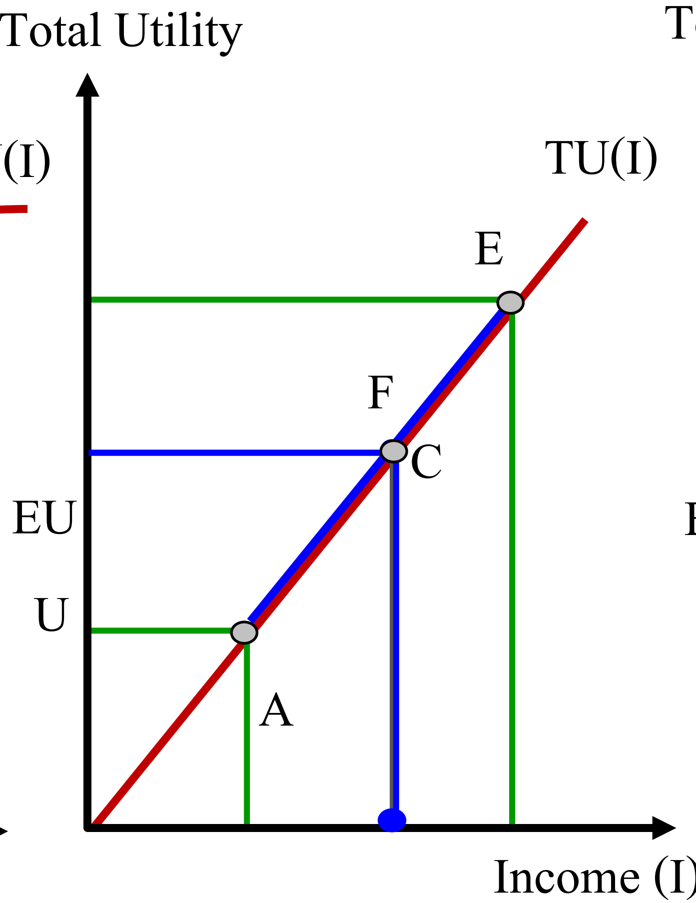
$$E(u) = (0.5)(3) + (0.5)(37) = 20 \text{ – Point F}$$

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

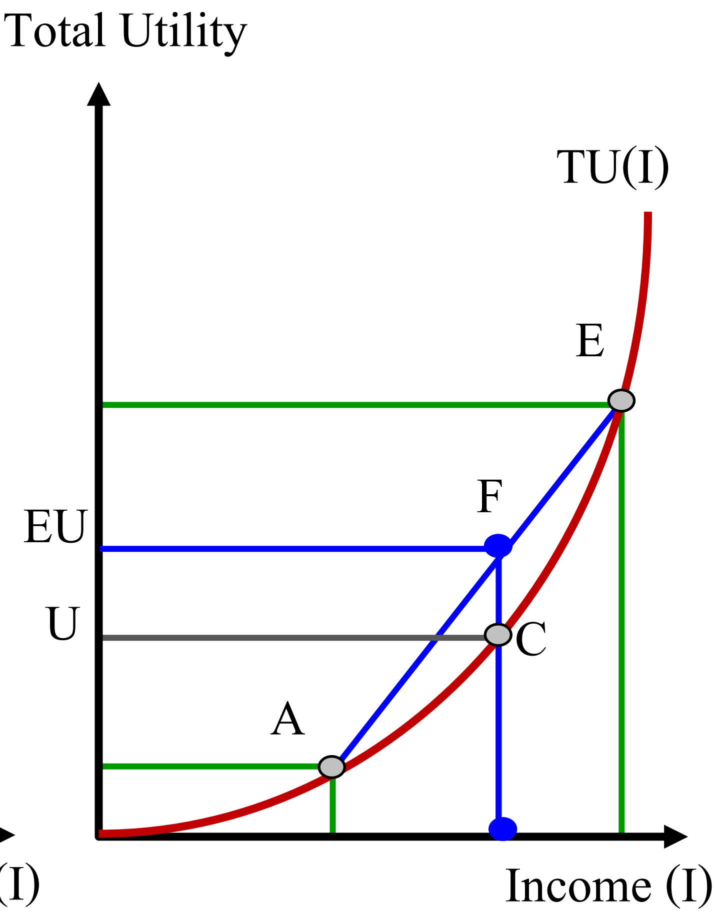
Summary



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

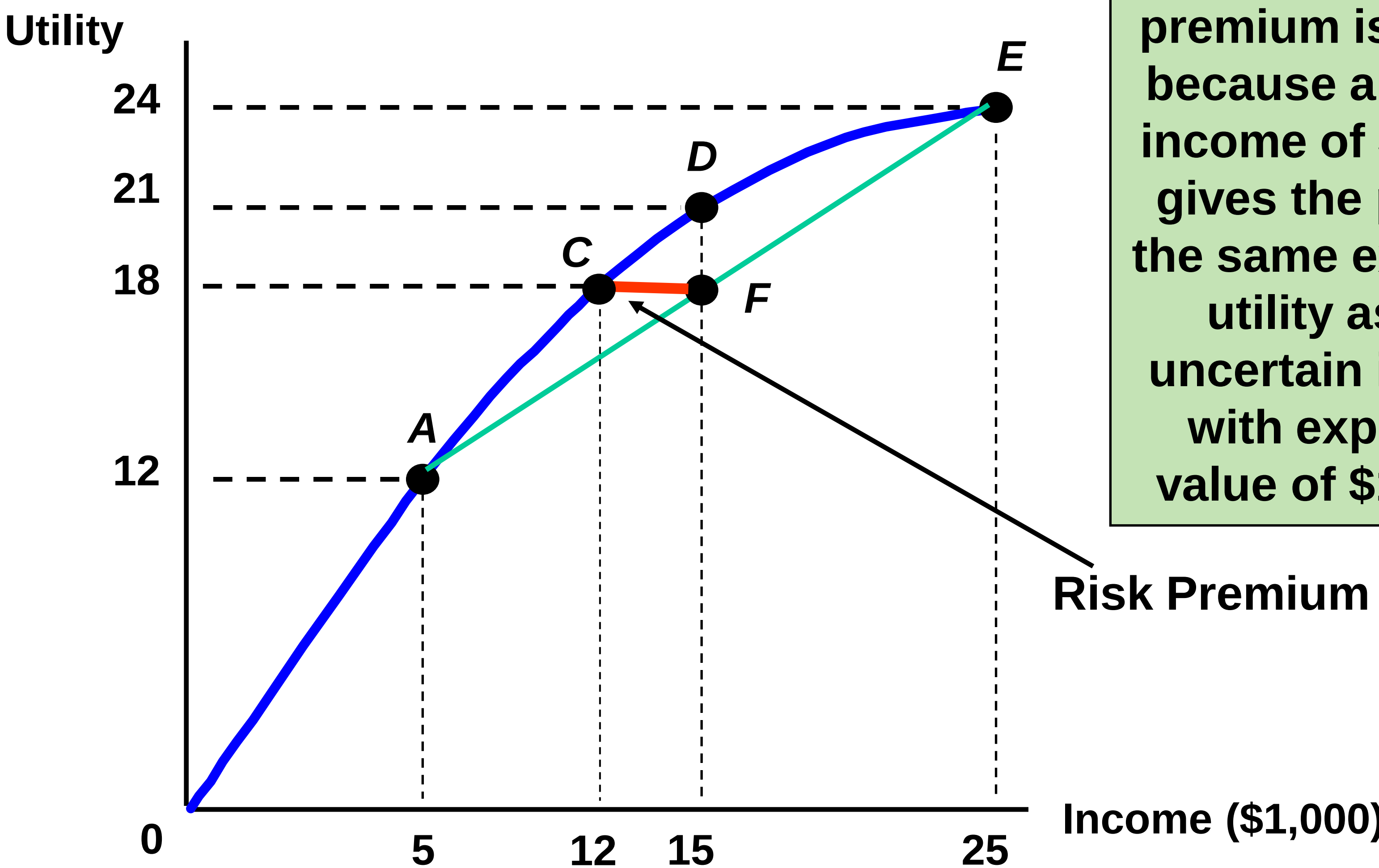
- Speculative risk may generate gains or losses and consumers are willing to pay for insurance premium to avoid risk.

- 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



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 – 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 firms 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

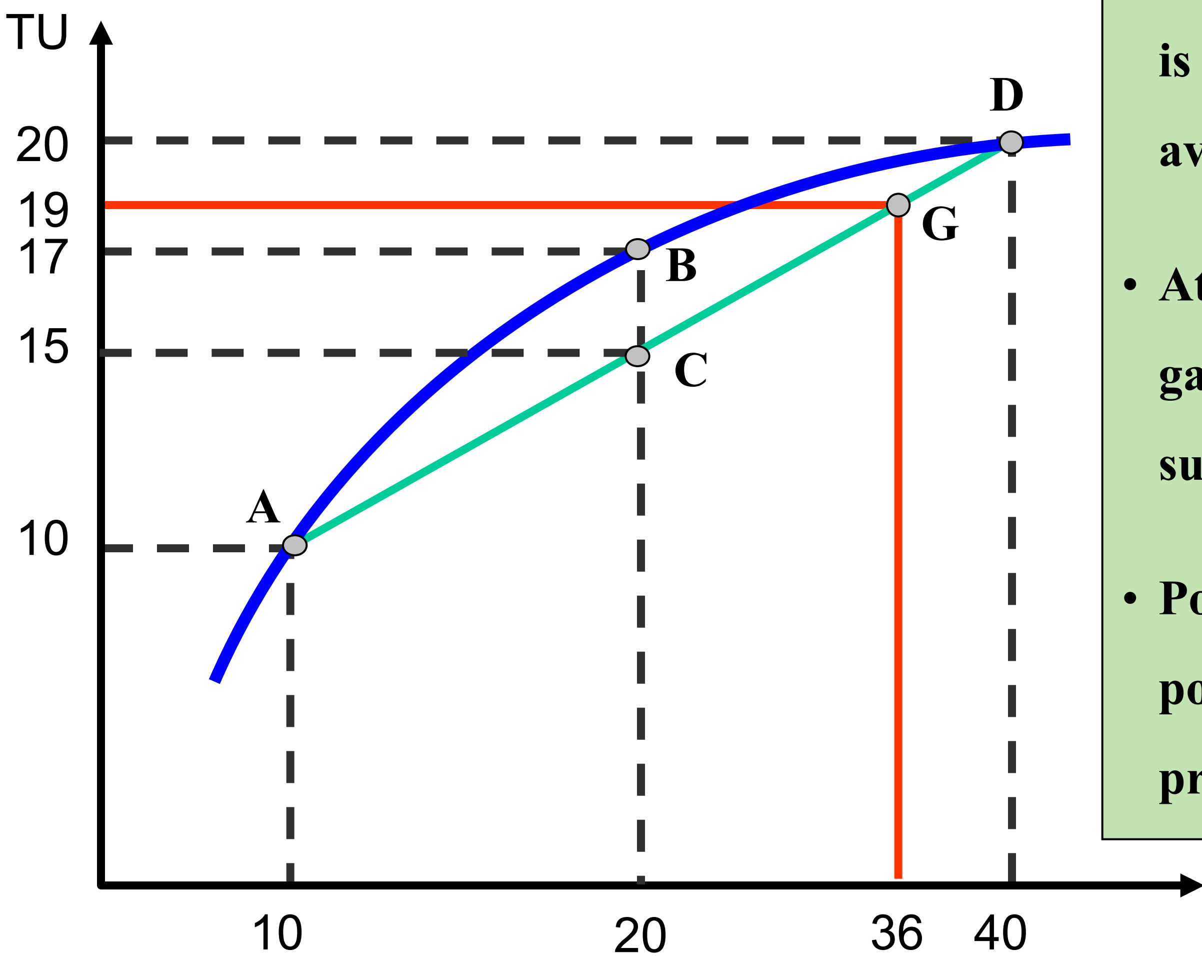
Reducing Risk – The Stock Market

- 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 may 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 wining 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, σ_m
  - Standard deviation of risky portfolio, σ_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, σ_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

$$Slope = (R_m - R_f)/\sigma_m$$

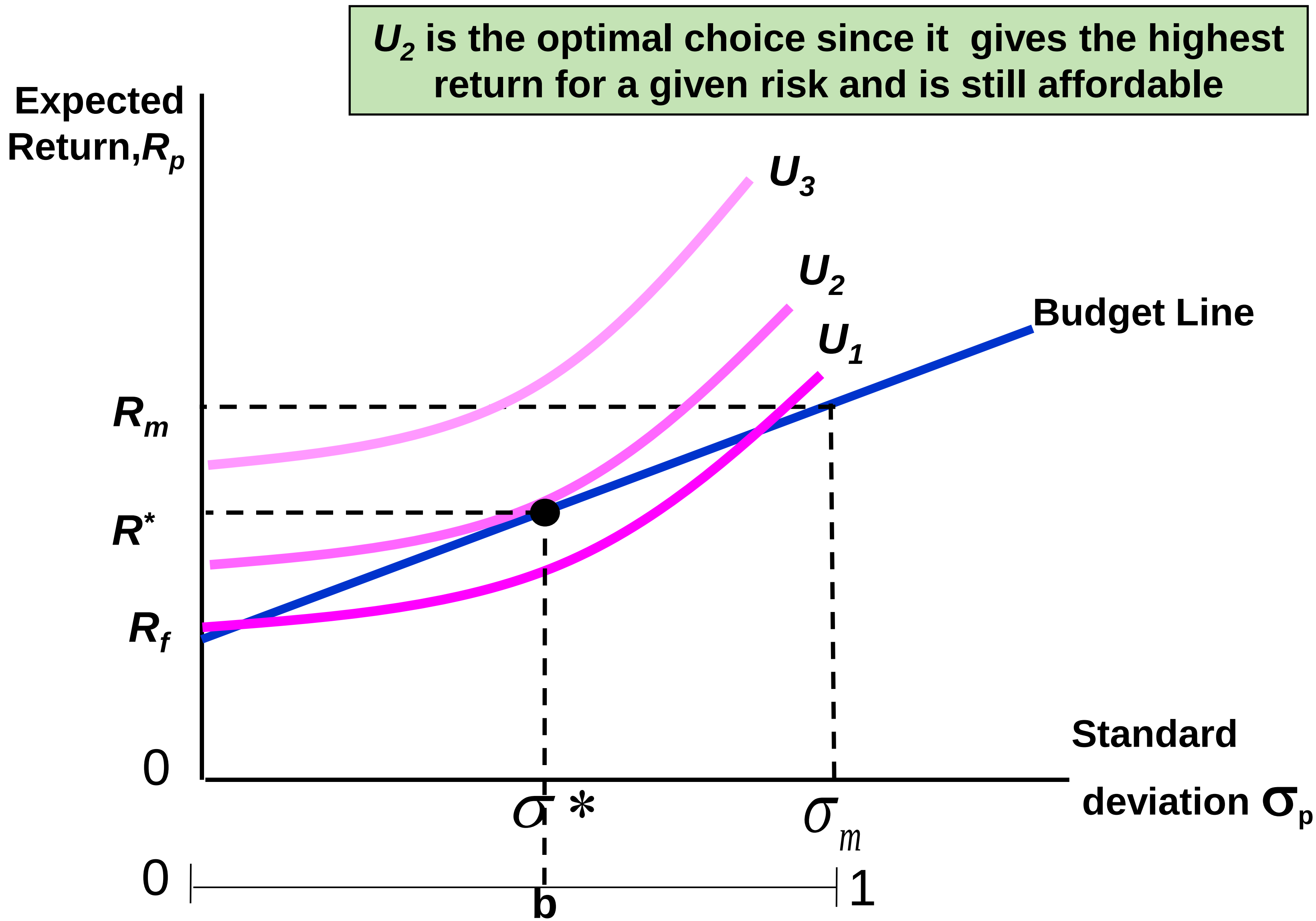
Choosing Between Risk & Return

- 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 σ_m
- Funds may be invested between the assets with expected return between R_f and R_m, with standard deviation between σ_m and 0

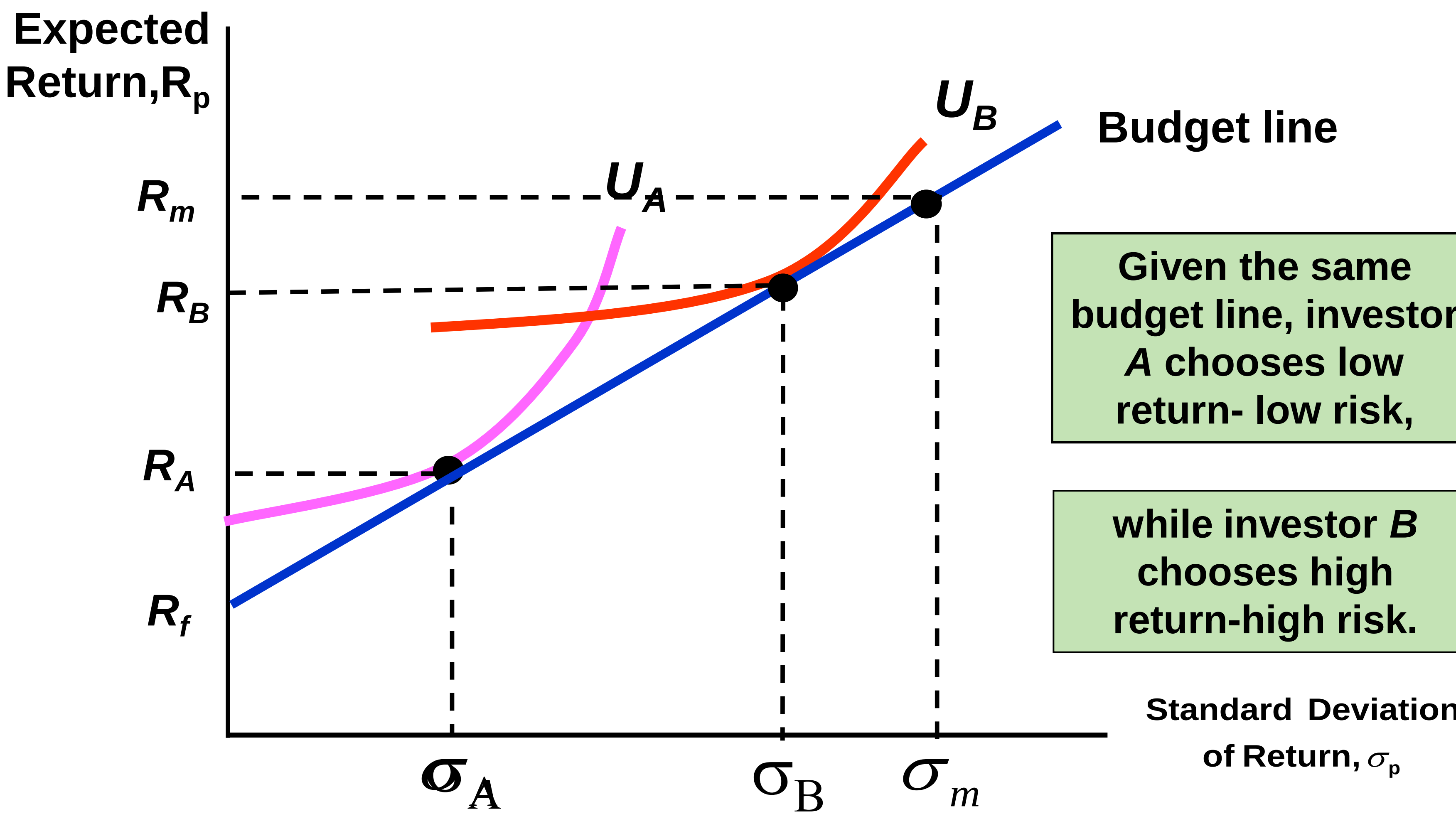
Choosing Between Risk & Return

- 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



The Choices of Two Different Investors



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