Chapter 5

Uncertainty and Consumer Behavior

Topics to be Discussed

- How do we make choices when certain variables such as income and prices are uncertain (making choices with risk)?
- Describing Risk
- Preferences Toward Risk
- Reducing Risk
- The Demand for Risky Assets

Describing Risk

- To measure risk we must know:

1. All of the possible outcomes
2. The **probability** or likelihood that each outcome will occur

Describing Risk

- Interpreting Probability
  1. Objective Interpretation
     - Based on the observed frequency of past events
  2. Subjective Interpretation
     - Based on perception that an outcome will occur

Describing Risk

- With an interpretation of probability, must determine 2 measures to help describe and compare risky choices
  1. Expected value
  2. Variability

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

Expected Value – An Example

- Investment in offshore drilling exploration:
- Two outcomes are possible
  - Success – the stock price increases from $30 to $40/share
  - Failure – the stock price falls from $30 to $20/share

Expected Value – An Example

- Objective Probability
  - 100 explorations, 25 successes and 75 failures
  - Probability (Pr) of success = 1/4 and the probability of failure = 3/4

Expected Value – An Example

$$EV = \Pr(\text{success})(\text{value of success}) + \Pr(\text{failure})(\text{value of failure})$$

$$EV = 1/4(\$40/\text{share}) + 3/4(\$20/\text{share})$$

$$EV = \$25/\text{share}$$

Expected Value

- In general, for n possible outcomes:
  - Possible outcomes having payoffs X_1, X_2, …, X_n
  - Probabilities of each outcome is given by Pr_1, Pr_2, …, Pr_n

$$E(X) = Pr_1 X_1 + Pr_2 X_2 + ... + Pr_n X_n$$

Describing Risk

- Variability
  - The extent to which possible outcomes of an uncertain event may differ
  - How much variation exists in the possible choice

Variability – An Example

- Suppose you are choosing between two part-time sales jobs that have the same expected income ($1,500)
- The first job is based entirely on commission
- The second is a salaried position

Variability – An Example

- There are two equally likely outcomes in the first job: $2,000 for a good sales job and $1,000 for a modestly successful one
- The second pays $1,510 most of the time (.99 probability), but you will earn $510 if the company goes out of business (.01 probability)

Variability – An Example

	Outcome 1		Outcome 2	
	Prob.	**Income**	**Prob.**	**Income**
Job 1: Commission	.5	2000	.5	1000
Job 2: Fixed Salary	.99	1510	.01	510

Variability – An Example

- Income from Possible Sales Job

Job 1 Expected Income

$$E(X_1) = .5(\$2000) + .5(\$1000) = \$1500$$

Job 2 Expected Income

$$E(X_2) = .99(\$1510) + .01(\$510) = \$1500$$

Variability

- While the expected values are the same, the variability is not
- Greater variability from expected values signals greater risk
- Variability comes from **deviations** in payoffs
  - Difference between expected payoff and actual payoff

Variability – An Example

Deviations from Expected Income ($)				
	Outcome 1	**Deviation**	**Outcome 2**	**Deviation**
Job 1	$2000	$500	$1000	-$500
Job 2	1510	10	510	-990

Variability

- Average deviations are always zero so we must adjust for negative numbers
- We can measure variability with **standard deviation**
  - The square root of the average of the squares of the deviations of the payoffs associated with each outcome from their expected value

Variability

- Standard deviation is a measure of risk
  - Measures how variable your payoff will be
  - More variability means more risk
  - Individuals generally prefer less variability – less risk

Variability

- The standard deviation is written:

$$\sigma = \sqrt{\Pr_1\left[\boldsymbol{X}_1 - \boldsymbol{E}(\boldsymbol{X})\right]^2 + \Pr_2\left[\boldsymbol{X}_2 - \boldsymbol{E}(\boldsymbol{X})\right]^2}$$

Standard Deviation – Example 1

- Standard deviations of the two jobs are:

$$\sigma = \sqrt{\Pr_1\left[\boldsymbol{X}_1 - \boldsymbol{E}(\boldsymbol{X})\right]^2 + \Pr_2\left[\boldsymbol{X}_2 - \boldsymbol{E}(\boldsymbol{X})\right]^2}$$

$$\sigma_1 = \sqrt{0.5(\$250{,}000) + 0.5(\$250{,}000)}$$

$$\sigma_1 = \sqrt{250{,}000} = 500$$

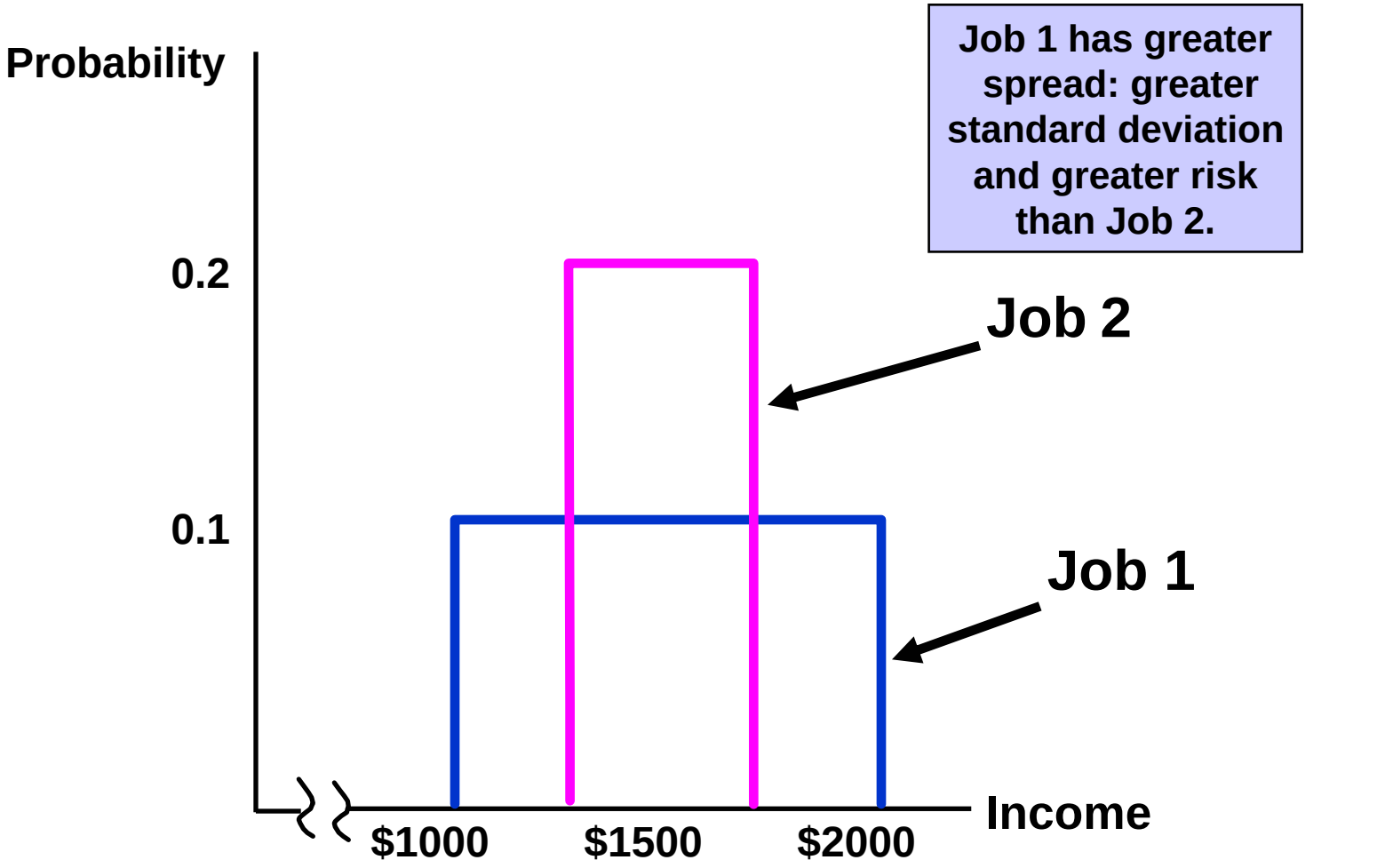
$$\sigma_2 = \sqrt{0.99(\$100) + 0.01(\$980{,}100)}$$

$$\sigma_2 = \sqrt{9{,}900} = 99.50$$

Standard Deviation

- Job 1 has a larger standard deviation and therefore it is the riskier alternative
- The standard deviation also can be used when there are many outcomes instead of only two

Illustration



Decision Making

- Which job should be chosen?
  - Depends on the individual
  - Some may be willing to take risk with higher expected income
  - Some will prefer less risk even with lower expected income

Preferences Toward Risk - Example

- A person is earning $15,000 and receiving 14 units of utility from the job
- She is considering a new, but risky job
  - 0.50 chance of $30,000
  - 0.50 chance of $10,000

Preferences Toward Risk - Example

- Utility at $30,000 is 18
- Utility at $10,000 is 10
- Must compare utility from the risky job with current utility of 14
- 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

E(u) = (Prob. of Utility 1) *(Utility 1)
+ (Prob. of Utility 2)*(Utility 2)

Preferences Toward Risk – Example

- The expected is:

$$E(u) = (1/2)u(\$10{,}000) + (1/2)u(\$30{,}000)$$
$$= 0.5(10) + 0.5(18)$$
$$= 14$$

  - E(u) of new job is 14 and utility of old job is 14. Which does she prefer?

Preferences Toward Risk

- People differ in their preference toward risk
- People can be *risk averse, risk neutral,* or *risk loving*

Preferences Toward Risk

- Risk Averse
  - A person who prefers a certain given income to a risky income with the same expected value
  - The person has a diminishing marginal utility of income
  - Most common attitude towards risk
    - Ex: Market for insurance

Risk Averse

- A person can have a $20,000 job with 100% probability and receive a utility level of 16
- The person could have a job with a 0.5 chance of earning $30,000 and a 0.5 chance of earning $10,000
- Expected Utility of Risky Job

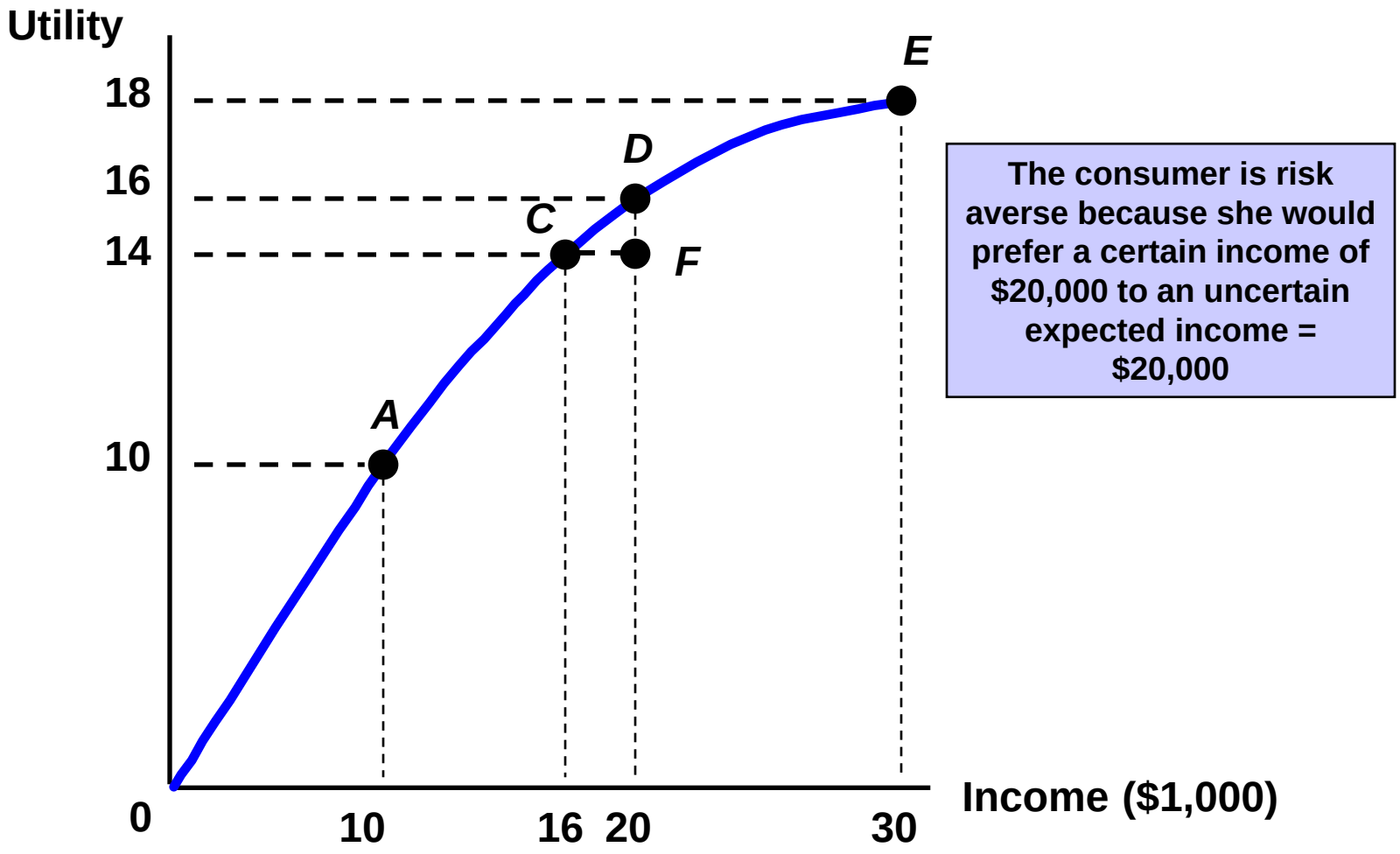
  $E(u) = (0.5)(10) + (0.5)(18)$

  $E(u) = 14$

Risk Averse

- Can see risk averse choices graphically
- Risky job has expected income = $20,000 with expected utility = 14
  - Point F
- Certain job has expected income = $20,000 with utility = 16
  - Point D

Risk Averse Utility Function



The consumer is risk averse because she would prefer a certain income of $20,000 to an uncertain expected income = $20,000

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
- Constant marginal utility of income

Risk Neutral

- Expected value for risky option is the same as utility for certain outcome

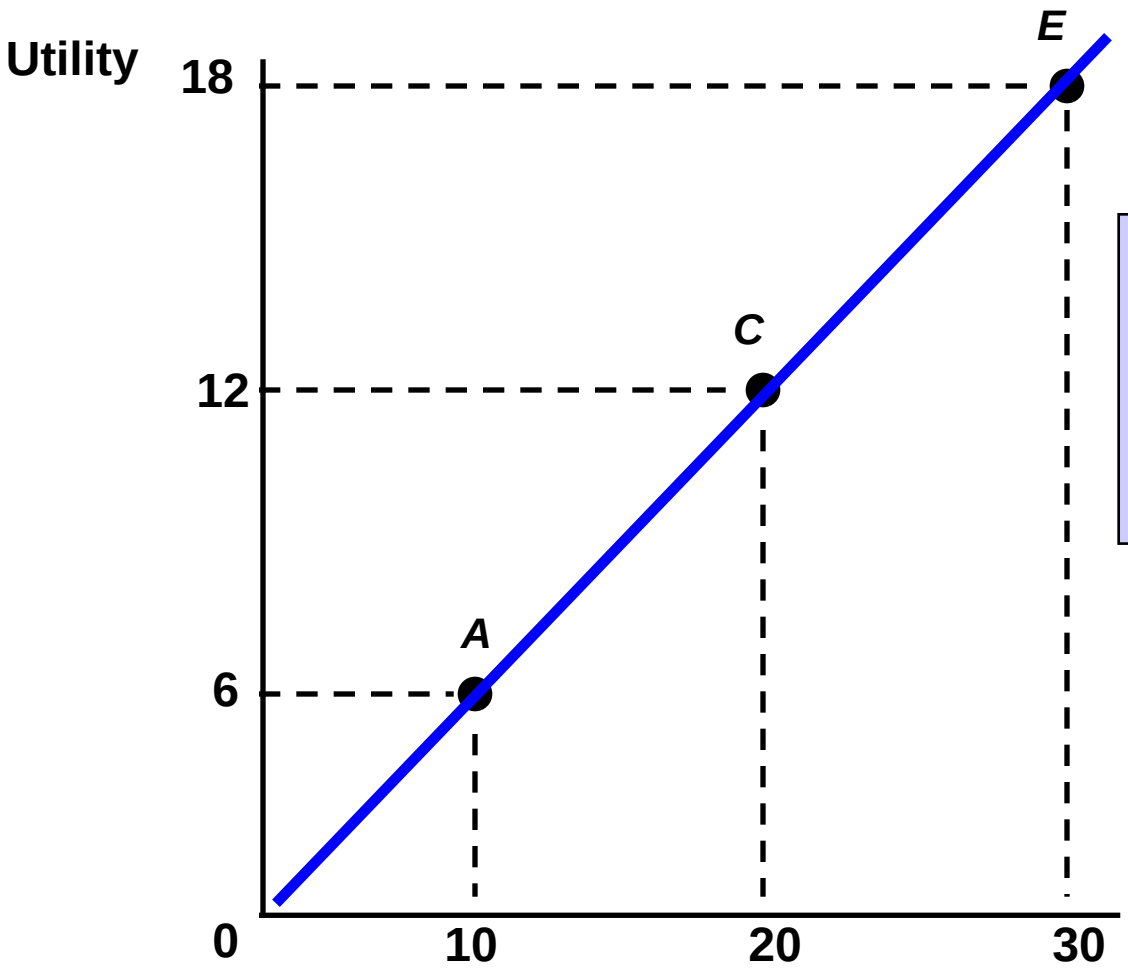
  E(I) = (0.5)($10,000) + (0.5)($30,000)

  = $20,000

  E(u) = (0.5)(6) + (0.5)(18) = 12

- This is the same as the certain income of $20,000 with utility of 12

Risk Neutral Utility Function



The consumer is risk neutral and is indifferent between certain events and uncertain events with the same expected income.

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
  - Examples: Gambling, some criminal activities
- Increasing marginal utility of income

Risk Loving

- Expected value for risky option – point F

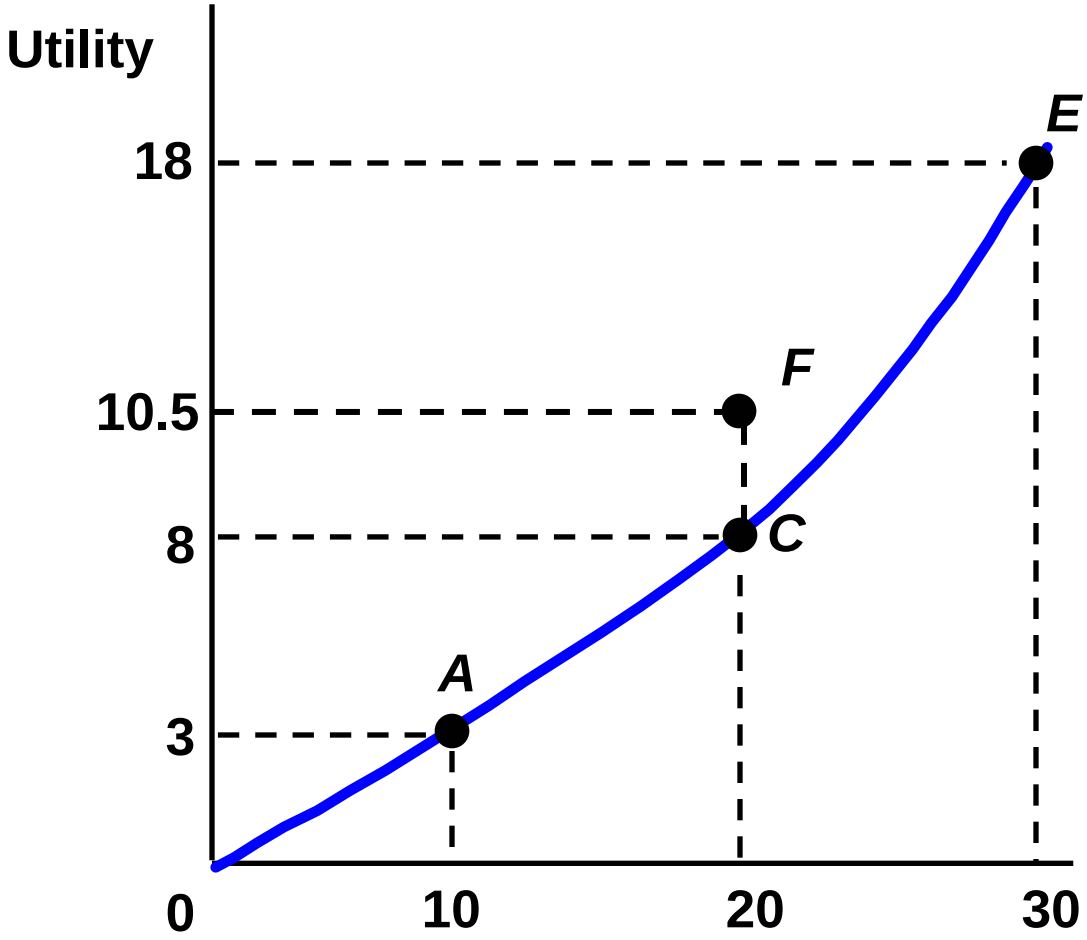
  E(I) = (0.5)($10,000) + (0.5)($30,000)

  = $20,000

  E(u) = (0.5)(3) + (0.5)(18) = 10.5

- Certain income is $20,000 with utility of 8 – point C
- Risky alternative is preferred

Risk Loving Utility Function

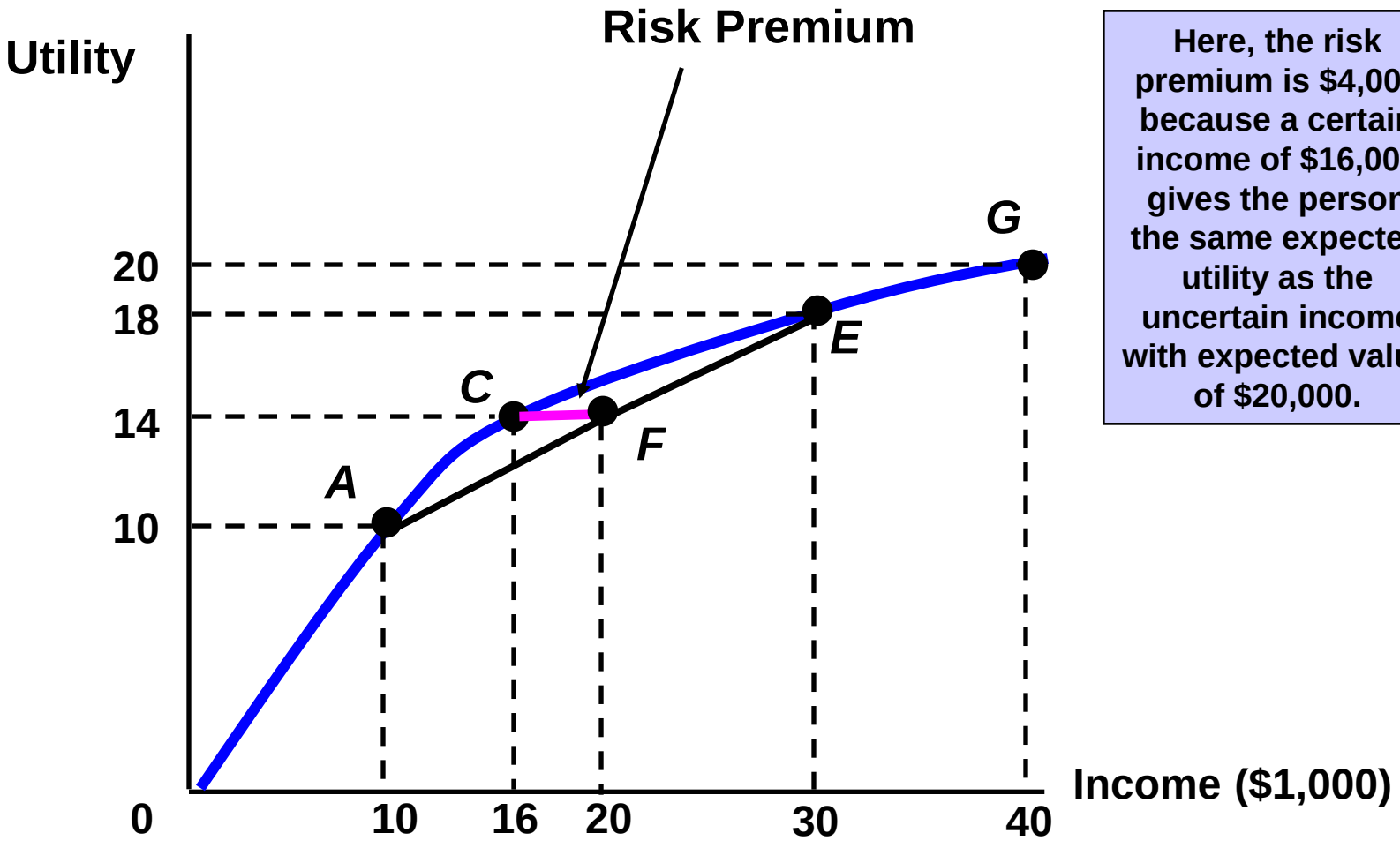


The consumer is risk loving because she would prefer the gamble to a certain income.

Risk Premium

- The **risk premium** is the maximum amount of money that a risk-averse person would pay to avoid taking a risk
- The risk premium depends on the risky alternatives the person faces

Risk Premium – Example



Here, the risk premium is $4,000 because a certain income of $16,000 gives the person the same expected utility as the uncertain income with expected value of $20,000.

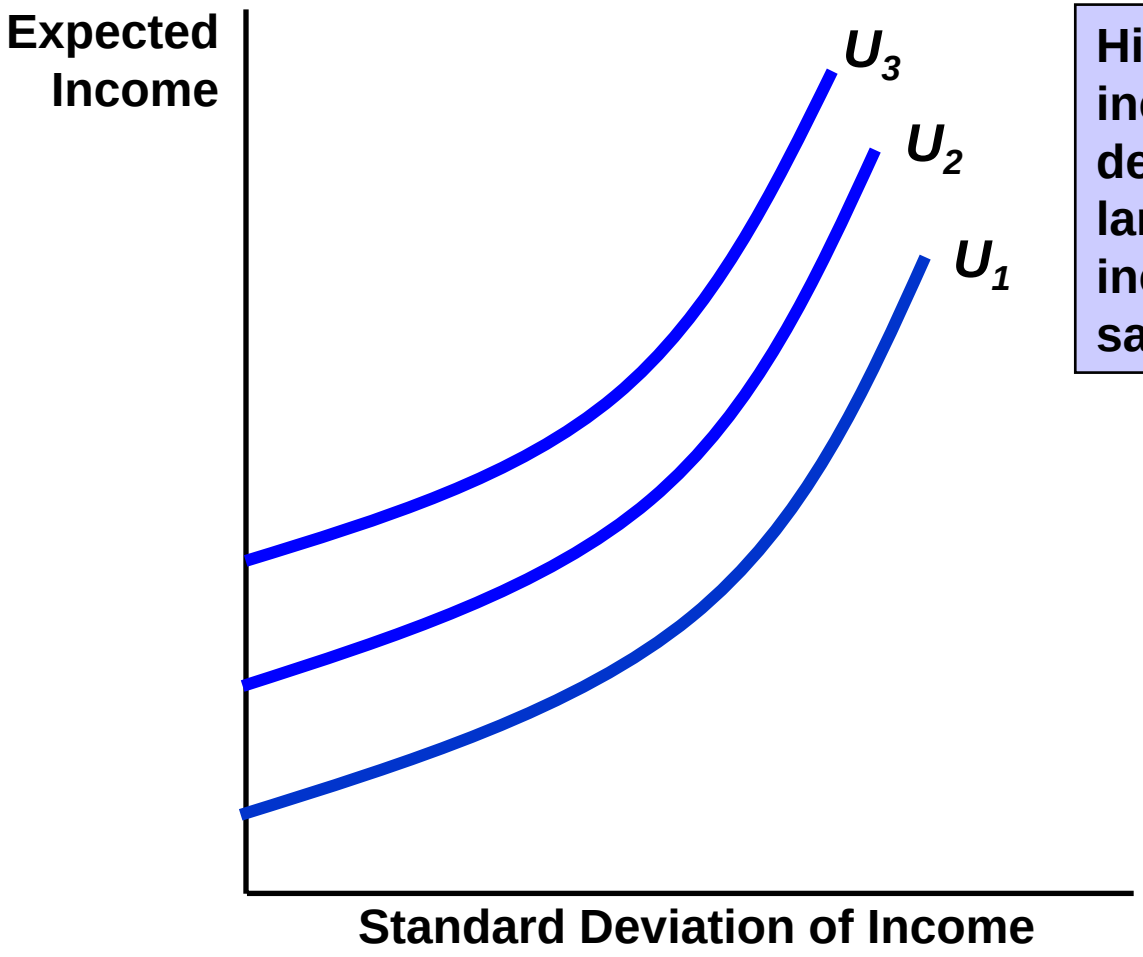
Risk and Crime Deterrence

- Attitudes toward risk affect willingness to break the law
- Suppose a city wants to deter people from double parking
- The maximum amount of fine/penalty can be determined by risk premium and other costs.
- Risk premium is determined by preference towards risk and probability of apprehension.

Risk Aversion and Indifference Curves

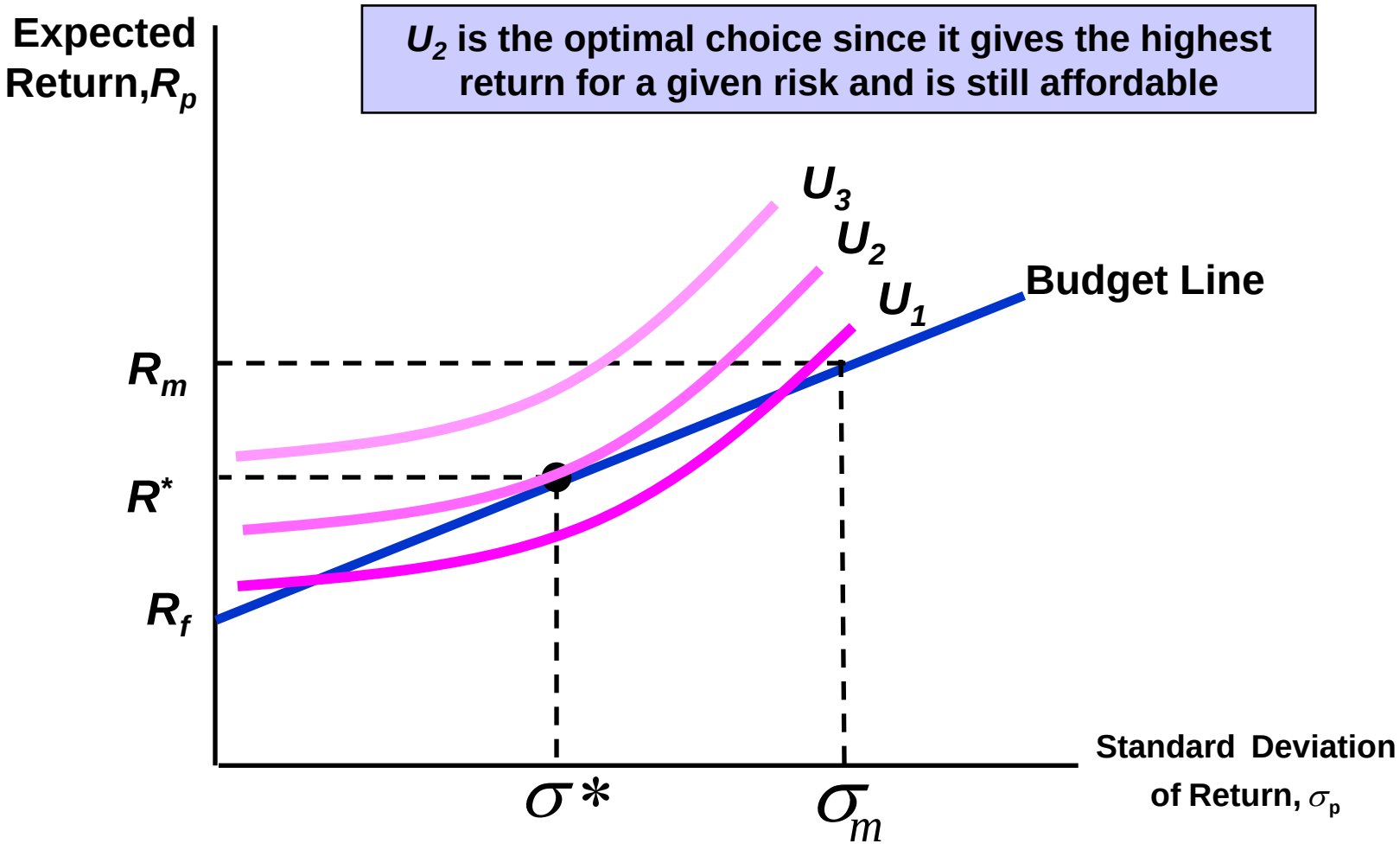
- Can describe a person's risk aversion using indifference curves that relate expected income to variability of income (standard deviation)
- Since risk is undesirable, greater risk requires greater expected income to make the person equally well off
- Indifference curves are therefore upward sloping

Risk Aversion and Indifference Curves



Highly Risk Averse: An increase in standard deviation requires a large increase in income to maintain satisfaction.

Choosing Between Risk and Return



Reducing Risk

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

Reducing Risk

- Diversification
  - Reducing risk by allocating resources to a variety of activities whose outcomes are not closely related
- 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

Reducing Risk – Insurance

- Risk averse are willing to pay to avoid 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

The Decision to Insure

Insurance	Burglary (Pr = .1)	No Burglary (Pr = .9)	Expected Wealth	Standard Deviation
No	40,000	50,000	49,000	3000
Yes	49,000	49,000	49,000	0

The Value of Information

- Risk often exists because we don’t know all the information surrounding a decision
- Because of this, information is valuable and people are willing to pay for it