MEE1014 Industrial Engineering and Management

B.Tech (Mechanical)

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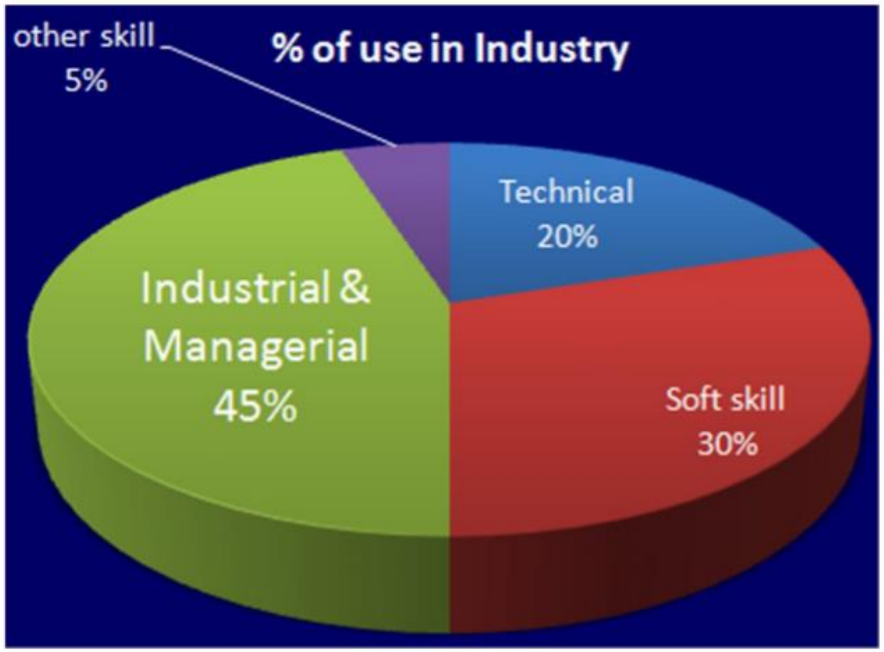
Why to Study this Course

- Not only for manufacturing industry
- To understand, develop and implement systems involving persons and other resources
- You will learn about the methods to manage and optimize the utilization of resources available by applying mathematical and engineering tools
- Industrial engineers are appropriate for any industry, starting from manufacturing to planning, logistics to supply chain management, consultancy to software



Objectives

- To understand the functioning of industries.
- To apply productivity techniques for achieving continuous improvement.

Expected Outcome at the end of the course

CO1	Analyze the way price of a product affects the demand for a product for consequent actions and predict demand for a product by making use of different demand forecasting techniques.
CO2	Explain Break even analysis to determine safe production levels and costing of industrial products.
CO3	Apply productivity techniques for continuous improvement in different functionalities of an industry.
CO4	Analyze the existing operations that happen in factories for establishing time standards for different activities.
CO5	Demonstrate the knowledge of selection of location for the new plant & optimizing the layout within the plant for smooth production.
CO6	Apply cellular manufacturing concepts in industry.
CO7	Compute material requirement needed to satisfy the Master Production Schedule of a factory by having thorough understanding of MRP logic.

Syllabus: Module-1

Introduction to macro and micro ecnomics:

Macro economic measures – micro economics – Demand and supply – Determinants of demand and supply – Elasticity of demand – Demand forecasting techniques (short term & long term) – Problems. (6 Hours)

Syllabus: Module-2

Elements of Cost:

Determination of Material cost - Labour cost – Expenses - Types of cost – Cost of production – Overhead expenses– break even analysis - Problems.(6 Hours)

Syllabus: Module-3

Productivity:

Definition – Factors affecting- Increasing productivity of resources - Kinds of productivity measures - Case study. (6 Hours)

Syllabus: Module-4

Introduction to Work study:

Method study – Time study – stopwatch time study – Work measurement - performance rating-allowances – Ergonomics.(6 Hours)

Syllabus: Module-5

Plant Location and Plant Layout:

Plant location –need - Factors – comparison – quantitative methods for evaluation

Plant layout: objectives-principles – factors influencing – tools and techniques including computer based layout design – CRAFT, ALDEP, CORELAP. (7 Hours)c

Syllabus: Module-6

Cellular manufacturing:

Group Technology – Cellular layout – Machine-Part Cell Formation (MPCF) – Heuristic approaches – Hierarchical clustering for MPCF. (6 Hours)

Syllabus: Module-7

Material Requirement Planning (MRP):

Objectives – functions – MRP system – MRP logic – Management information from MRP – lot sizing consideration – Manufacturing resource planning – capacity requirement planning (CRP) –Bill of material.(6 Hours)

Syllabus: Module-8

Contemporary issues:

Delivered by industrial experts.(2 hours)

References

Text Book

- R Dan Reid and Nada R. Sanders (2012), Operations Management, John wiley& Sons, 5th Edition.

Reference Books

- Martand Telsang (2006), Industrial Engineering and Production Management, S. Chand.
- R Panneerselvam (2012), Production and Operations Management, PHI publications, 3rd Edition.

Assessment Process

CAT-1	**15**
CAT-2	**15**
Assignments/Quizzes	**30**
FAT	**40**
Total	**100**

Module-1

Introduction to macro and micro economics: Macro economic measures – micro economics – Demand and supply – Determinants of demand and supply – Elasticity of demand – Demand forecasting techniques (short term & long term) – Problems. (6 Hours)

Demand

Demand

Demand involves the **relationship** between **price** and **quantity**

Demand

Demand is the **quantity** of a **product** or commodity that buyers are **willing to purchase** from the market **at a given price**

Demand

Conditions

- ✓Desire to buy
- ✓Willingness to pay for it
- ✓Ability to pay for it

Demand

A student may **want** a new iPhone but **not have the means** to purchase it

Demand Schedule

It is a table showing how much of a given product, a household would be **willing to buy at different prices**

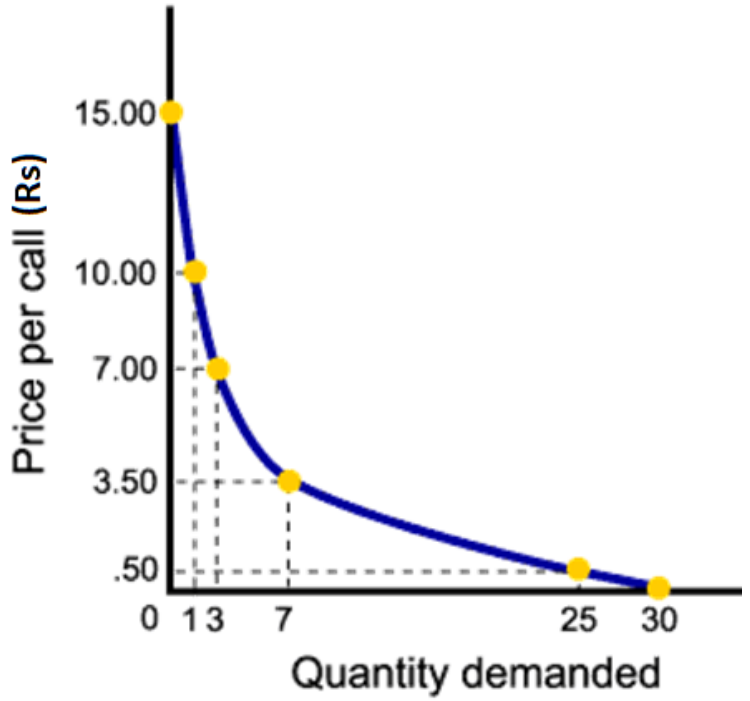
Demand Schedule

Labour's demand Schedule for Mobile Calls	
PRICE (PER CALL)	QUANTITY DEMANDED (CALLS PER MONTH)
Rs 0	30
0.50	25
3.50	7
7.00	3
10.00	1
15.00	0

Demand Curves

Usually derived from demand schedules

Labour's demand Schedule for Mobile Calls	
PRICE (PER CALL)	QUANTITY DEMANDED (CALLS PER MONTH)
Rs 0	30
0.50	25
3.50	7
7.00	3
10.00	1
15.00	0



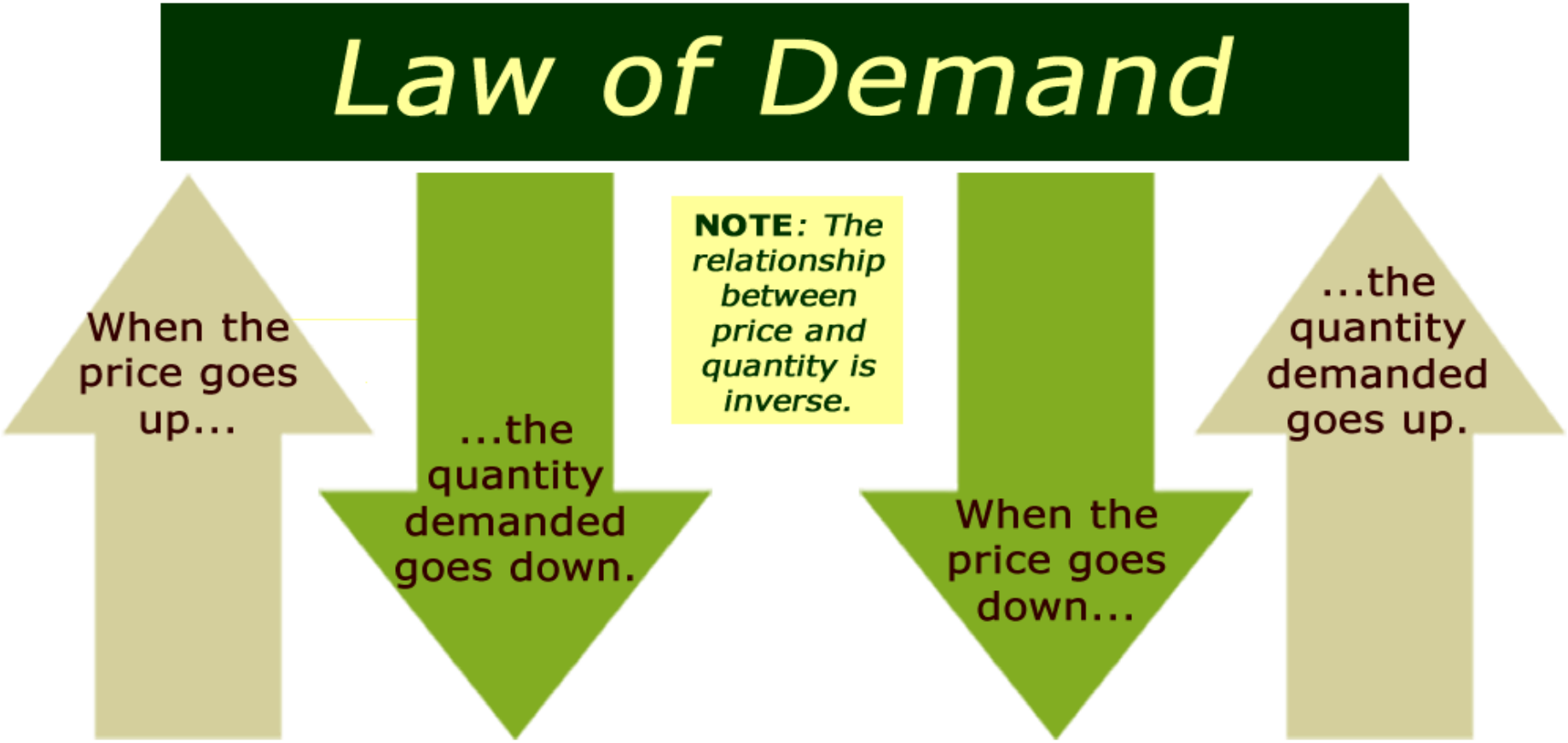
Law of Demand

It is the **inverse relationship** between **price** and the **quantity demanded** of a good or service during some period of time

Law of Demand

It states that the **quantity demanded** of a good **falls** when the **price** of the good **rises**, and vice versa, provided all other factors that affect buyers' decisions are unchanged

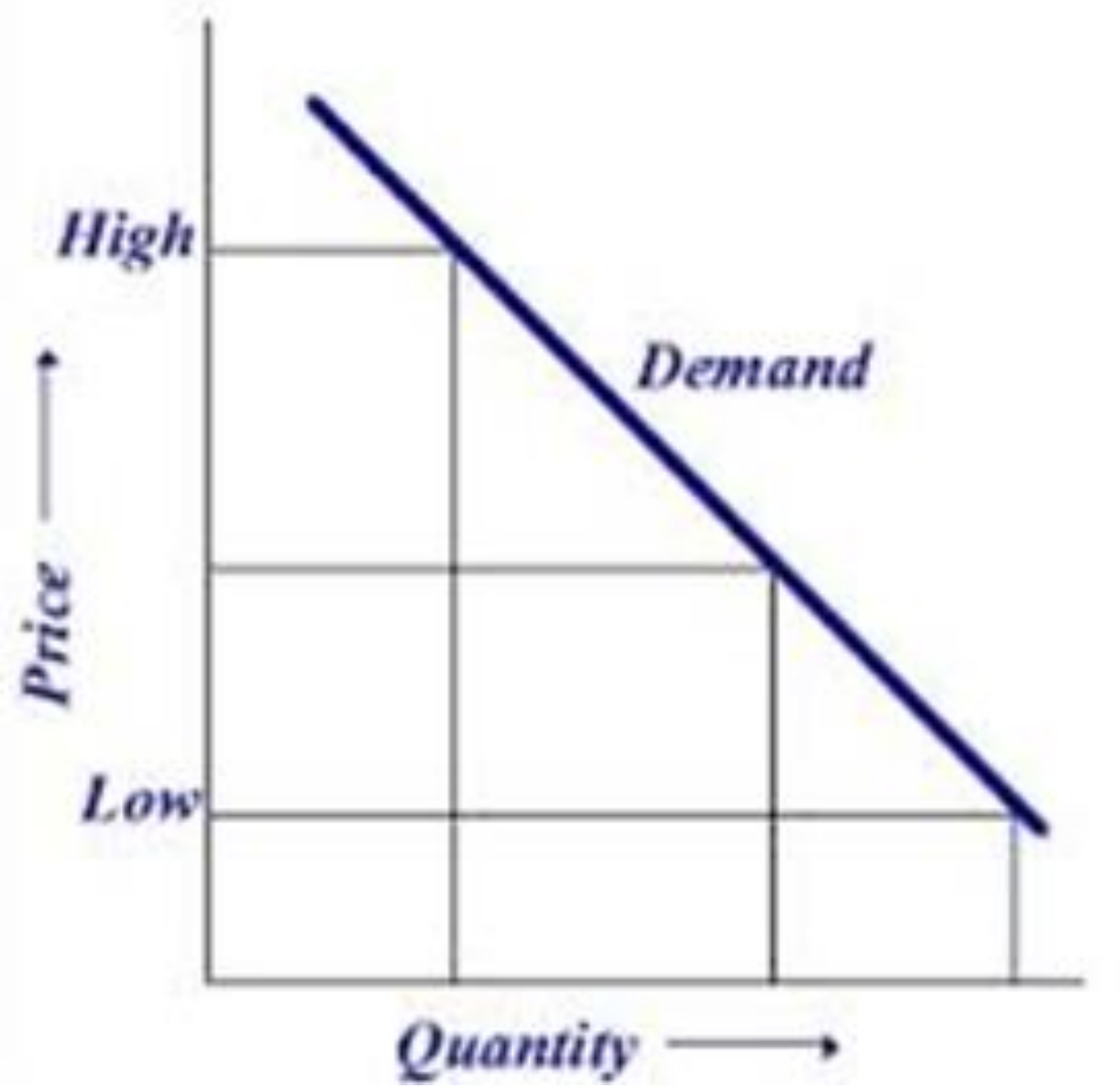
Law of Demand



Law of Demand

- **Example**
- I want a new computer. I have Rs. 27000 to buy it. When I go to the store to purchase computer, I find the price has increased to Rs. 32000. I do not have that extra money, so I can not buy the computer. However, I may not even be willing to pay that increased price.

Law of Demand



Factors that influence Demand

“P.O.I.N.T.”

Factors that influence Demand

- **"P.O.I.N.T."**

***P*rice of other goods**

(substitute (or) complementary)

Factors that influence Demand

- **“P.O.I.N.T.”**

Outlook

(consumer expectation of the future)

Factors that influence Demand

- **“P.O.I.N.T.”**

_I_ncome

(normal goods Vs inferior goods)

Factors that influence Demand

- **“P.O.I.N.T.”**

_N_umber of potential customers

(population of market)

Factors that influence Demand

- **“P.O.I.N.T.”**

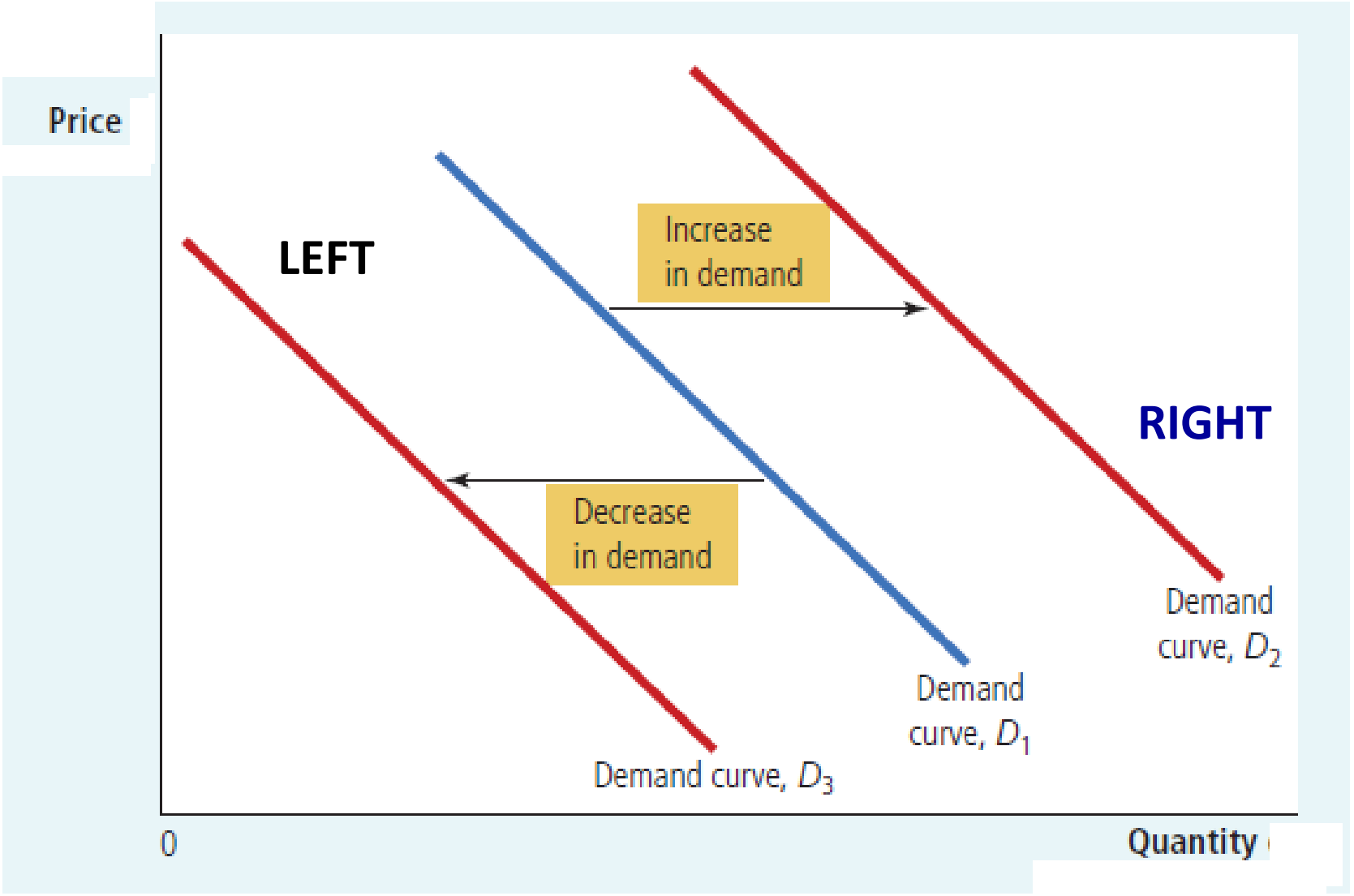
***T*aste**

(fads or trends)

Shift in Demand Curve

A demand curve shifts whenever a factor that affects the **demand** of the good (other than price) **changes**

Shift in Demand Curve



Factors that influence Demand

Price of other goods

Substitutes are goods that can serve as replacements for one another

Factors that influence Demand

Price of other goods

When the price of one increases, demand for the other goes up.

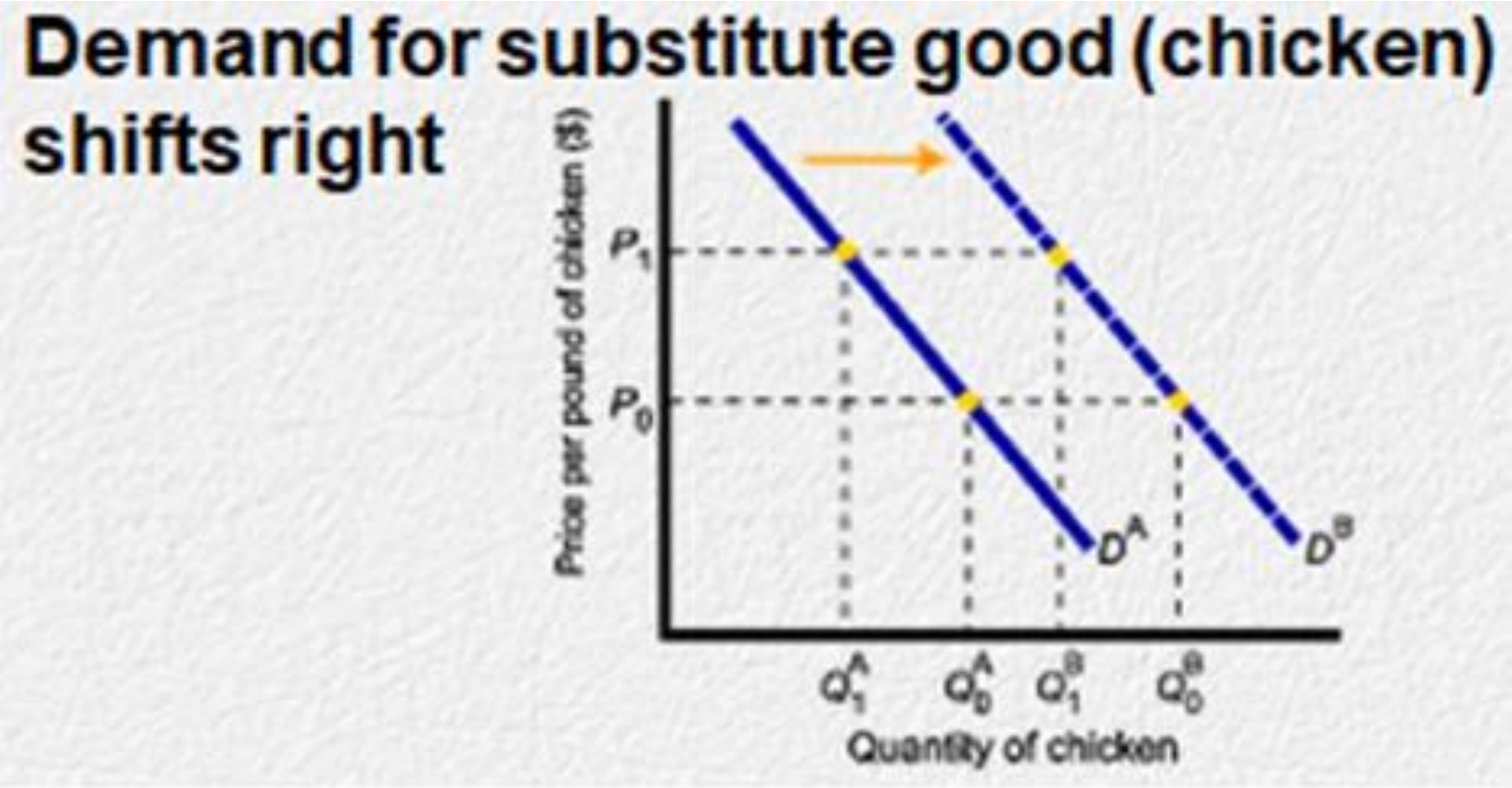
Factors that influence Demand

Price of other goods

Perfect substitutes are identical products

Factors that influence Demand

Price of other goods



Factors that influence Demand

Price of other goods

Complements are goods that "go together"

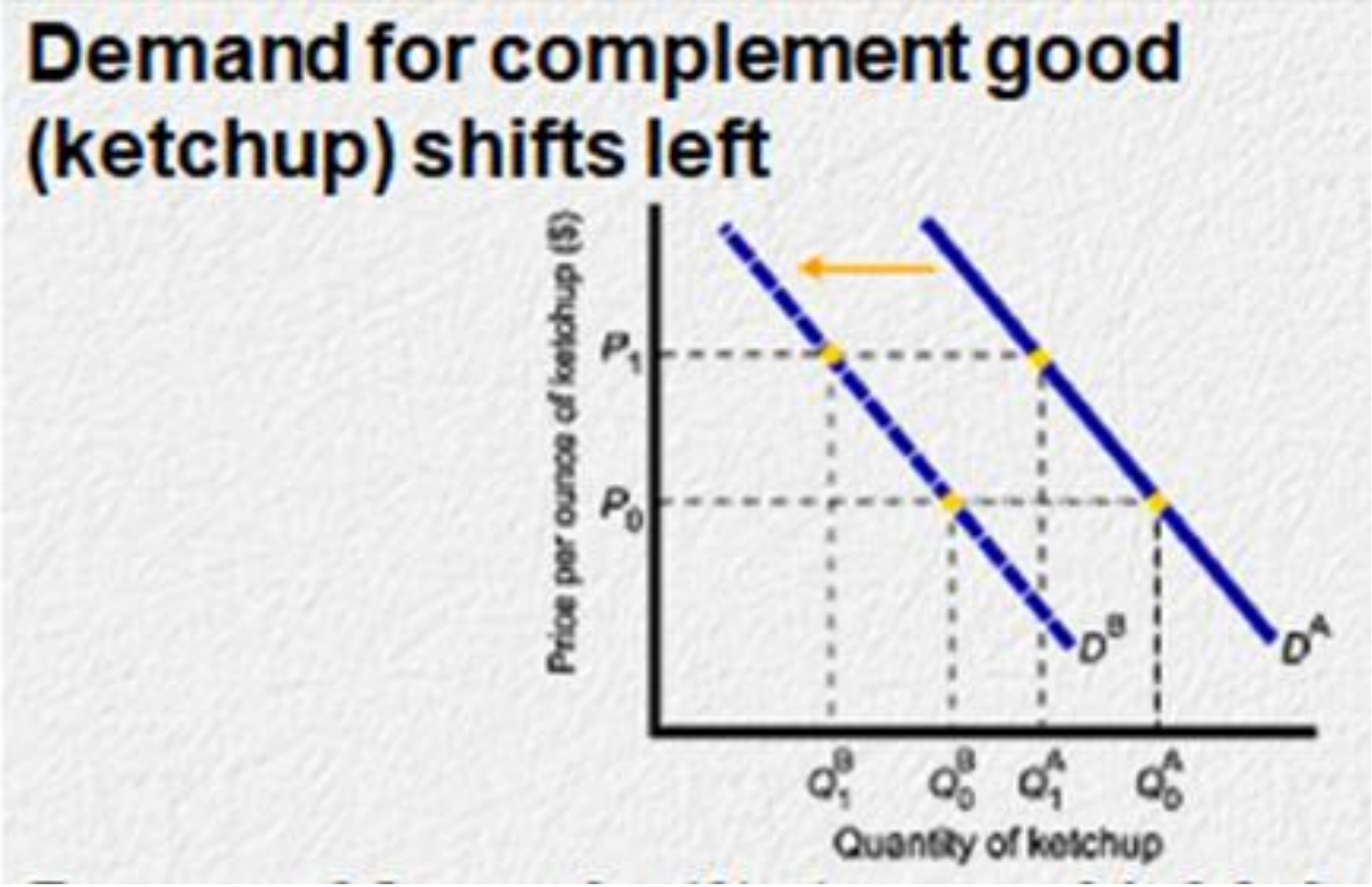
Factors that influence Demand

Price of other goods

A decrease in the price of one results in an increase in demand for the other, and vice versa.

Factors that influence Demand

Price of other goods



Factors that influence Demand

Outlook (consumer expectation of the future)

An increase in the expected future price of a good increases current demand and vice versa

Factors that influence Demand

Outlook (consumer expectation of the future)

Example: When a good is temporarily put on sale, people stock up on the good

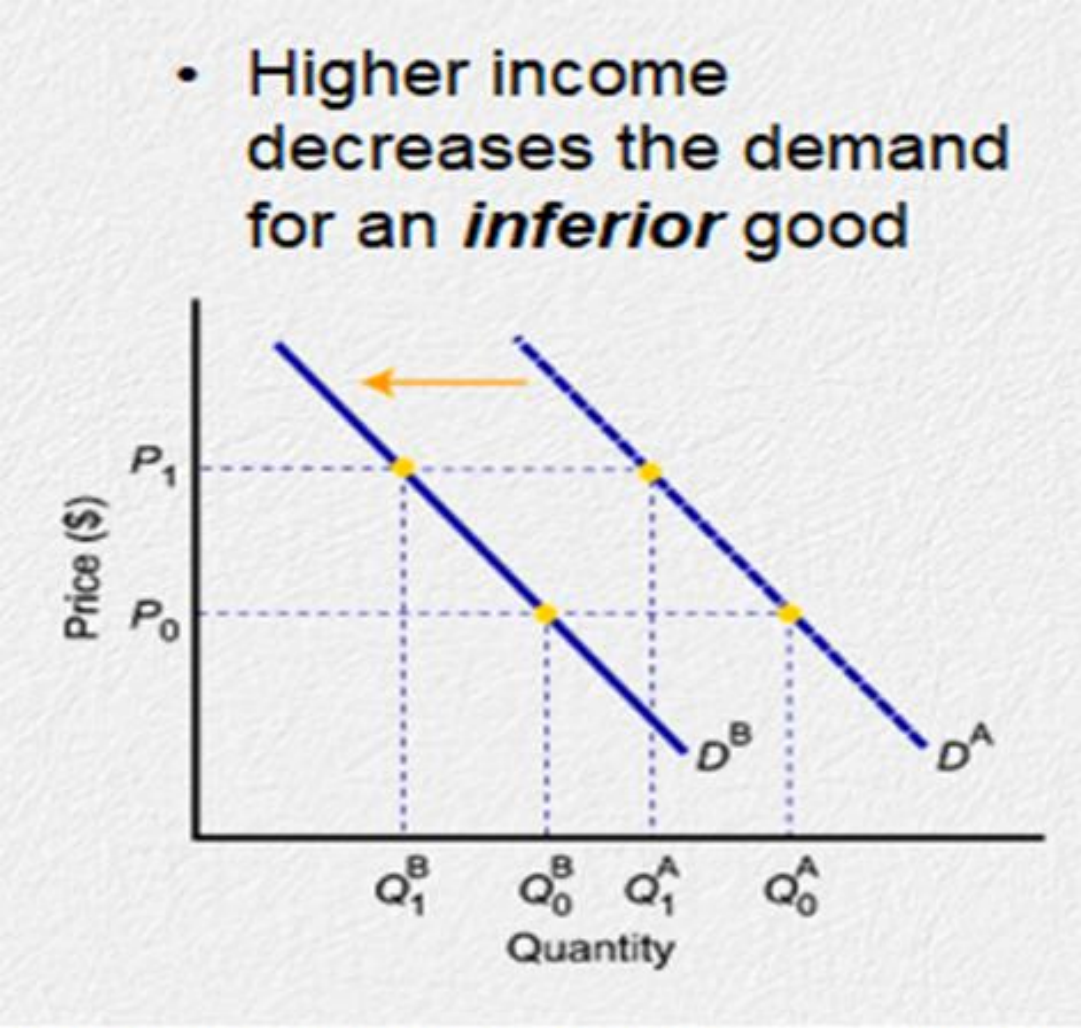
Factors that influence Demand

Income (normal goods Vs inferior goods)

Generally when income increases consumers have more money to spend, or more ability ➔ Greater demand for goods

Factors that influence Demand

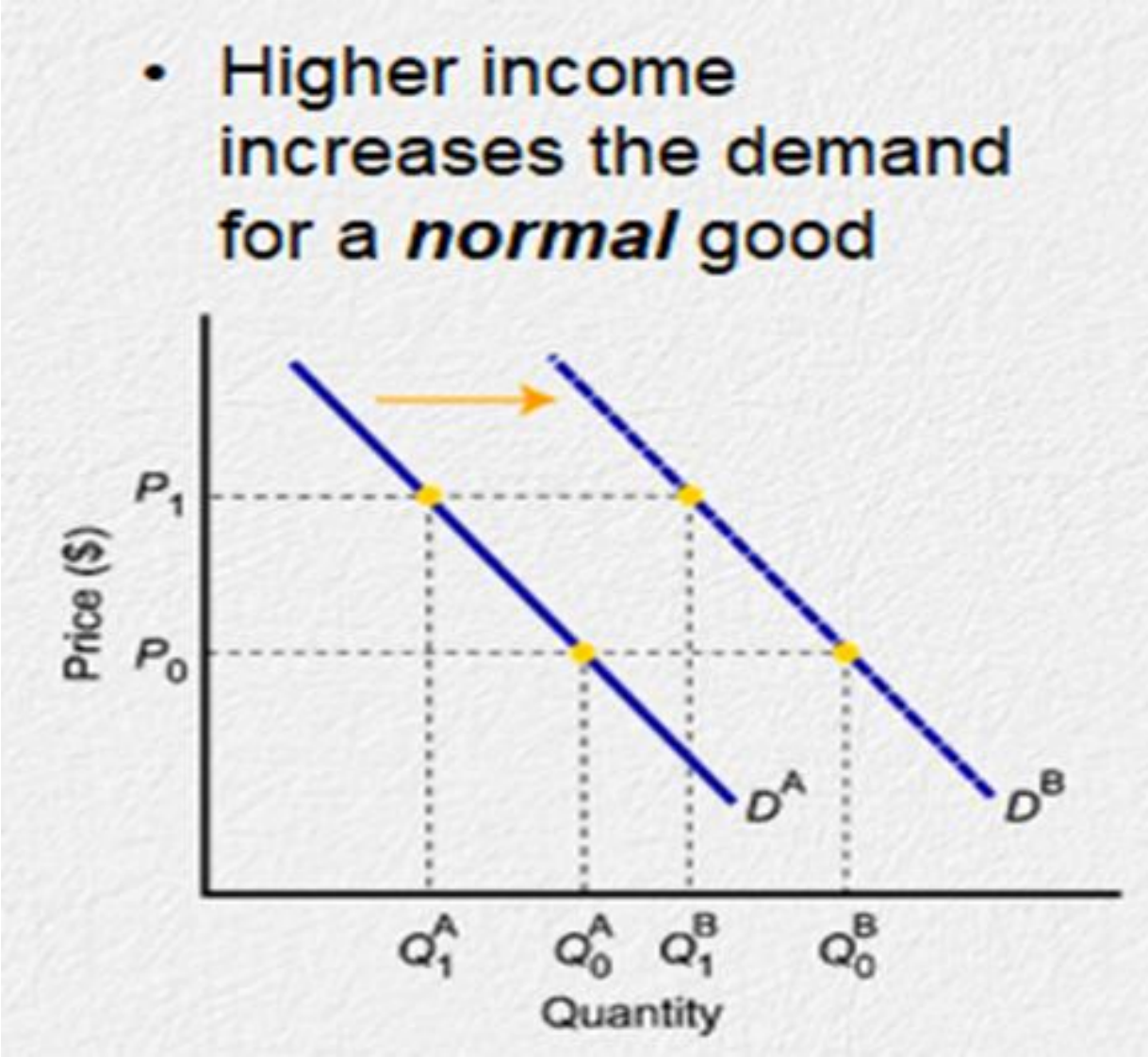
Income (normal goods Vs inferior goods)



 Principles

Factors that influence Demand

Income (normal goods Vs inferior goods)



Factors that influence Demand

Number of potential customers (population of market)

A larger market means more demand, but a smaller market means less demand.

Factors that influence Demand

Taste (Fads or Trends)

As a new brand becomes popular the demand for that brand grows

Factors that influence Demand

Taste (Fads or Trends)

When the brand gets poor reviews the demand decreases

Elasticity of Demand

Elasticity

Elasticity, a measure of how much buyers and sellers respond to changes in market conditions

Elasticity of Demand

Buyers usually demand more of a good

- ✓ when its price is lower,
- ✓ when their incomes are higher,
- ✓ when the prices of substitutes for the goods are higher, or
- ✓ when the prices of complements of the goods are lower.

Elasticity of Demand

Our discussion of demand was qualitative, not quantitative.

That is, we discussed the direction in which the quantity demanded moves, but not the size of the change.

Elasticity of Demand

To measure how much demand responds to changes in its determinants, economists use the concept of elasticity.

Elasticity of Demand

The **price elasticity of demand** measures how much the quantity demanded responds to a change in price

Elasticity of Demand

Demand for a good is said to be **elastic** if the quantity demanded responds substantially to changes in the price

Elasticity of Demand

Demand is said to be **inelastic** if the quantity demanded responds only slightly to changes in the price

Determinants of Price Elasticity of Demand

- Necessities versus Luxuries
- Availability of Close Substitutes
- Definition of the Market
- Time Horizon

Determinants of Price Elasticity of Demand

- Necessities versus Luxuries
  - ✓ Necessities tend to have inelastic demands
  - ✓ Luxuries have elastic demands

Determinants of Price Elasticity of Demand

Availability of Close Substitutes

- ✓Goods with close substitutes tend to have more elastic demand because it is easier for consumers to switch from that good to others

Determinants of Price Elasticity of Demand

- Definition of the Market
  - ✓ The elasticity of demand in any market depends on how we draw the boundaries of the market
  - ✓ Narrowly defined markets tend to have more elastic demand than broadly defined markets, because it is easier to find close substitutes for narrowly defined goods

Determinants of Price Elasticity of Demand

- Time Horizon
  - ✓ Goods tend to have more elastic demand over longer time horizons

Computing the Price Elasticity of Demand

$$\textbf{Price Elasticity of Demand} = \frac{\textbf{Percentage change in Quantity Demanded}}{\textbf{Percentage change in Price}}$$

- **Example**: If the price of a pencil increases from Rs. 2 to Rs. 2.20 and the amount you buy falls from 10 to 8 pencils, then your elasticity of demand would be calculated as

$$\frac{\frac{(10-8)}{10}\times 100}{\frac{(2.20-2.00)}{2.00}\times 100} = \frac{20 \text{ percent}}{10 \text{ percent}} = 2$$

- The elasticity is 2, reflecting that the change in the quantity demanded is proportionately twice as large as the change in the price

Computing the Price Elasticity of Demand

Midpoint Method

- Better way to calculate the percentage changes and elasticity

Point-A:	Price: Rs. 4	Quantity = 120
Point-B:	Price: Rs. 6	Quantity = 80

- Calculate the Elasticity.
- The elasticity from point A to point B seems different from the elasticity from point B to point A
- Use midpoint method to calculate the elasticities.
- Midpoint method gives the same answer regardless of the direction of change, it is often used when calculating the price elasticity of demand between two points.

Computing the Price Elasticity of Demand

Midpoint Method

- **Formula**

$$\text{Price elasticity of demand} = \frac{(Q_2 - Q_1)/[(Q_2 + Q_1)/2]}{(P_2 - P_1)/[(P_2 + P_1)/2]}.$$

where

- Q1 and Q2 represent quantity
- P1 and p2 represent Price

Computing the Price Elasticity of Demand

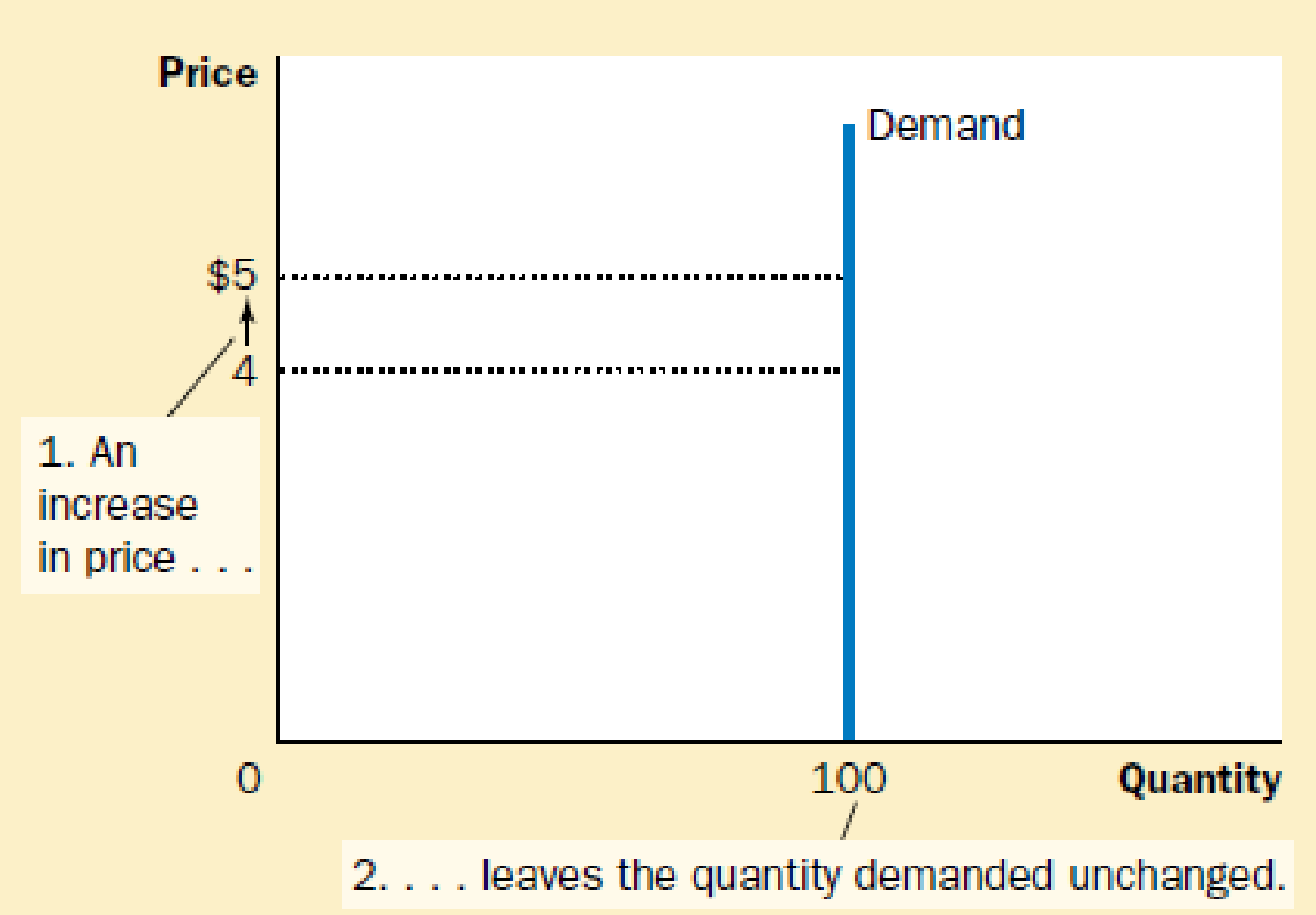
Midpoint Method

- **Example**: If the price of a pencil increases from Rs. 2 to Rs. 2.20 and the amount you buy falls from 10 to 8 pencils, then your elasticity of demand would be calculated as

$$\frac{\dfrac{(10-8)}{(10+8)/2}}{\dfrac{(2.20-2.00)}{(2.00+2.20)/2}} = \frac{22\ percent}{9.5\ percent} = 2.32$$

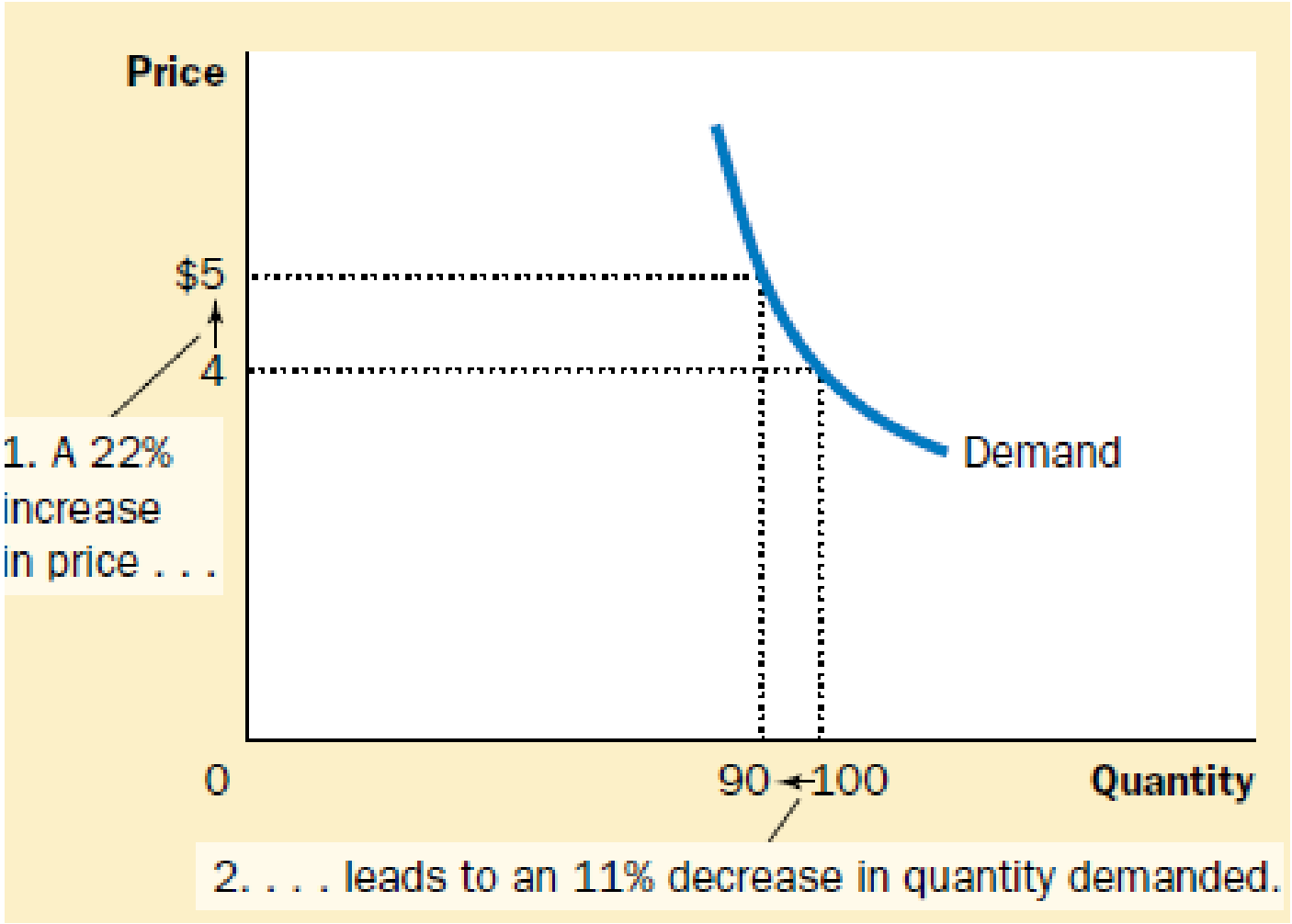
Price Elasticity of Demand

- **Perfectly inelastic demand: Elasticity equals to 0**



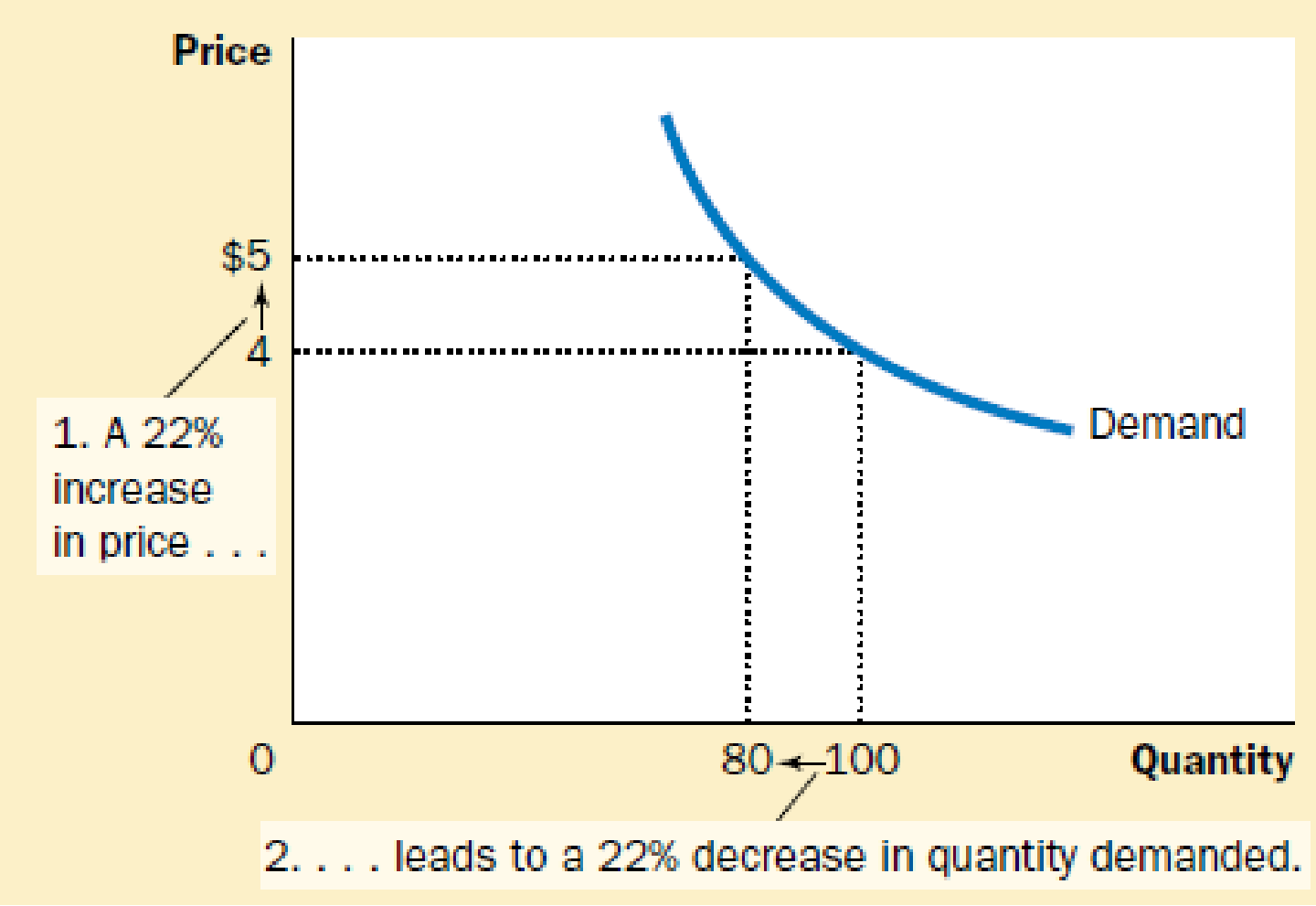
Price Elasticity of Demand

- **Inelastic demand: Elasticity is less than 1**



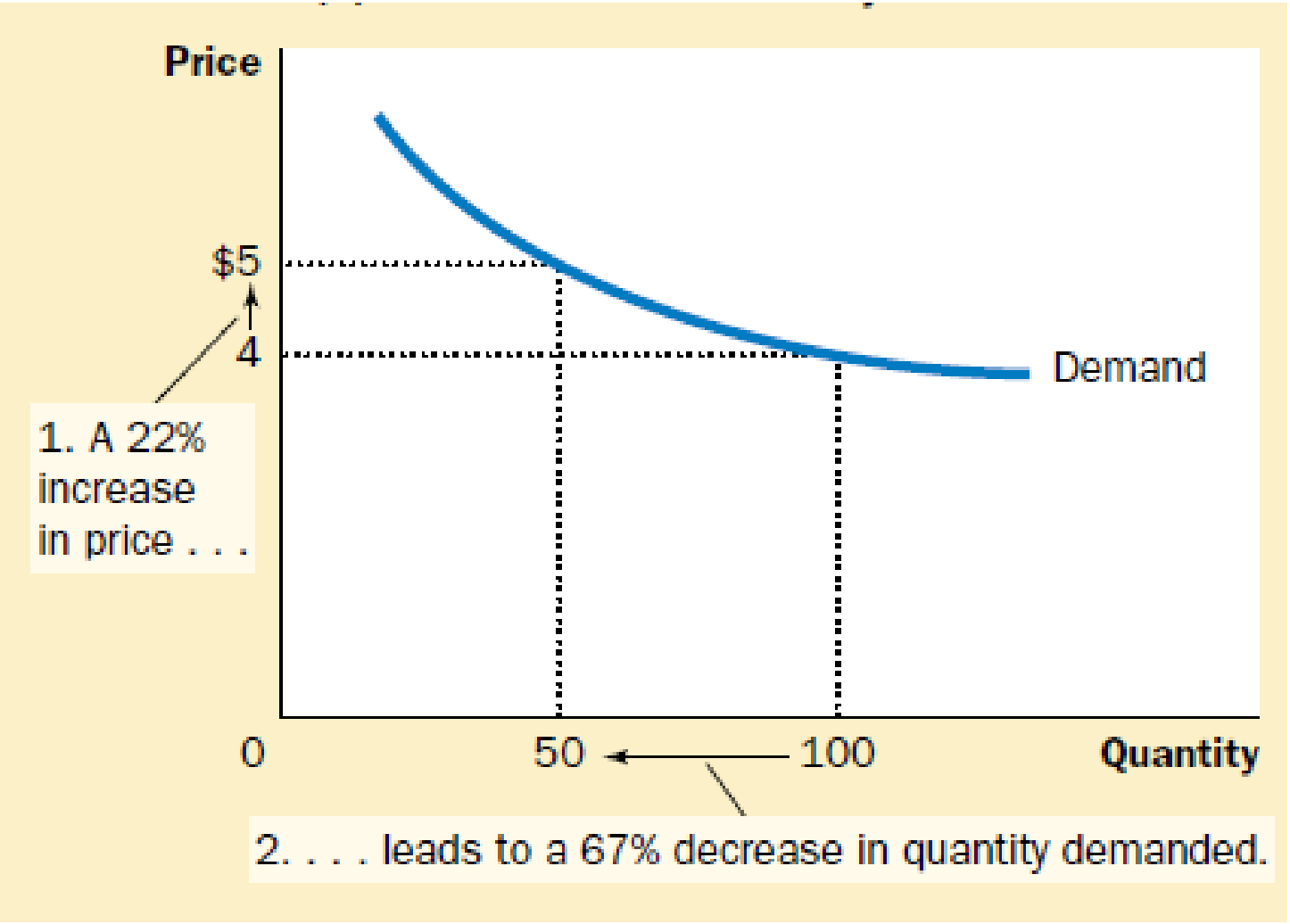
Price Elasticity of Demand

- **Unit Elastic demand: Elasticity equals 1**



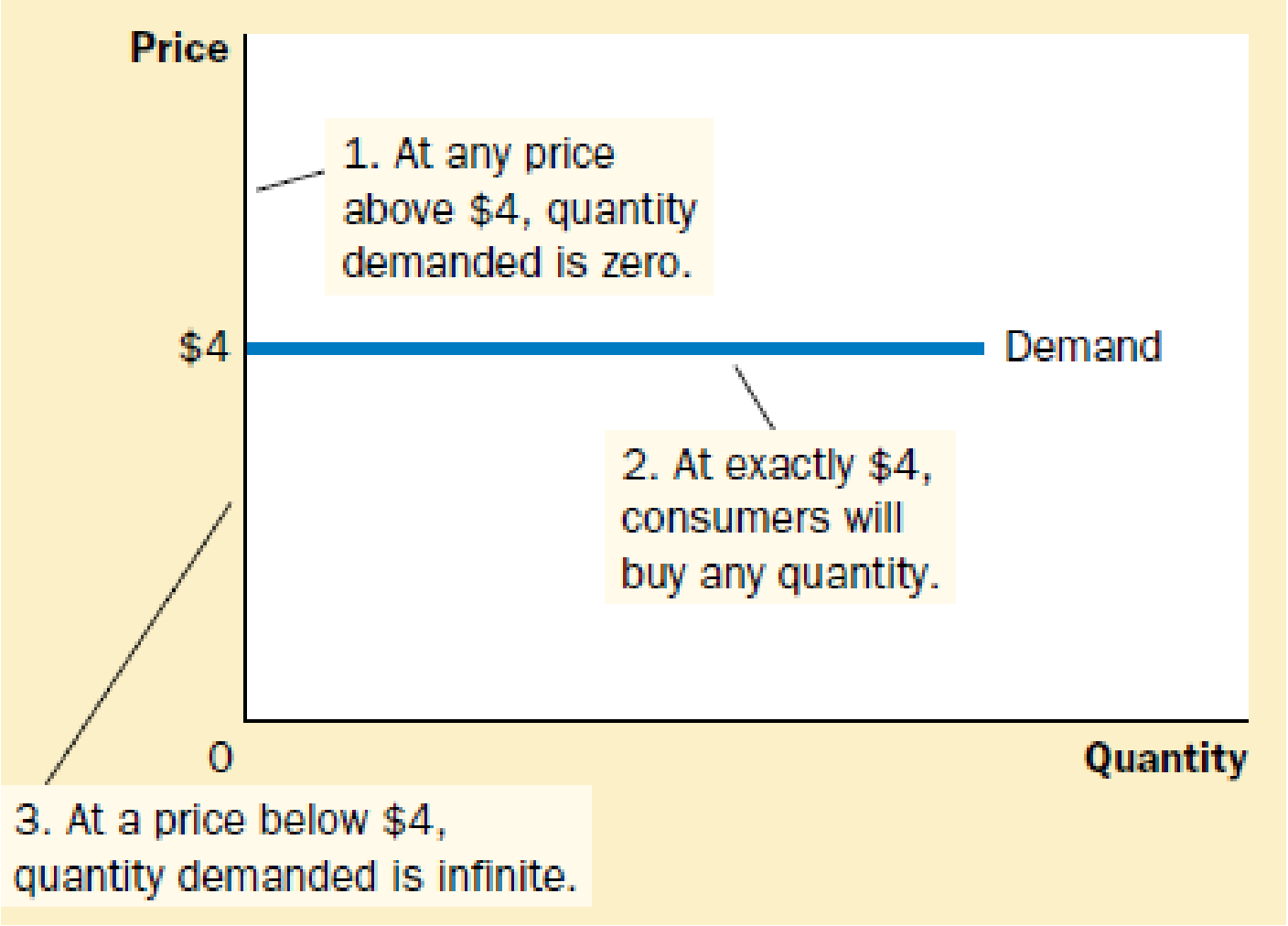
Price Elasticity of Demand

- **Elastic demand: Elasticity is greater than 1**



Price Elasticity of Demand

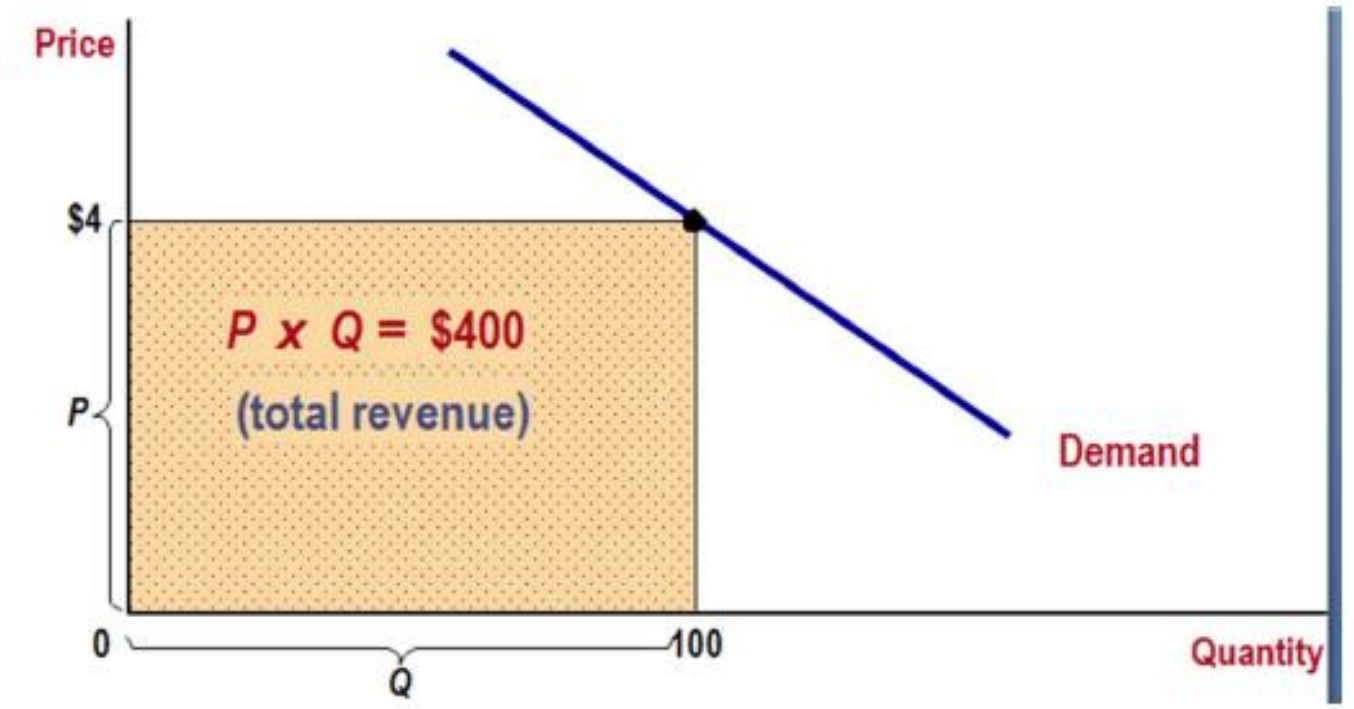
- **Perfectly Elastic demand: Elasticity equals infinity**



Computing the Price Elasticity of Demand

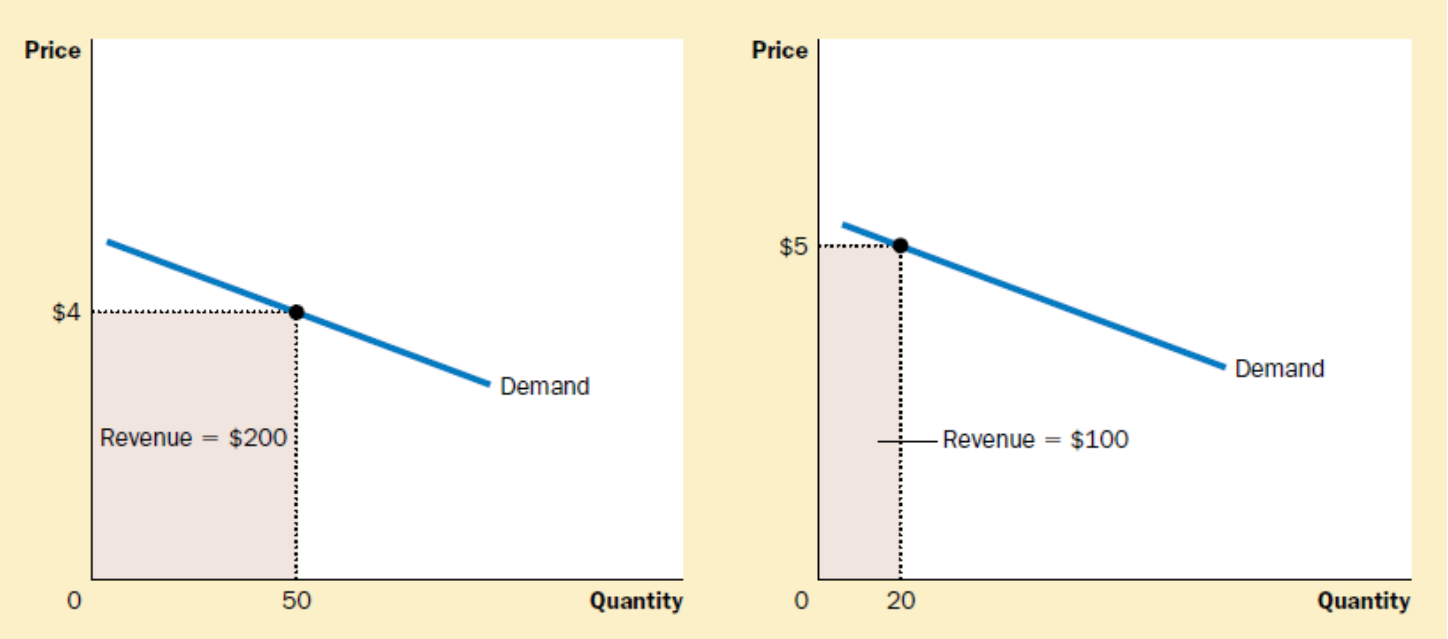
Total Revenue (TR)

- **Total revenue is the amount paid by buyers and received by sellers of a good**
- **Computed as the price (P) of the good times the quantity (Q) sold**
- **TR = P x Q**



Computing the Price Elasticity of Demand

How total revenue changes when price changes: Elastic Demand



- With an elastic demand curve, an increase in the price leads to a decrease in quantity demanded that is proportionately larger. Therefore, total revenue (the product of price and quantity) decreases.
- Here, an increase in the price from $4 to $5 causes the quantity demanded to fall from 50 to 20, so total revenue falls from $200 to $100.

Demand Forecasting Techniques

Demand Forecasting

- A prediction, projection, or estimate of future demand for the firm's product
- A forecast can be determined by mathematical means **using historical**, it can be created subjectively by **using estimates** from informal sources, or it can represent a **combination of both techniques**

Demand Forecasting

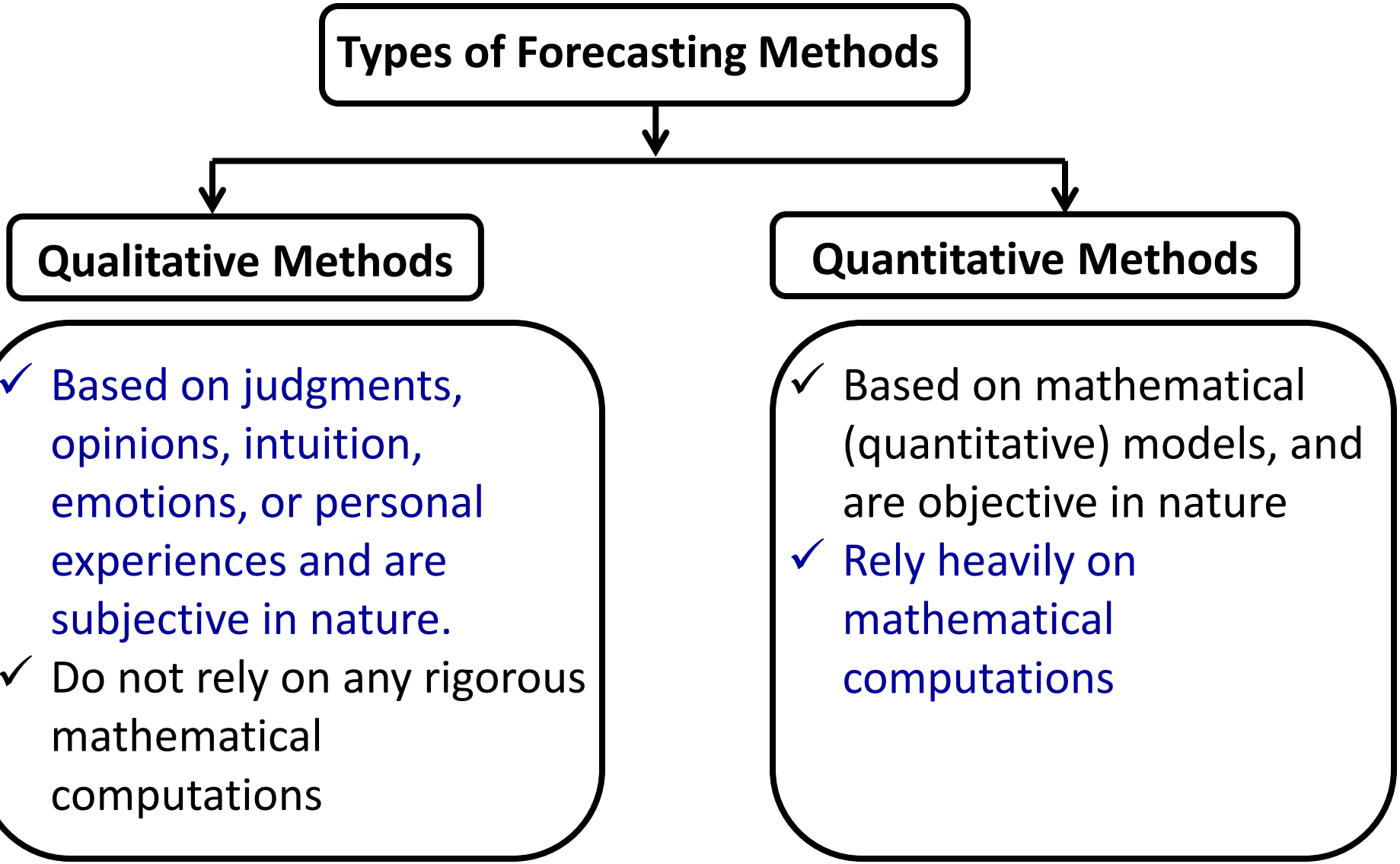
Why forecast?

- To plan for the future by reducing uncertainty
- To anticipate and manage change
- To increase communication and integration of planning teams
- To anticipate inventory and capacity demands and manage lead times
- To project costs of operations into budgeting processes
- To improve competitiveness and productivity through decreased costs and improved delivery and responsiveness to customer needs

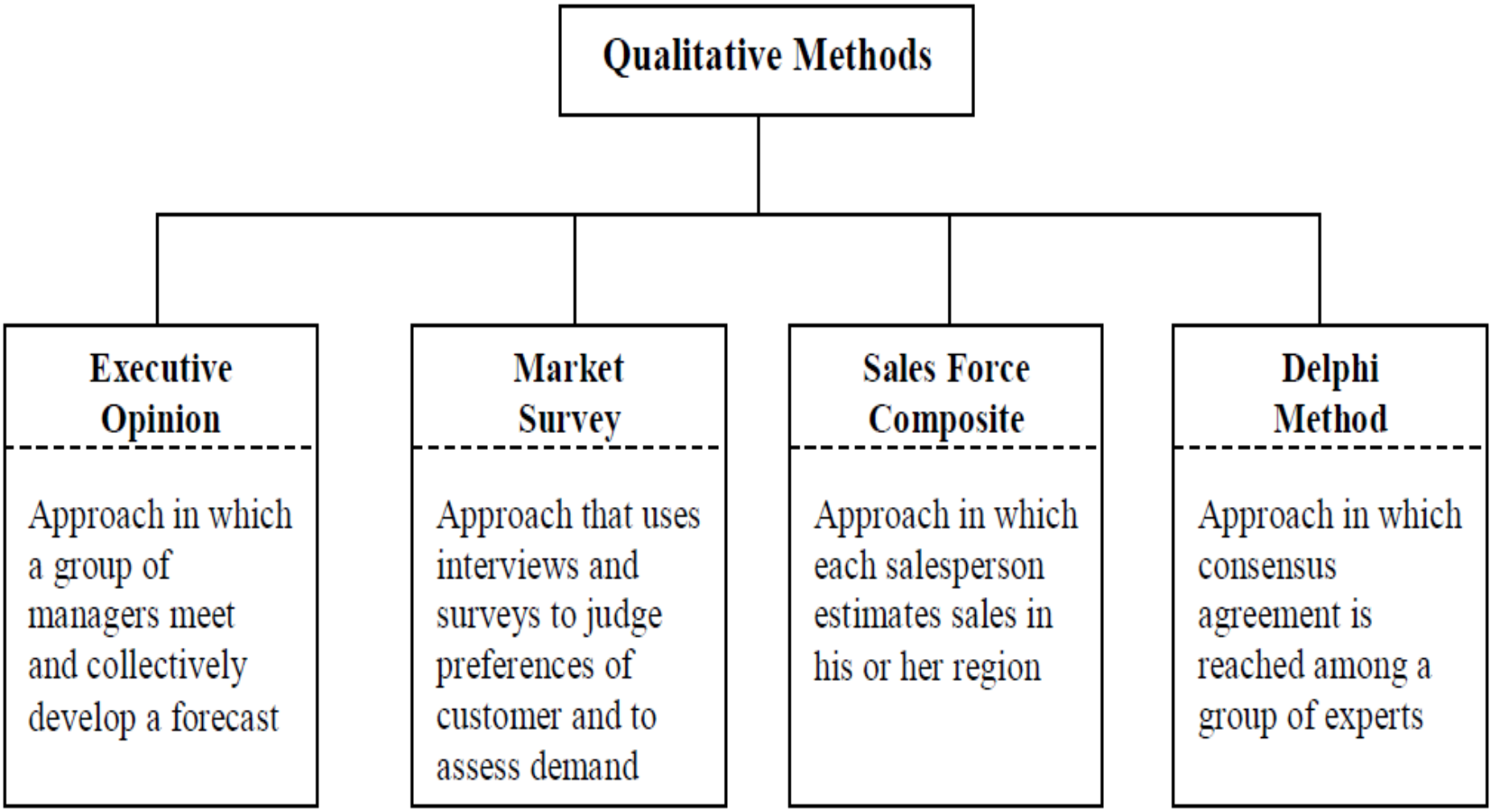
Demand Forecasting – Steps

- Specify the objective
- Determine the time perspective
- Make choice of method of demand forecasting
- Collection of data
- Estimation and interpretation of results

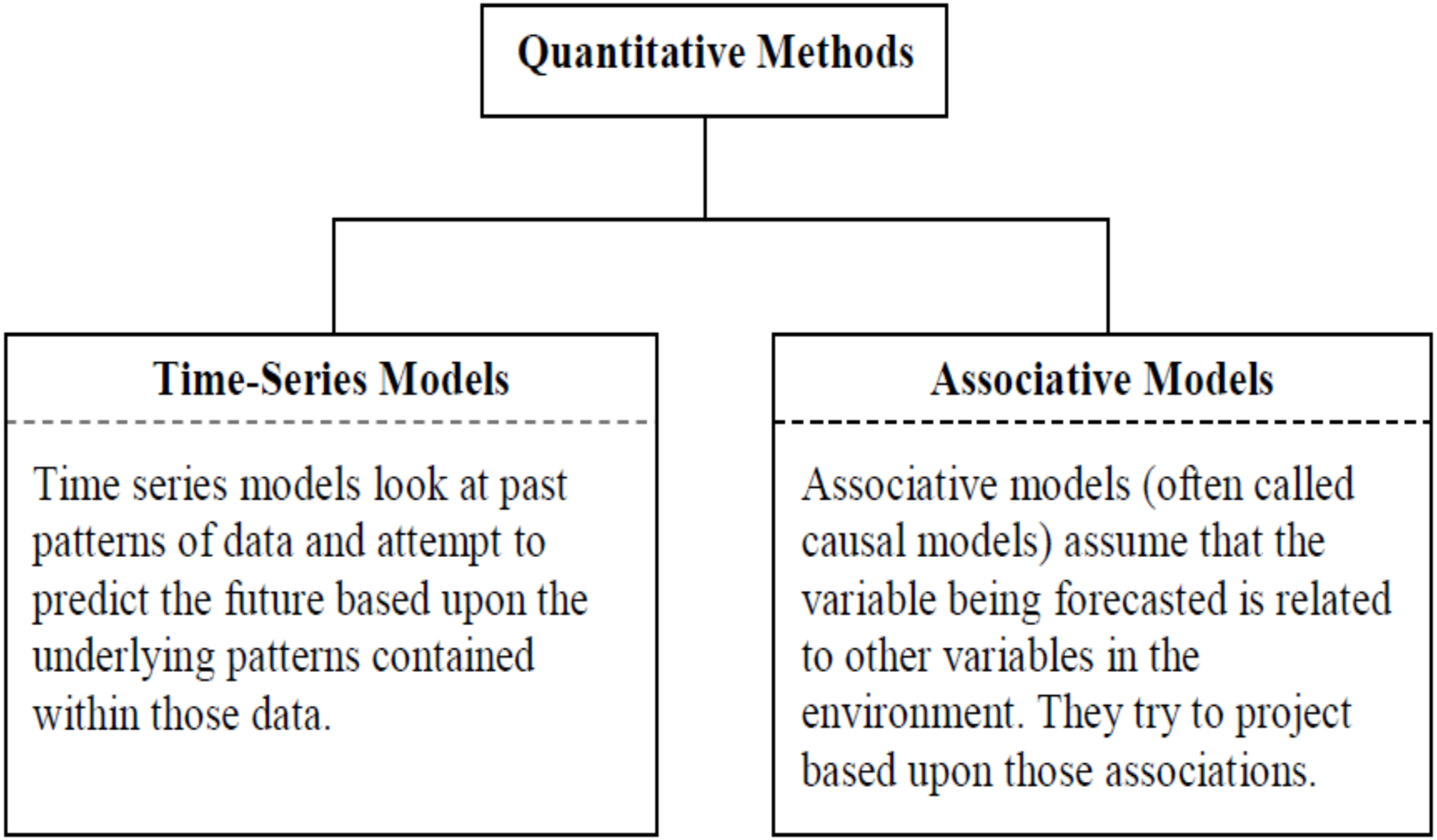
Demand Forecasting – Types



Demand Forecasting – Qualitative Methods



Demand Forecasting – Quantitative Methods



Demand Forecasting – Quantitative Methods

Time Series Models

Model	Description
Naive	Uses last period's actual value as a forecast
Simple Mean (Average)	Uses an average of all past data as a forecast
Simple Moving Average	Uses an average of a specified number of the most recent observations, with each observation receiving the same emphasis (weight)
Weighted Moving Average	Uses an average of a specified number of the most recent observations, with each observation receiving a different emphasis (weight)

Demand Forecasting – Quantitative Methods

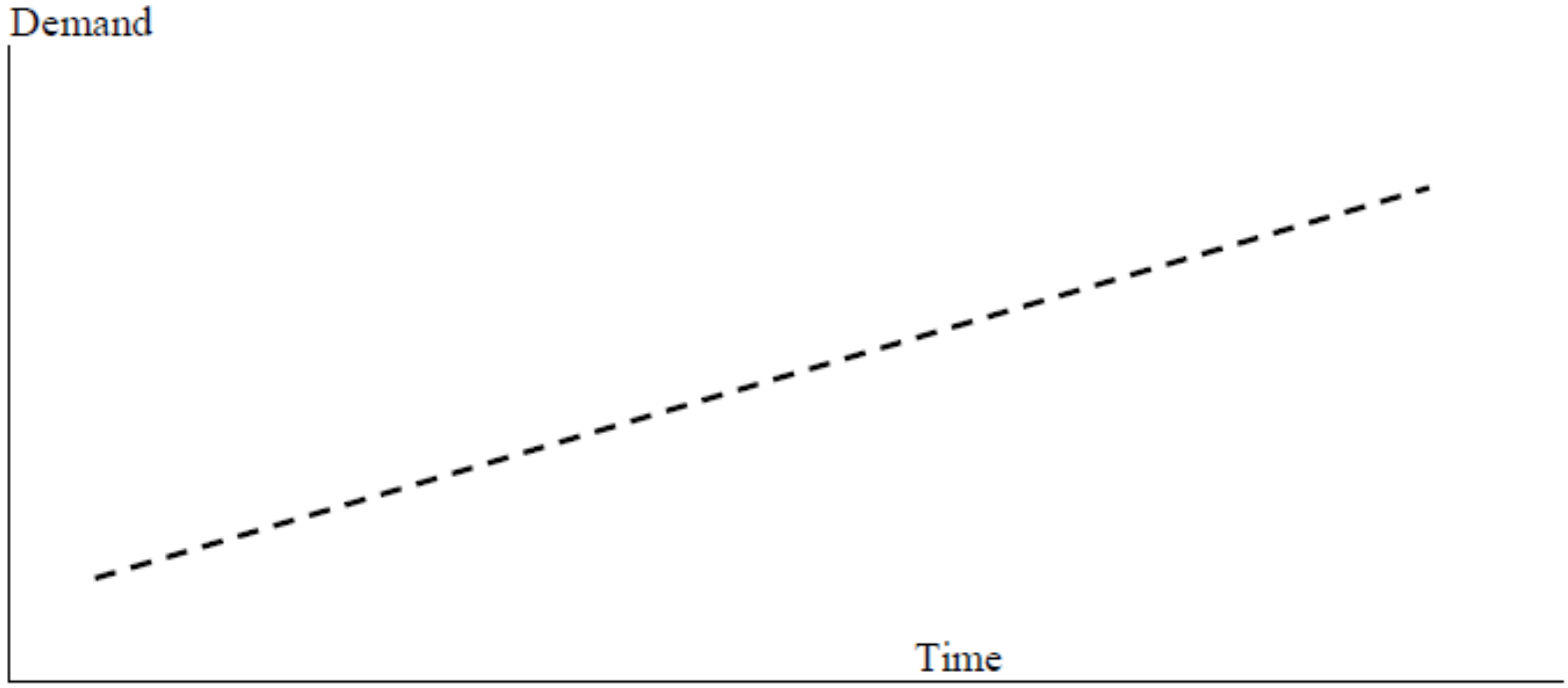
Time Series Models

Model	Description
Exponential Smoothing	A weighted average procedure with weights declining exponentially as data become older
Trend Projection	Technique that uses the least squares methods to fit a straight line to the data
Seasonal Indexes	A mechanism for adjusting the forecast to accommodate any seasonal patterns inherent in the data

Decomposition of Time Series

Patterns that may be present in the time series

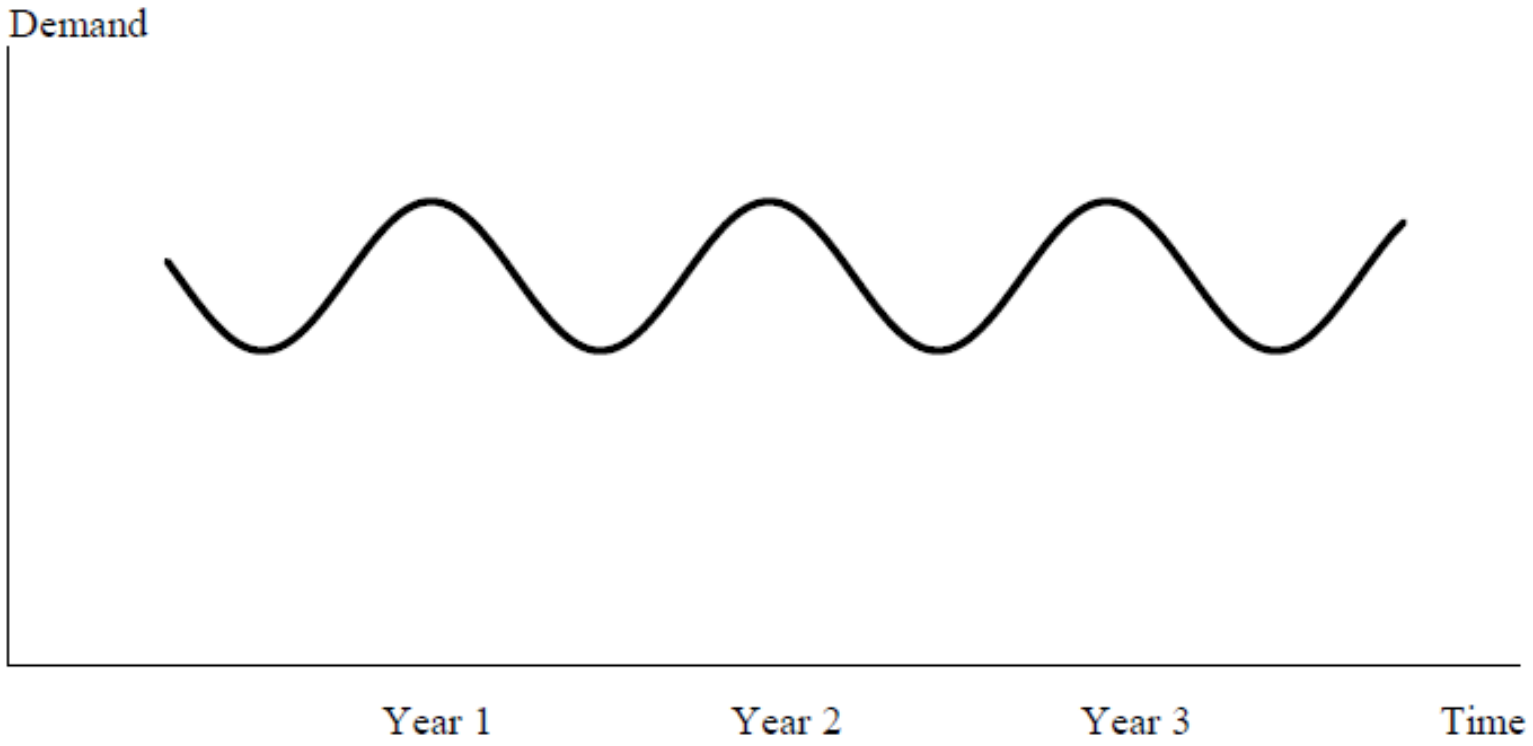
- **Trend**: Data exhibit a steady growth or decline over time



Decomposition of Time Series

Patterns that may be present in the time series

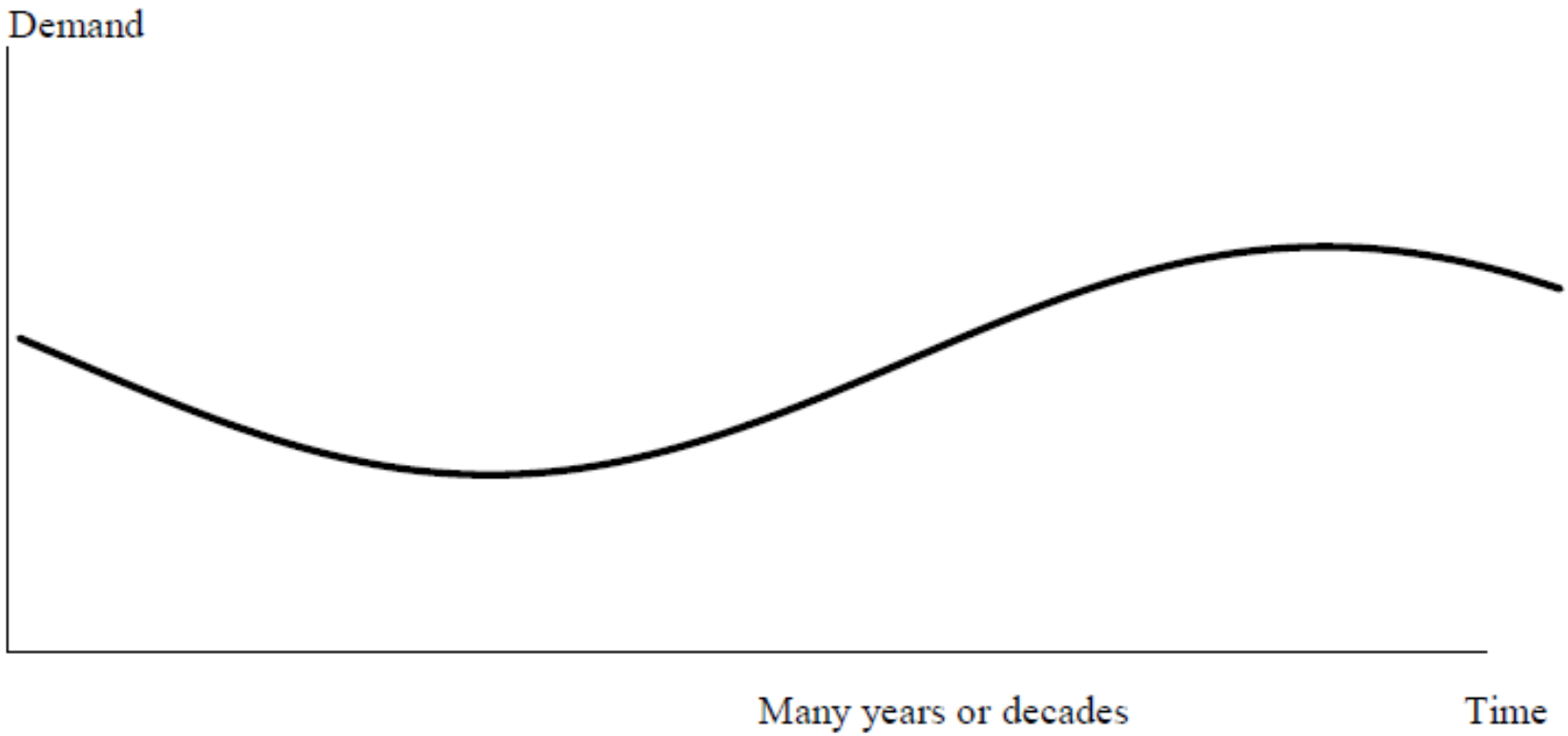
- **Seasonality**: Data exhibit upward and downward swings in a short to intermediate time frame (most notably during a year)



Decomposition of Time Series

Patterns that may be present in the time series

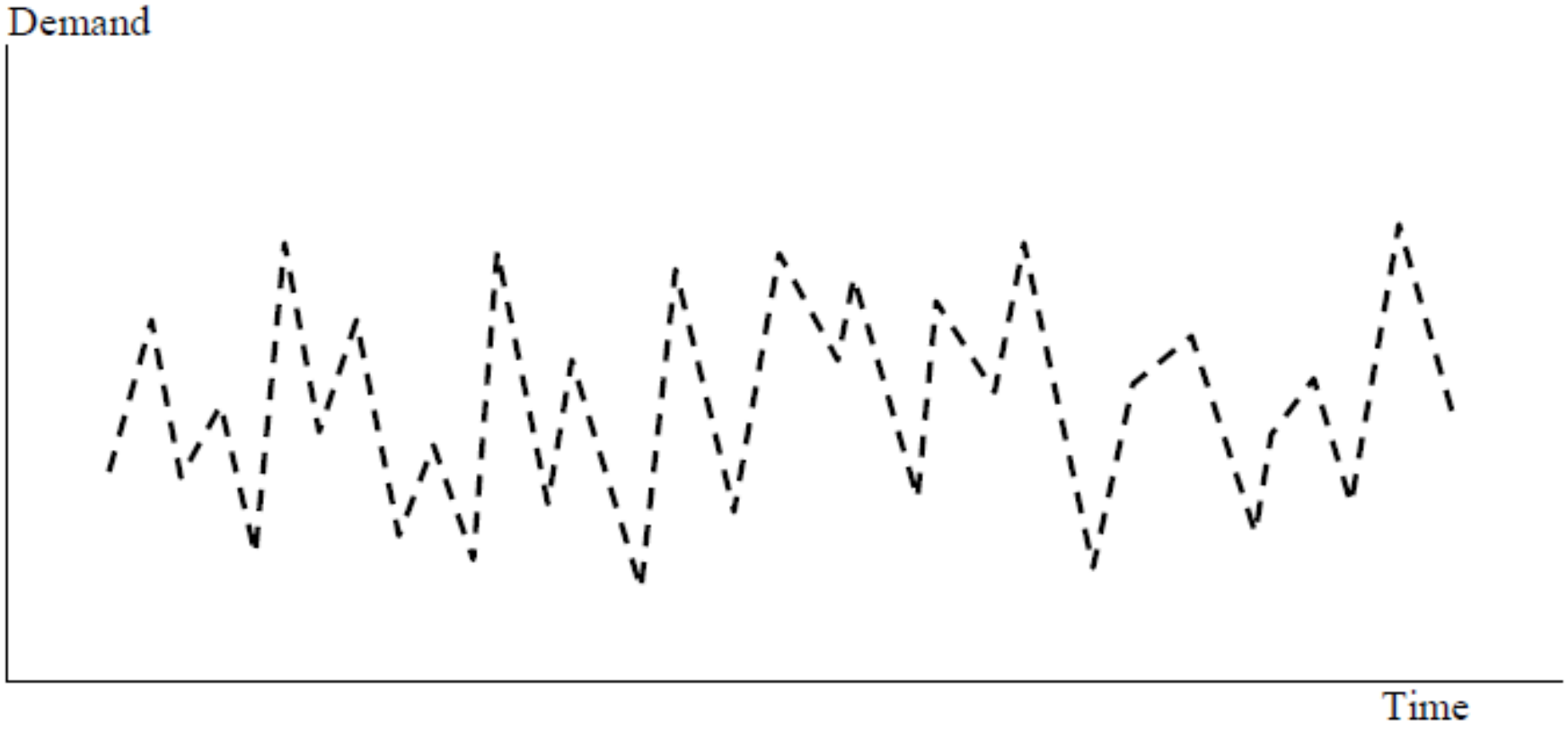
- **Cycles**: Data exhibit upward and downward swings in over a very long time frame



Decomposition of Time Series

Patterns that may be present in the time series

- **Random variations**: Erratic and unpredictable variation in the data over time with no discernable pattern



Decomposition of Time Series

Naïve Method

- The forecast for next period (period t+1) will be equal to this period's actual demand (A_t).

Year	Actual Demand (A_t)	Forecast (F_t)	Remarks
1	110	--	No prior demand data on which to base a foreast for year-1
2	165	110	From here, the forecasts were made on a year-by-year basis
3	195		
4	215		
5	250		
6	265		
7			

Decomposition of Time Series

Naïve Method

- The forecast for next period (period t+1) will be equal to this period's actual demand (A_t).

Year	Actual Demand (A_t)	Forecast (F_t)	Remarks
1	110	--	No prior demand data on which to base a foreast for year-1
2	165	110	From here, the forecasts were made on a year-by-year basis
3	195	165	
4	215	195	
5	250	215	
6	265	250	
7		265	

Decomposition of Time Series

Simple Average Method

- The forecast for next period (period t+1) will be equal to the average of all past historical demands

Year	Actual Demand (A_t)	Forecast (F_t)	Remarks
1	110	100	This forecast is the guess at the beginning
2	165	110	From here, the forecasts were made on a year-by-year basis
3	195		
4	215		
5	250		
6	265		
7			

Decomposition of Time Series

Simple Average Method

- The forecast for next period (period t+1) will be equal to the average of all past historical demands

Year	Actual Demand (A_t)	Forecast (F_t)	Remarks
1	110	100	This forecast is the guess at the beginning
2	165	110	From here, the forecasts were made on a year-by-year basis
3	195	137.5	
4	215	156.67	
5	250	171.25	
6	265	187	
7		200	

Decomposition of Time Series

Simple Moving Average Method

- The forecast for next period (period t+1) will be equal to the average of a specified number of the most recent observations, with each observation receiving the same emphasis (weight)

Year	Actual Demand (A_t)	Forecast (F_t)	Remarks
1	110	100	This forecast is the guess at the beginning
2	165	110	This forecast using naïve method
3	195	137.5	From here, the forecasts were made on a year-by-year basis **using 2 year moving average method**
4	215		
5	250		
6	265		
7			

Decomposition of Time Series

Simple Moving Average Method

- The forecast for next period (period t+1) will be equal to the average of a specified number of the most recent observations, with each observation receiving the same emphasis (weight)

Year	Actual Demand (A_t)	Forecast (F_t)	Remarks
1	110	100	This forecast is the guess at the beginning
2	165	110	This forecast using naïve method
3	195	137.5	From here, the forecasts were made on a year-by-year basis **using 2 year moving average method**
4	215	180	
5	250	205	
6	265	232.5	
7		257.5	

Decomposition of Time Series

Simple Moving Average Method

- The forecast for next period (period t+1) will be equal to the average of a specified number of the most recent observations, with each observation receiving the same emphasis (weight)

Year	Actual Demand (A_t)	Forecast (F_t)	Remarks
1	110	100	This forecast is the guess at the beginning
2	165	110	This forecast using naïve method
3	195	165	This forecast using naïve method
4	215		From here, the forecasts were made on a year-by-year basis **using 3 year moving average method**
5	250		
6	265		
7			

Decomposition of Time Series

Simple Moving Average Method

- The forecast for next period (period t+1) will be equal to the average of a specified number of the most recent observations, with each observation receiving the same emphasis (weight)

Year	Actual Demand (A_t)	Forecast (F_t)	Remarks
1	110	100	This forecast is the guess at the beginning
2	165	110	This forecast using naïve method
3	195	165	This forecast using naïve method
4	215	156.67	From here, the forecasts were made on a year-by-year basis **using 3 year moving average method**
5	250	191.67	
6	265	220	
7		243.33	

Decomposition of Time Series

Weighted Moving Average Method

- The forecast for next period (period t+1) will be equal to the weighted average of a specified number of the most recent observations

Year	Actual Demand (A_t)	Forecast (F_t)	Remarks
1	110	100	This forecast is the guess at the beginning
2	165	110	This forecast using naïve method
3	195	165	This forecast using naïve method
4	215	169	From here, the forecasts were made on a year-by-year basis **using 3 year weighted moving average method.** Most recent year, 0.5; year prior to that, 0.3; year prior to that, 0.2
5	250		
6	265		
7			

Decomposition of Time Series

Weighted Moving Average Method

- The forecast for next period (period t+1) will be equal to the weighted average of a specified number of the most recent observations

Year	Actual Demand (A_t)	Forecast (F_t)	Remarks
1	110	100	This forecast is the guess at the beginning
2	165	110	This forecast using naïve method
3	195	165	This forecast using naïve method
4	215	169	From here, the forecasts were made on a year-by-year basis **using 3 year weighted moving average method.** Most recent year, 0.5; year prior to that, 0.3; year prior to that, 0.2
5	250	199	
6	265	228.5	
7		250.5	

Decomposition of Time Series

Exponential Smoothing Method

- New Forecast = Last Period's Forecast + α (Last Period's Actual Demand – Last Period's Forecast)

$$F_t = F_{t-1} + \alpha(A_{t-1} - F_{t-1}) \Longrightarrow F_t = \alpha A_{t-1} + (1-\alpha)F_{t-1}$$

Year	Actual Demand (A_t)	Forecast (F_t)	Remarks
1	110	100	This forecast is the guess at the beginning
2	165	101	From this point forward, these forecasts were made on a year-by-year basis using exponential smoothing with α=0.1
3	195		
4	215		
5	250		
6	265		
7			

Decomposition of Time Series

Exponential Smoothing Method

- New Forecast = Last Period's Forecast + α (Last Period's Actual Demand – Last Period's Forecast)

$$F_t = F_{t-1} + \alpha(A_{t-1} - F_{t-1}) \quad \Longrightarrow \quad F_t = \alpha A_{t-1} + (1-\alpha)F_{t-1}$$

Year	Actual Demand (A_t)	Forecast (F_t)	Remarks
1	110	100	This forecast is the guess at the beginning
2	165	101	From this point forward, these forecasts were made on a year-by-year basis using exponential smoothing with α=0.1
3	195	107.4	
4	215	116.16	
5	250	126.044	
6	265	138.4396	
7		151.0956	

Decomposition of Time Series

Exponential Smoothing Method

- New Forecast = Last Period's Forecast + α (Last Period's Actual Demand – Last Period's Forecast)

$$F_t = F_{t-1} + \alpha(A_{t-1} - F_{t-1}) \Longrightarrow F_t = \alpha A_{t-1} + (1-\alpha)F_{t-1}$$

Year	Actual Demand (A_t)	Forecast (F_t)	Remarks
1	110	100	This forecast is the guess at the beginning
2	165	102	From this point forward, these forecasts were made on a year-by-year basis using exponential smoothing with α=0.2
3	195		
4	215		
5	250		
6	265		
7			

Decomposition of Time Series

Exponential Smoothing Method

- New Forecast = Last Period's Forecast + α (Last Period's Actual Demand – Last Period's Forecast)

$$F_t = F_{t-1} + \alpha(A_{t-1} - F_{t-1}) \Longrightarrow F_t = \alpha A_{t-1} + (1-\alpha)F_{t-1}$$

Year	Actual Demand (A_t)	Forecast (F_t)	Remarks
1	110	100	This forecast is the guess at the beginning
2	165	102	From this point forward, these forecasts were made on a year-by-year basis using exponential smoothing with α=0.2
3	195	114.6	
4	215	130.68	
5	250	147.544	
6	265	168.0352	
7		187.4282	

Decomposition of Time Series

Linear Regression Model

- Trend projection

$$Y = a + bt$$

where t is the independent variable and

Y is the dependent variable

b is the slope

a is the Y - intercept

Here,

Year is Independent Variable (t)

Actual Demand is dependent variable (Y)

Year	Actual Demand (A_t)
1	110
2	165
3	195
4	215
5	250
6	265
7	

Decomposition of Time Series

Linear Regression Model

- Trend projection

$$Y = a + bt$$

- To find out “a” and “b”

$$\sum Y = na + b\sum t$$

$$\sum Yt = a\sum t + b\sum t^2$$

Decomposition of Time Series

Linear Regression Model

Year (t)	Actual Demand (Y)	Yt	t^2
1	110	110	1
2	165	330	4
3	195	585	9
4	215	860	16
5	250	1250	25
6	265	1590	36
$\Sigma t = 21$	$\Sigma Y = 1200$	$\Sigma yt = 4725$	$\Sigma t^2 = 91$

$$Y = a + bt$$

$$\sum Y = na + b \sum t$$

$$\sum Yt = a \sum t + b \sum t^2$$

Here n = 6

Solving **a = 95**

b = 30

Forecast for the year 7 is, Y = 95 + 30 * 7 = 305

Decomposition of Time Series

Seasonality

Year	1	2	3
Q1	33	38	42
Q2	18	21	23
Q3	27	30	34
Q4	40	45	51
Total	118	134	150

Decomposition of Time Series

Seasonality

Calculate Seasonality Index

	Seasonality Index			
Year	1	2	3	Average
Q1	0.279661	0.283582	0.28	0.281081
Q2	0.152542	0.156716	0.153333	0.154197
Q3	0.228814	0.223881	0.226667	0.226454
Q4	0.338983	0.335821	0.34	0.338268

Decomposition of Time Series

Seasonality

Year	1	2	3
Q1	33	38	42
Q2	18	21	23
Q3	27	30	34
Q4	40	45	51
Total	118	134	150

Using regression model, calculate the 4th Year forecast.

The 4th year Forecast value is 167

Decomposition of Time Series

Seasonality

Year	Average Seasonal Index	4
Q1	0.281081	46.94053
Q2	0.154197	25.75096
Q3	0.226454	37.81775
Q4	0.338268	56.49075
Total		167

Obtained by multiplying the forecast value with the average seasonal index for each quarter.

Measures of Forecast Accuracy

- Forecasting influences most of the decisions and hence must be estimated with highest level of precision
- Types of forecasting error:
  - ✓ Aggregate Error
  - ✓ Mean Absolute Deviation (MAD)
  - ✓ Mean Square Error (MSE)
  - ✓ Mean Forecast Error (MFE)
  - ✓ Mean Absolute Percent Error (MAPE)

Measures of Forecast Accuracy

- **Aggregate Error** – deviation of forecast values from the actual demands
- **MAD** – Mean of absolute deviations of forecast demands from actual demand values – also called Mean Absolute Error (MAE)

$$\mathbf{MAD} = \frac{\sum |\mathbf{actual} - \mathbf{forecast}|}{\mathbf{n}}$$

- **MSE** – Mean of the squares of the deviations of the forecast demands from the actual demand values

$$\mathbf{MSE} = \frac{\sum (\mathbf{actual} - \mathbf{forecast})^2}{\mathbf{n}}$$

- **MFE** – Mean of the deviations of the forecast demands from the actual demands
- **MAPE** – Mean of the % deviations of the forecast from the actual demands

Measures of Forecast Accuracy

- A forecast of 165 units had been made for the demand in every period for the data given below. Calculate the MAD and different types of error.

T	Demand	Forecast	Deviation	Absolute Deviation	Squared error	percent error	Absolute % error
1	150	165	-15	15	225	-10	10
2	160	165	-5	5	25	-3.125	3.125
3	165	165	0	0	0	0	0
4	175	165	10	10	100	5.714285714	5.71
5	180	165	15	15	225	8.333333333	8.33
sum			5	45	575		27.165
			MAD	45/5=9			
			MSE	575/5=115			
			MAPE	27.165/5=5.43%			
			MFE	5/5=1			

Correlation

- A correlation is a relationship between two variables.
- Is there a relationship between the number of employee training hours and the number of jobs produced?
- Is there a relationship between the number of hours a student spends studying for a Mathematics test and the student's score on that test?
- Let x to be the independent variable and y to be the dependent variable. Data is represented by a collection of ordered pairs (x, y).

Correlation

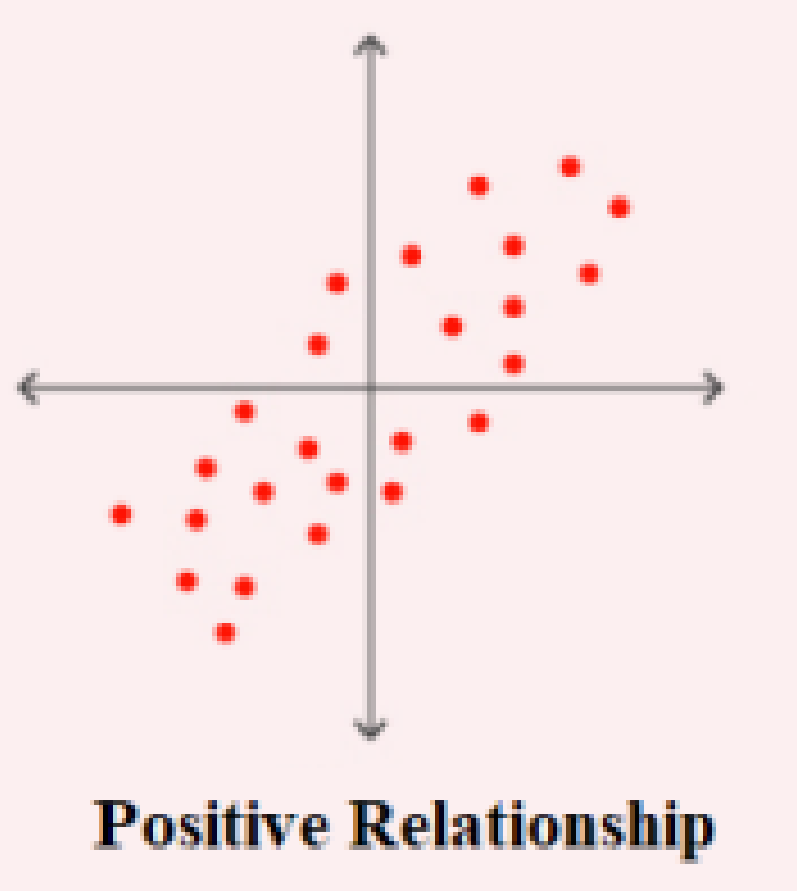
- Mathematically, the strength and direction of a linear relationship between two variables is represented by the correlation coefficient.
- The correlation coefficient r is given by

$$r = \frac{n\sum(xy) - (\sum x)(\sum y)}{\sqrt{n\sum x^2 - (\sum x)^2}\sqrt{n\sum y^2 - (\sum y)^2}}$$

Correlation

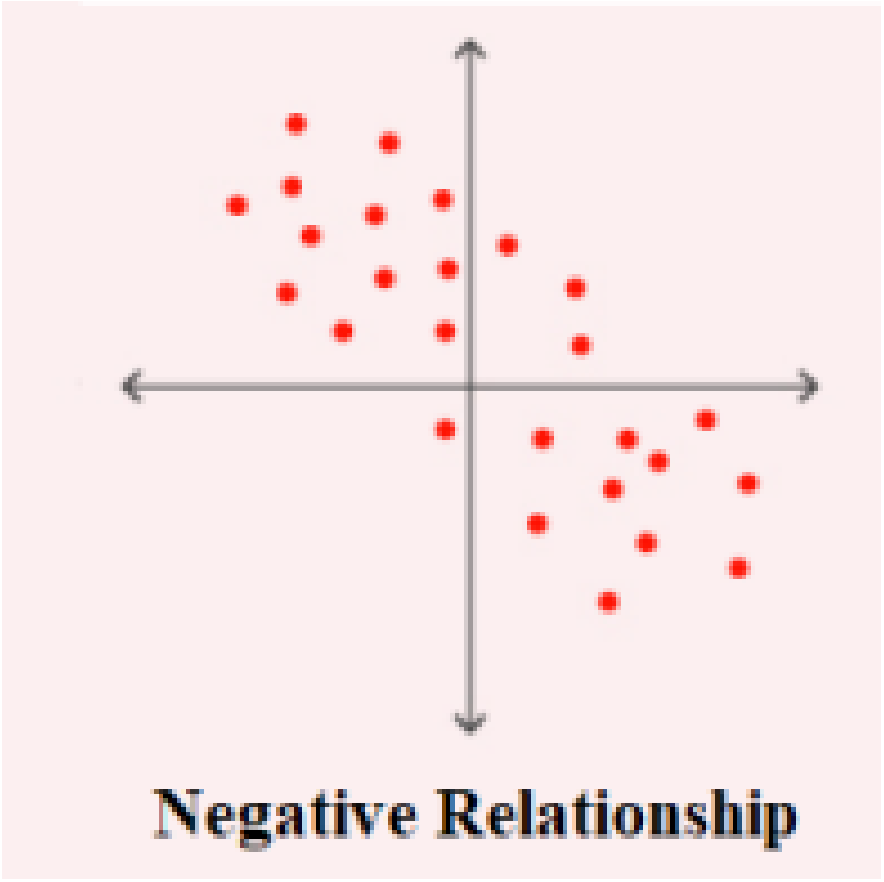
- This will always be a number between -1 and 1 (inclusive).
- If r is close to 1, the variables are positively correlated ➔ there is likely a strong linear relationship between the two variables, with a positive slope.
- If r is close to -1, the variables are negatively correlated ➔ there is likely a strong linear relationship between the two variables, with a negative slope.
- If r is close to 0, the variables are not correlated ➔ that there is likely no linear relationship between the two variables, however, the variables may still be related in some other way.

Correlation



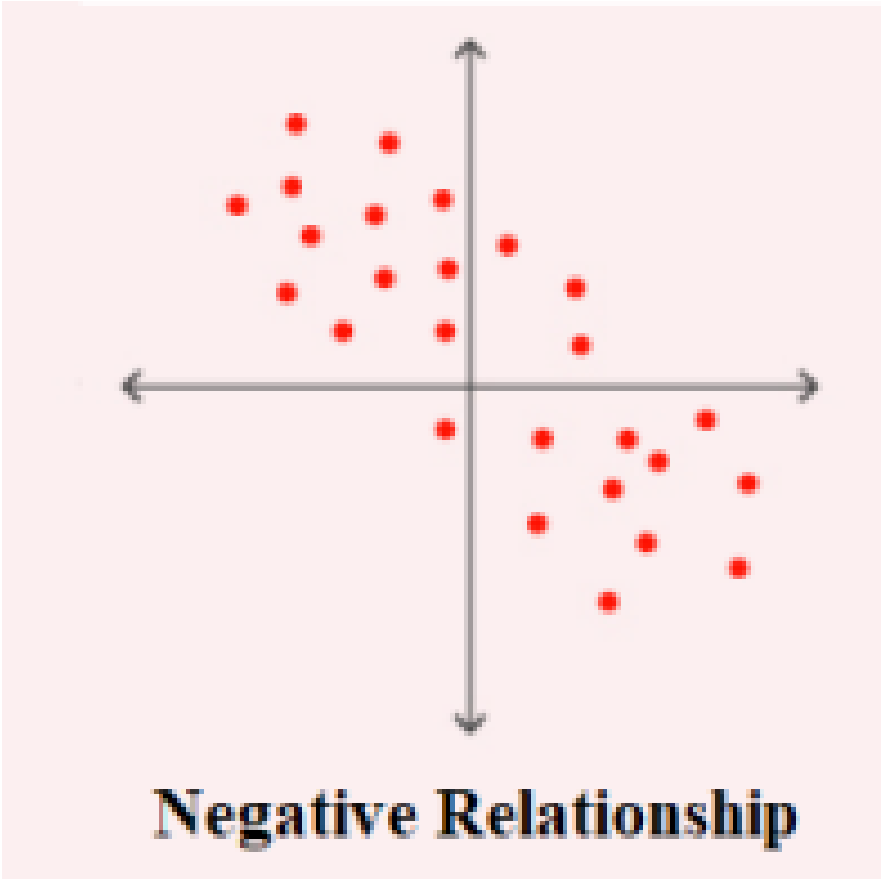
If r is close to 1, the variables are positively correlated ➔ there is likely a strong linear relationship between the two variables, with a positive slope.

Correlation



- If r is close to 1, the variables are positively correlated ➔ there is likely a strong linear relationship between the two variables, with a positive slope.

Correlation



- If r is close to -1, the variables are positively correlated ➔ there is likely a strong linear relationship between the two variables, with a negative slope.

Correlation

- The time x in years that an employee spent at a com ɔr 5 emp late and

$$r = \frac{n\sum(xy) - (\sum x)(\sum y)}{\sqrt{n\sum x^2 - (\sum x)^2}\sqrt{n\sum y^2 - (\sum y)^2}}$$

x	y
5	25
3	20
4	21
10	35
15	38

Correlation

x	y	x^2	y^2	xy
5	25	25	625	125
3	20	9	400	60
4	21	16	441	84
10	35	100	1225	350
15	38	225	1444	570
$\sum x = 37$	$\sum y = 139$	$\sum x^2 = 375$	$\sum y^2 = 4135$	$\sum xy = 1189$

Hint: Calculate the numerator:

$$n\sum(xy) - \left(\sum x\right)\left(\sum y\right) = 5 \cdot 1189 - 37 \cdot 139 = 802$$

Then calculate the denominator:

$$\sqrt{n\sum x^2 - \left(\sum x\right)^2}\sqrt{n\sum y^2 - \left(\sum y\right)^2} = \sqrt{5 \cdot 375 - (37)^2}\sqrt{5 \cdot 4135 - (139)^2}$$
$$= \sqrt{506}\sqrt{1354} \approx 827.72$$

Correlation

Now, divide to get $r \approx \dfrac{802}{827.72} \approx 0.97.$

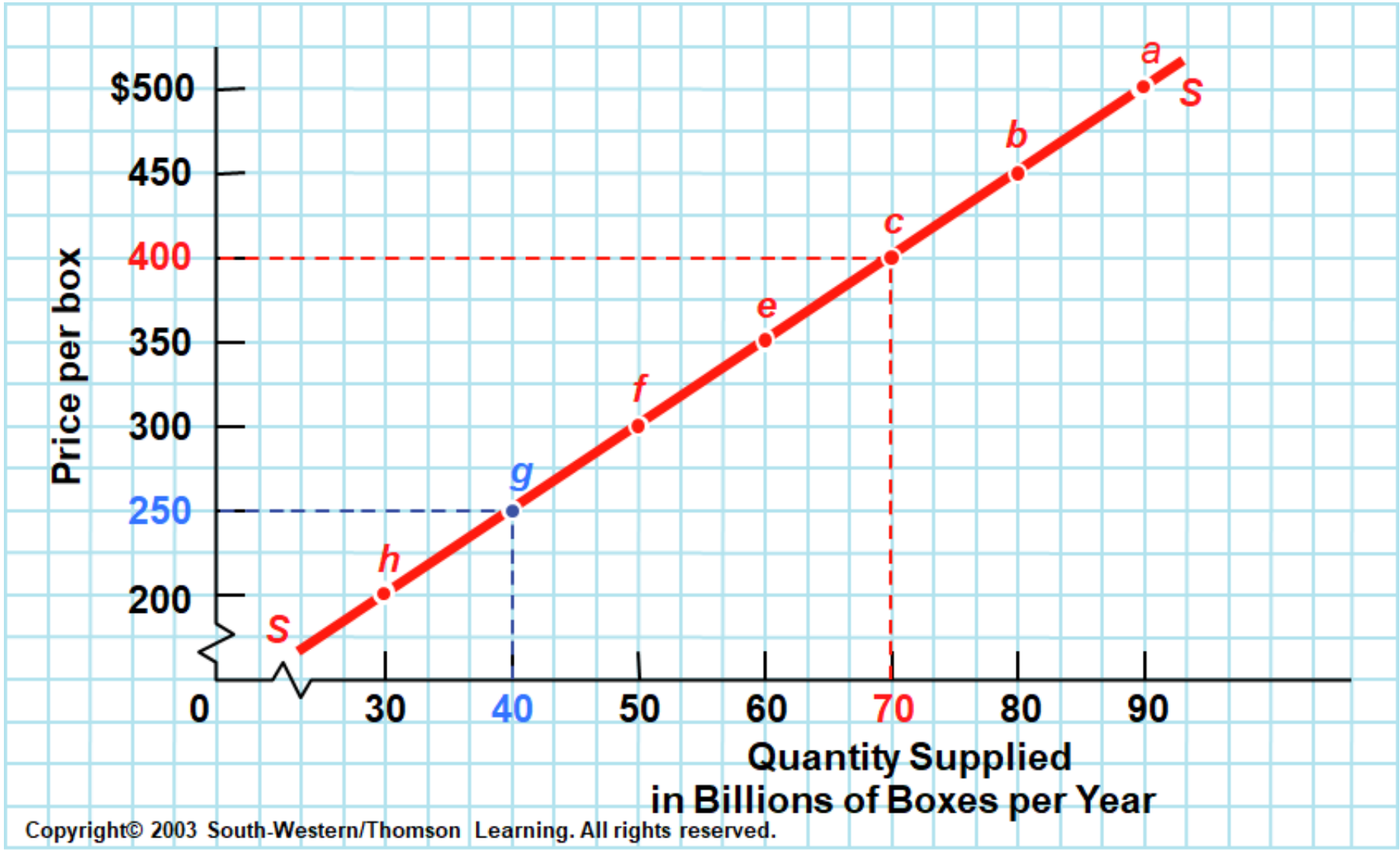
- Interpret this result: There is a strong positive correlation between the number of years and employee has worked and the employee's salary, since r is very close to 1

Supply

Supply

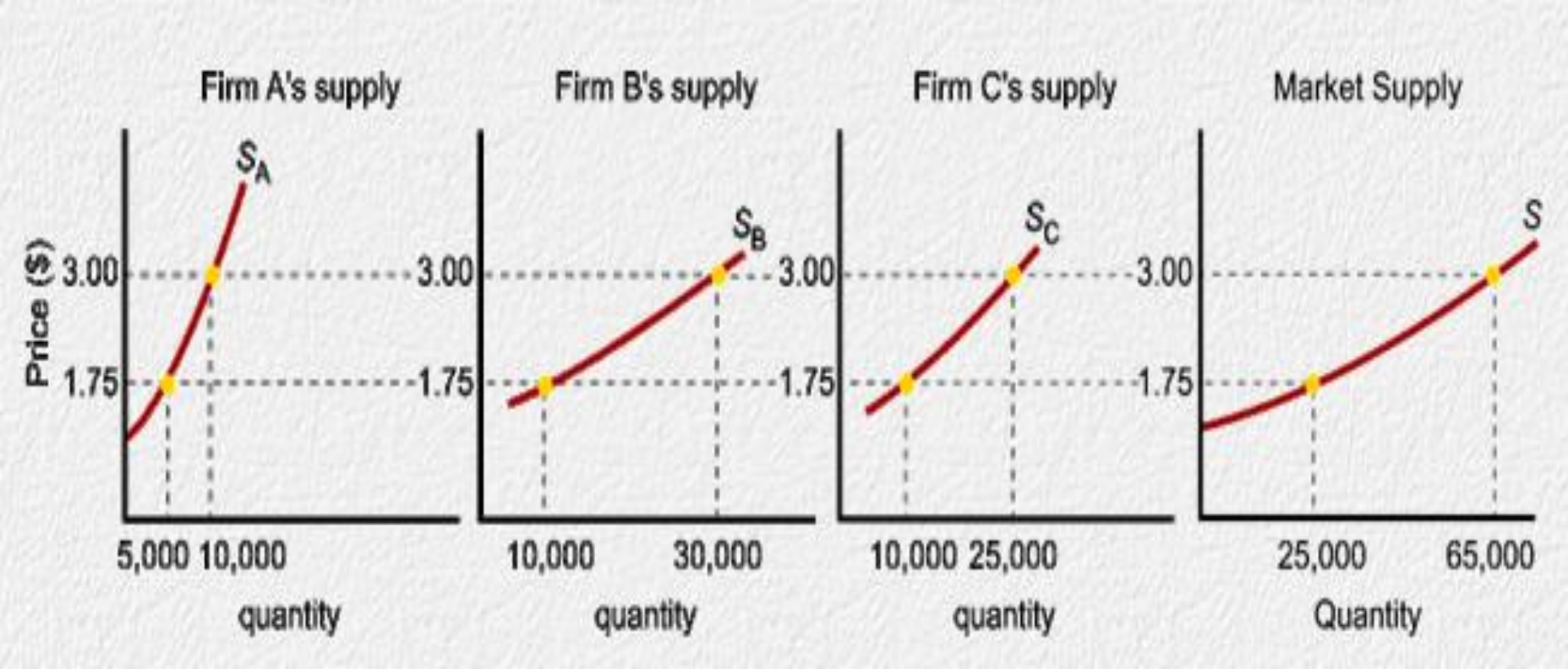
- Supply is the quantity of a product or commodity that sellers are willing to produce and able to sell to the market at a given price.
- **Law of Supply:** If nothing changes, a company will produce a greater quantity of products when the price for that good is high.
- Or we can say
- The **law of supply** states that when the price of a product is reduced, with no change in other factors, less of the product will be supplied.

Supply



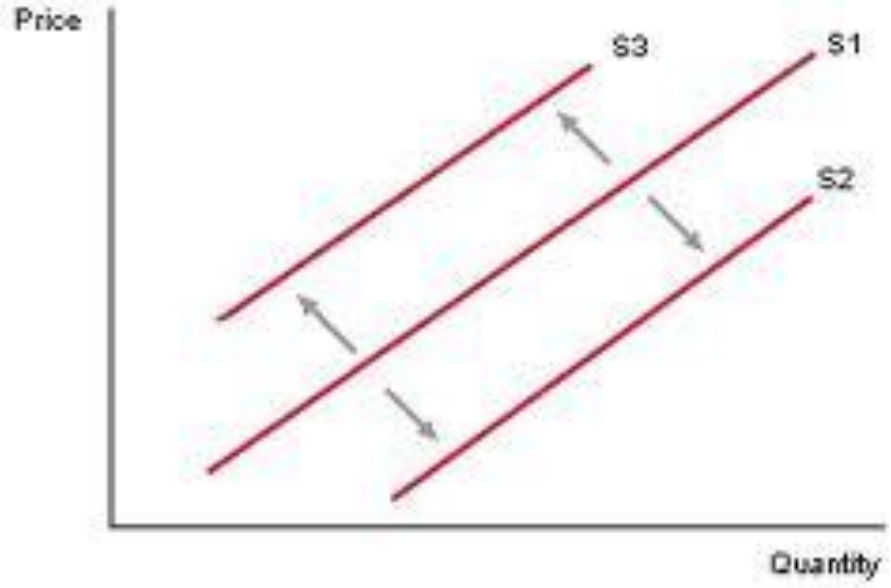
Market Supply

- As with market demand, market supply is the horizontal summation of individual firms' supply curves



Shifts in Supply Curve

- A supply curve shifts whenever a factor that affects the supply of the good (other than price) changes
- RIGHT: Increase in supply (at all prices)
- LEFT: Decrease in supply (at all prices)



Factors determine Supply

- **“P.I.G. T.O.E.S”**
- **Productivity** (workers, machines, and/or assembly)
- **Inputs** (Change in the price of materials needed to make the goods)
- **Government** Actions (Subsidies, Taxes, and Regulations)
- **Technology** (Improvements in machines and production)
- **Outputs** (Price changes in other products)
- **Expectations** (outlook of the future)
- **Size of Industry** (Number of companies in the industry)

Factors determine Supply

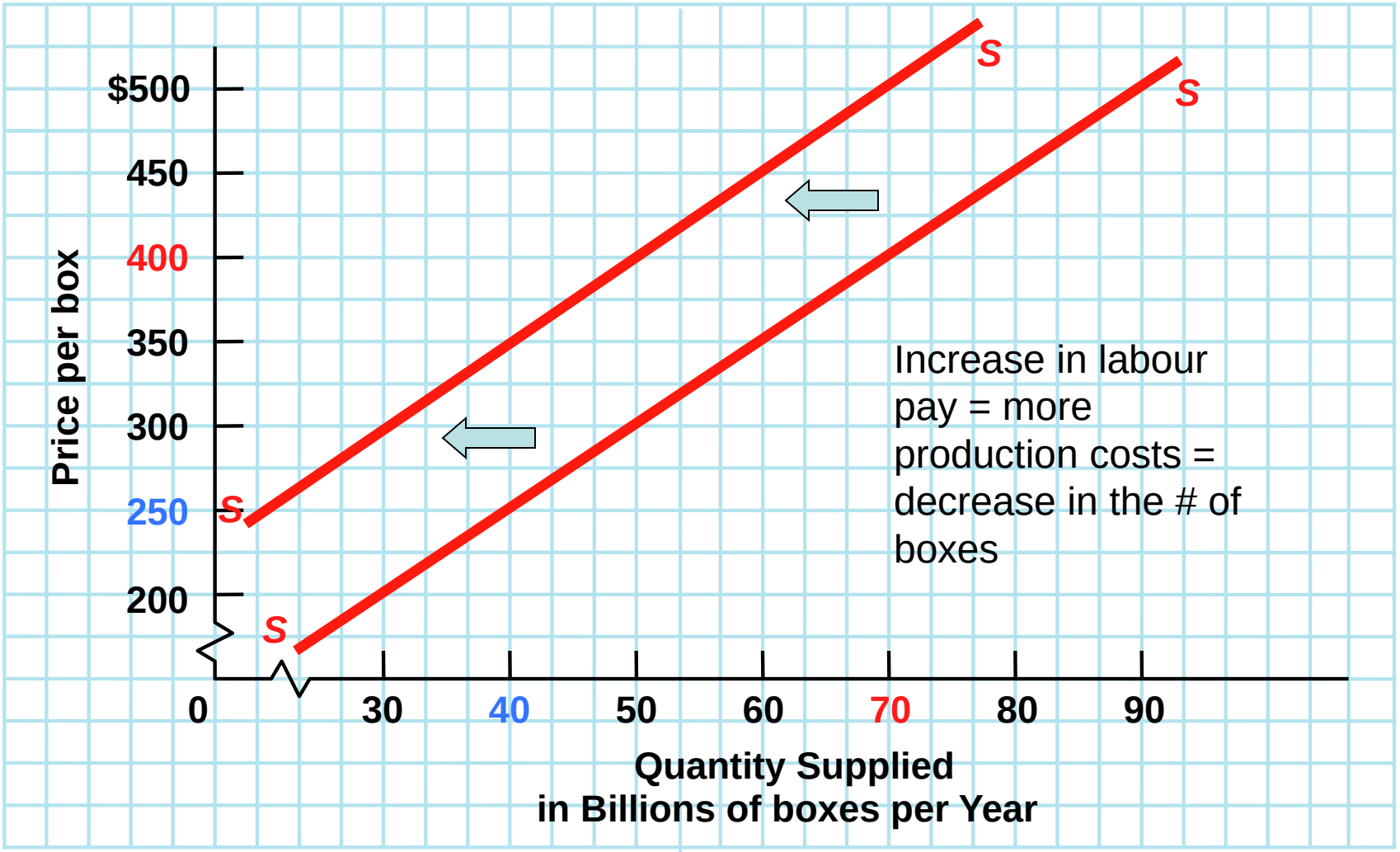
Example:

Our box factory finds out that our workers are getting a 30% pay raise (increase in the cost of labour)…

What happens to the supply curve?

Factors determine Supply

- **Example:**



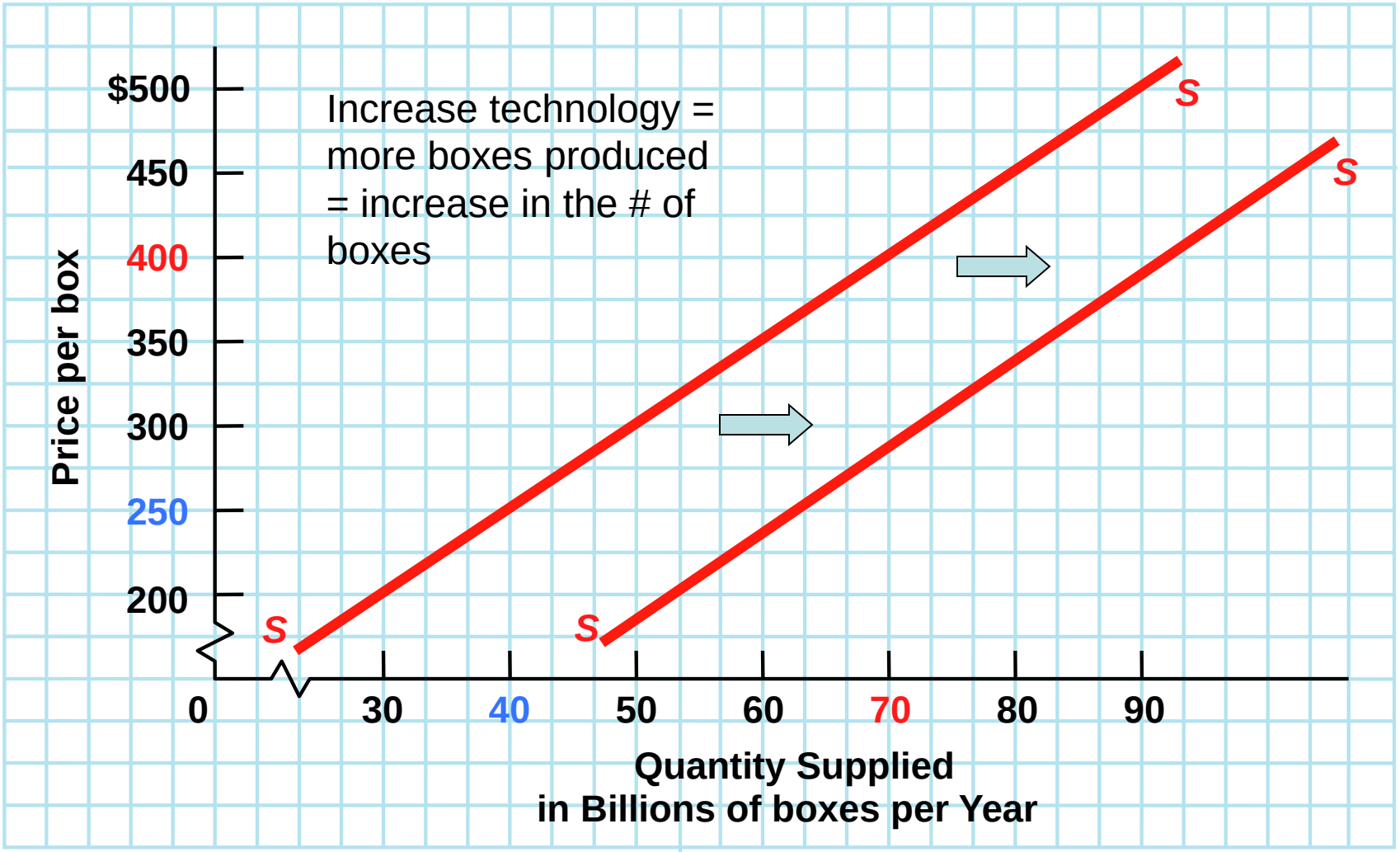
Factors determine Supply

- **Example:**
- Our box factory invents a technology that produces twice as many boxes in a day as before.

What happens to the supply curve?

Factors determine Supply

- **Example:**



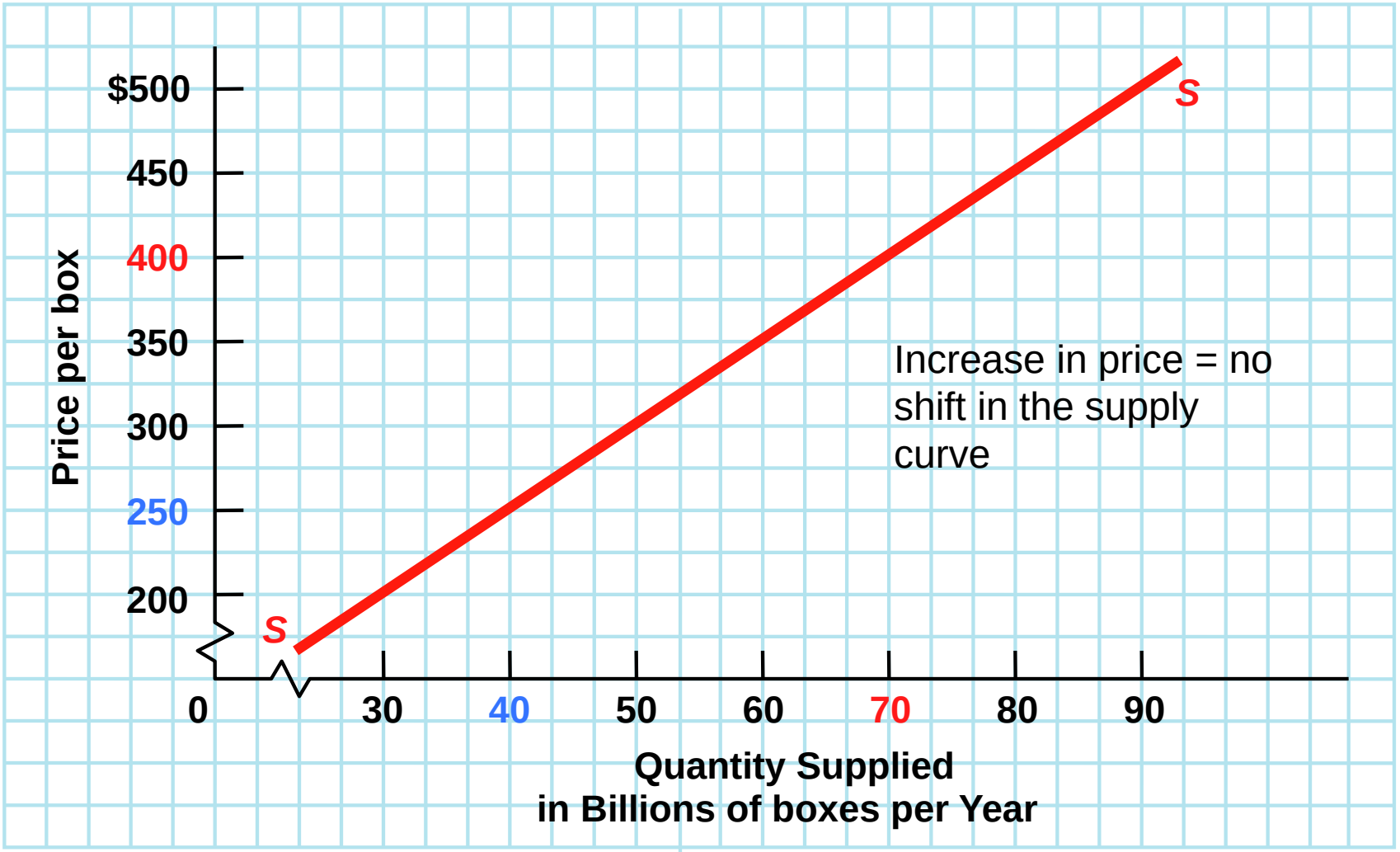
Factors determine Supply

- **Example:**
- The CEO of our box factory decides to increase the price of our boxes as a way to make more profit.

What happens to the supply curve?

Factors determine Supply

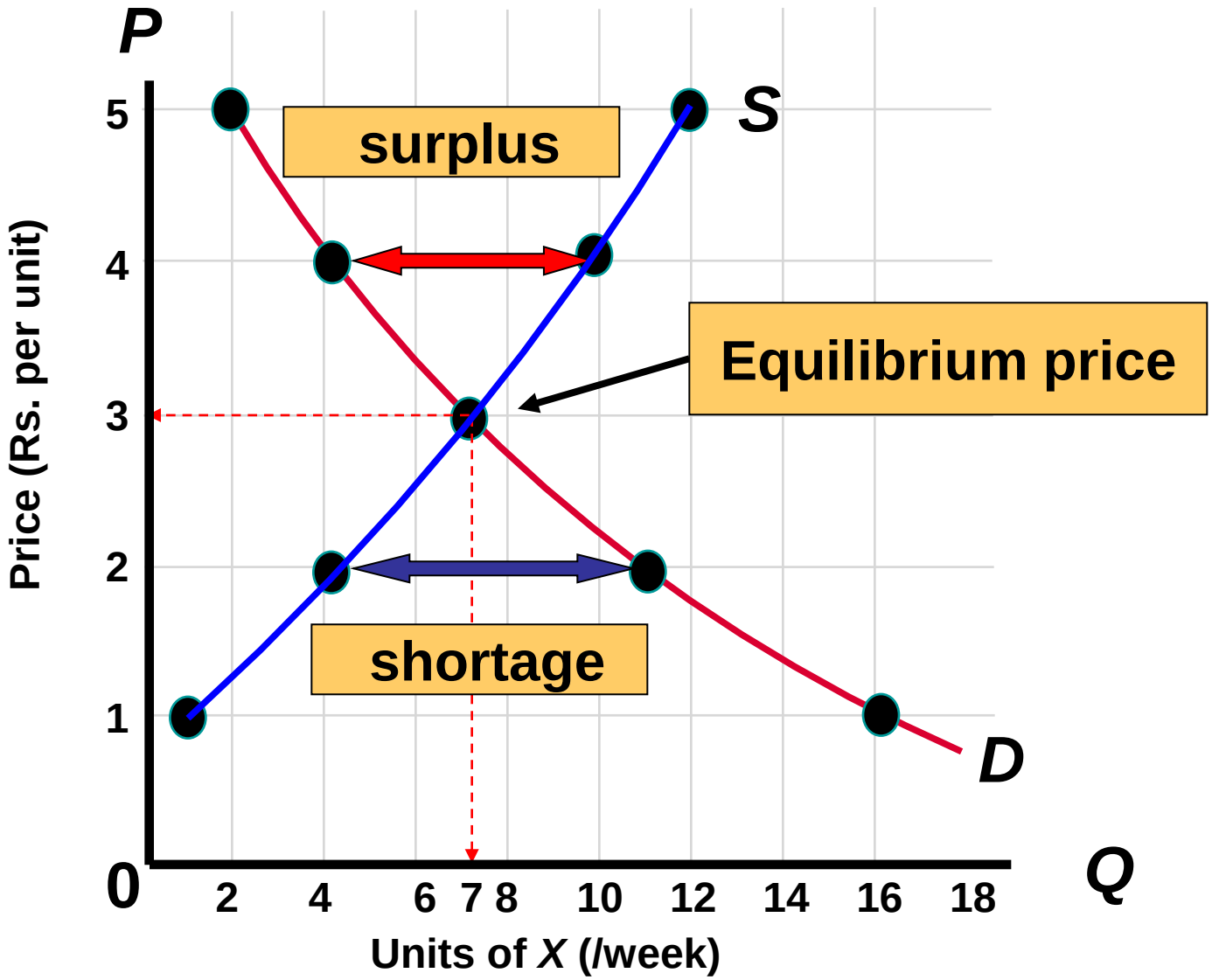
- **Example:**



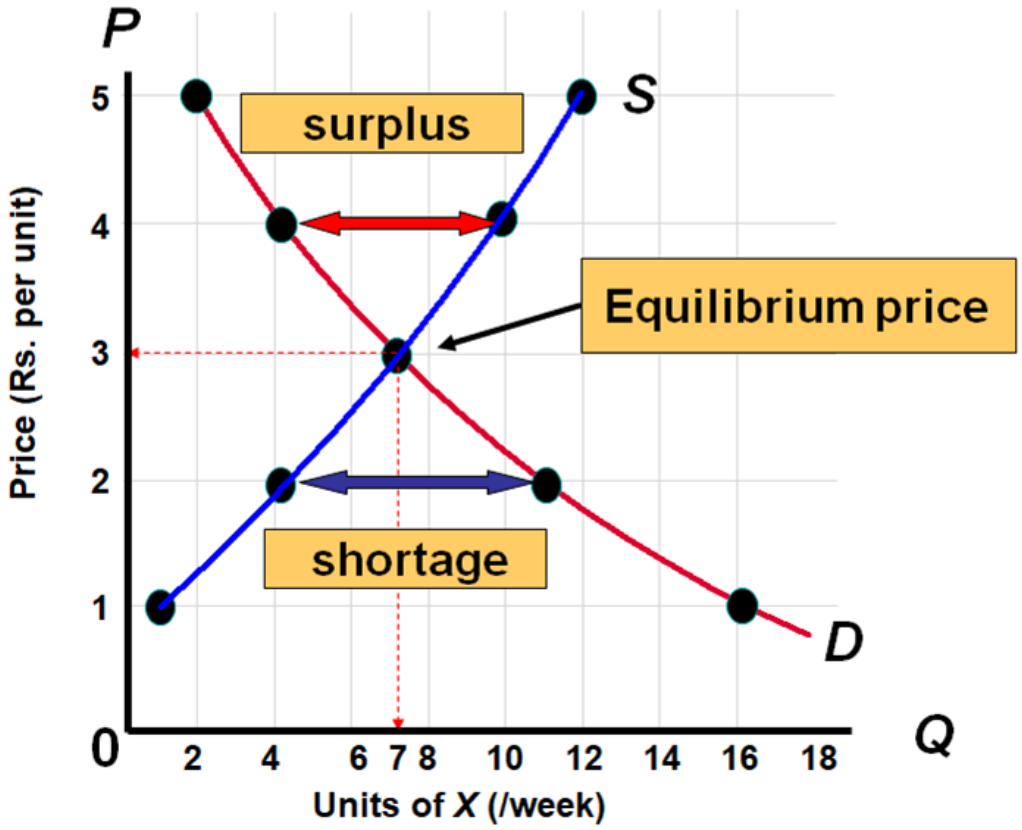
Market Equilibrium

- The operation of the market depends on the interaction between buyers and sellers.
- An **equilibrium** is the condition that exists when quantity supplied and quantity demanded are equal.
- At **equilibrium**, there is no tendency for the market price to change.
- Determines the **equilibrium price** and **equilibrium quantity** bought and sold in the market

Market Equilibrium

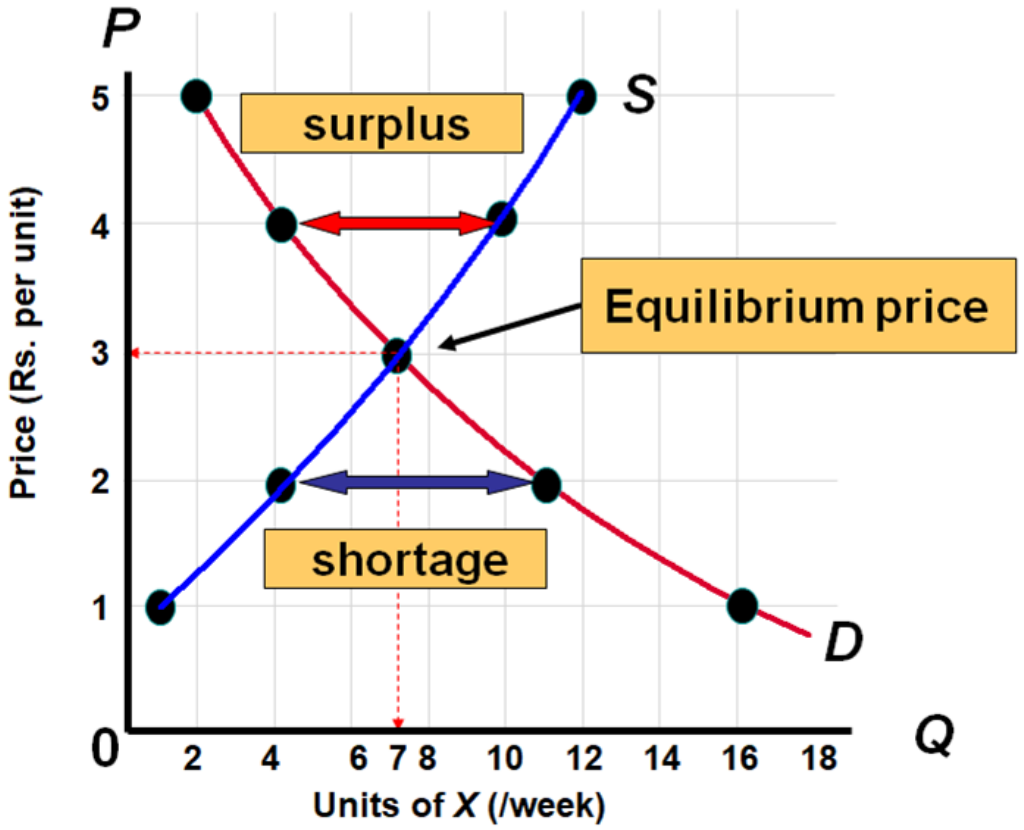


Market Equilibrium



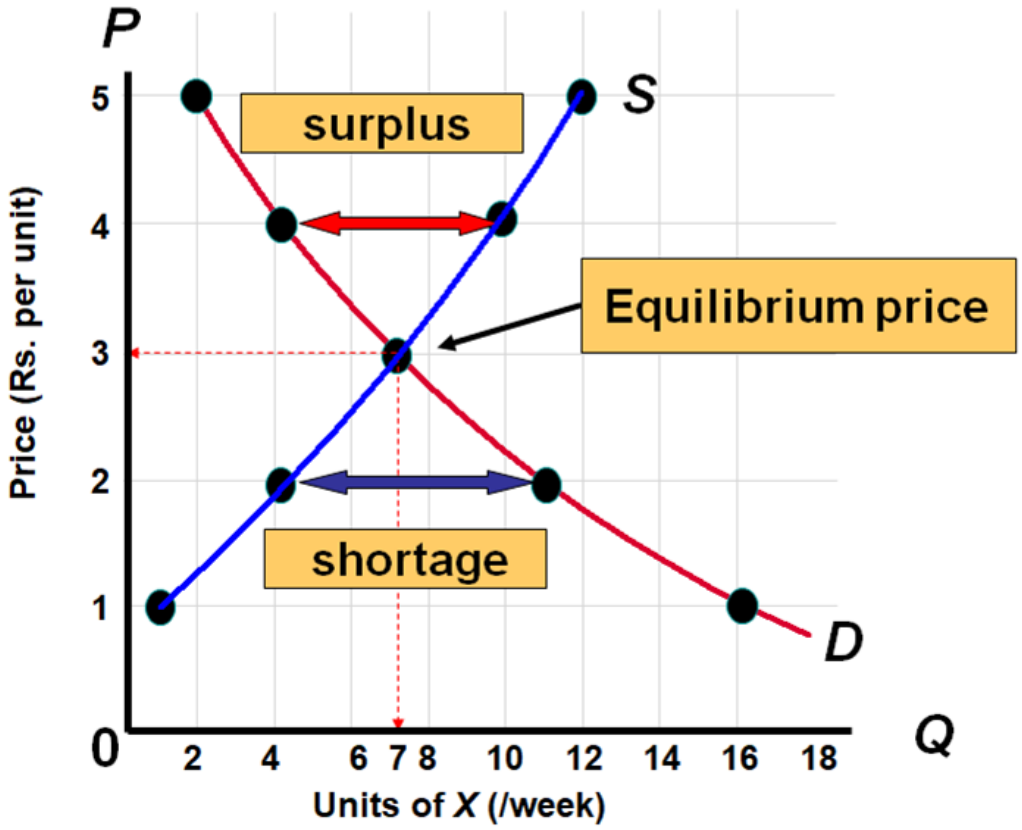
- Only in **equilibrium**, quantity supplied is equal to quantity demanded.

Market Equilibrium



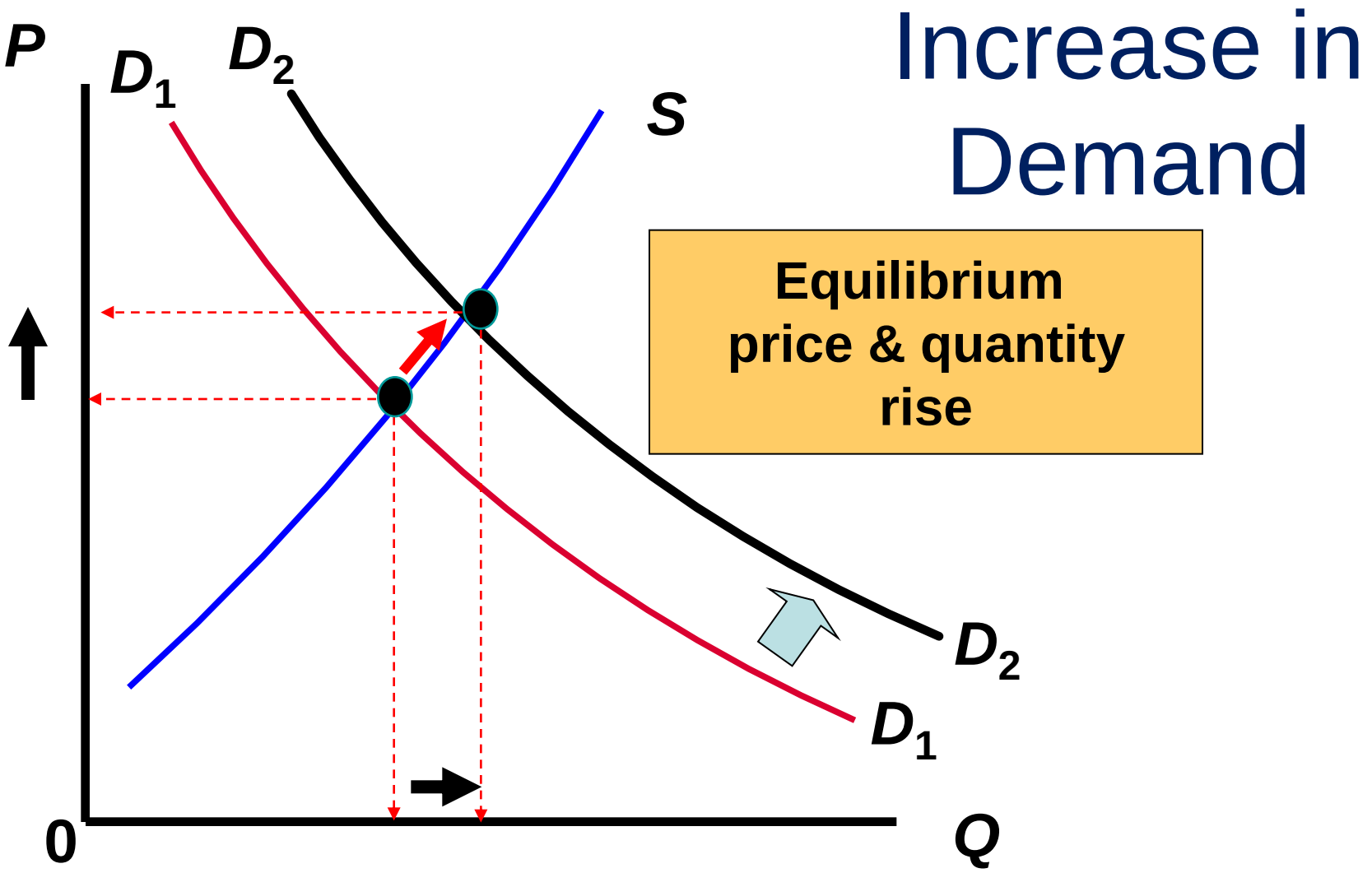
- ***Excess demand***, or **shortage**, is the condition that exists when quantity demanded exceeds quantity supplied at the current price.
- When quantity demanded exceeds quantity supplied, price tends to rise until equilibrium is restored.

Market Equilibrium

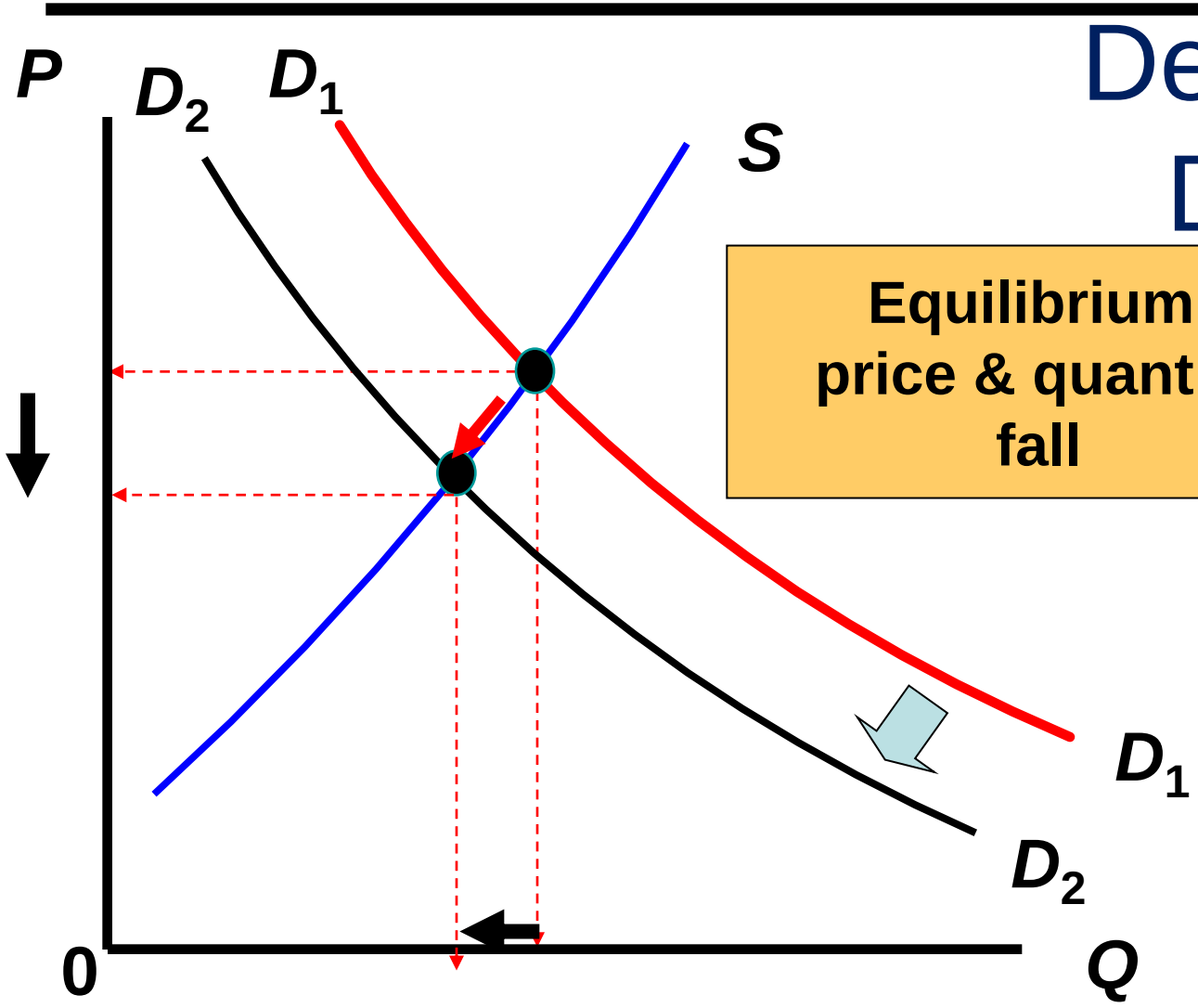


- *Excess supply*, or surplus, is the condition that exists when quantity supplied exceeds quantity demanded at the current price.
- When quantity supplied exceeds quantity demanded, price tends to fall until equilibrium is restored.

Market Equilibrium

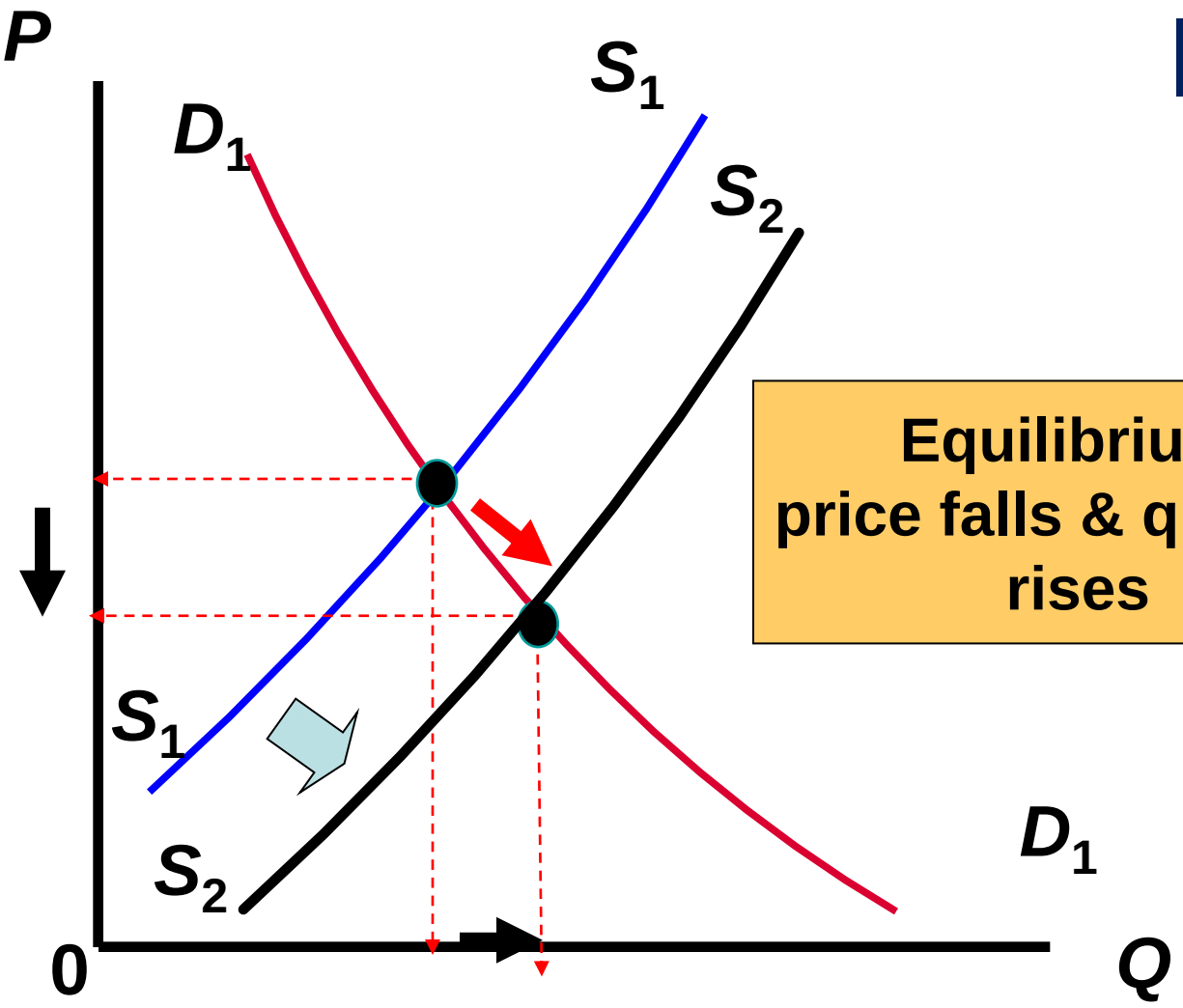


Market Equilibrium



Market Equilibrium

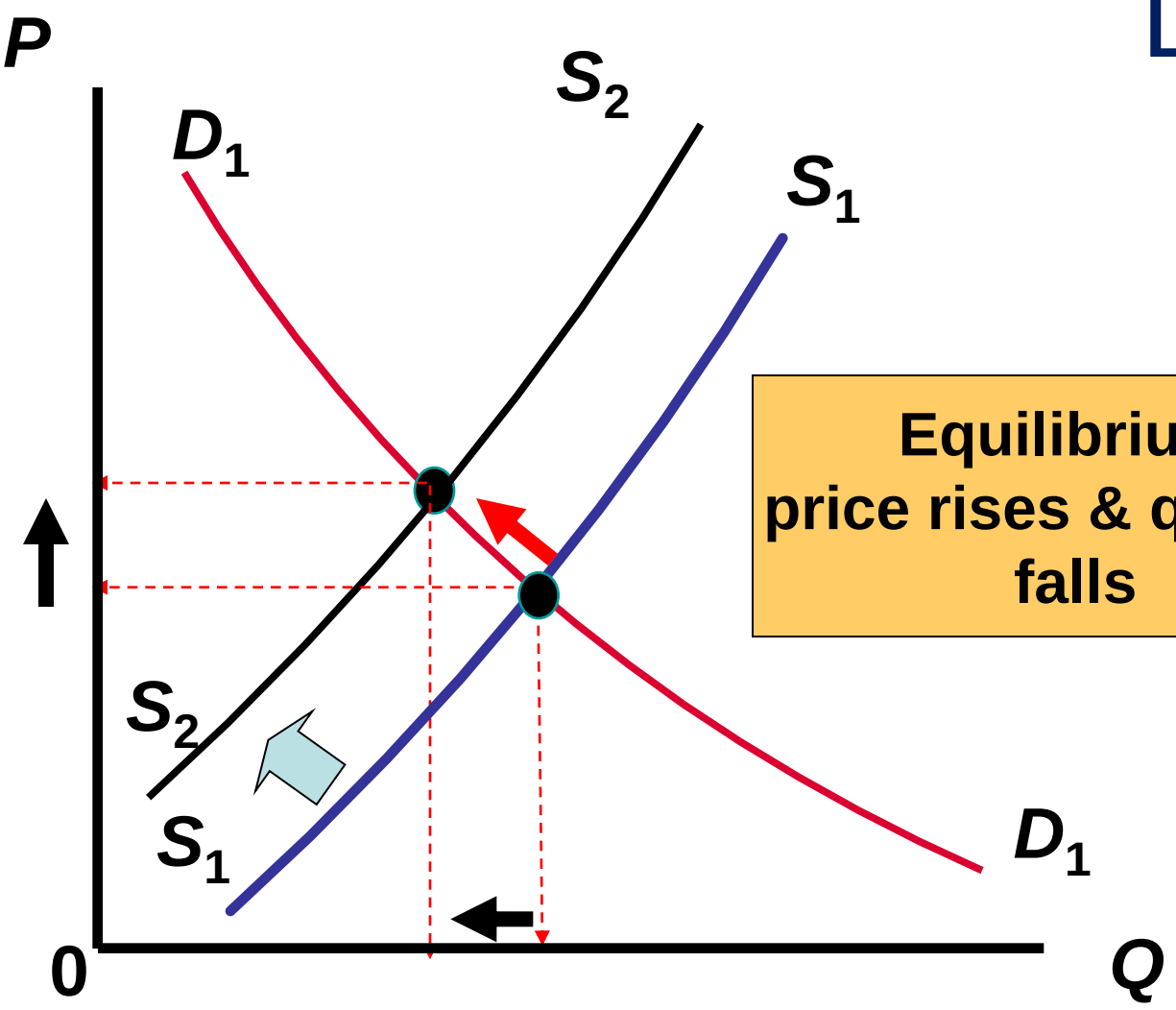
Increase in Supply



Equilibrium price falls & quantity rises

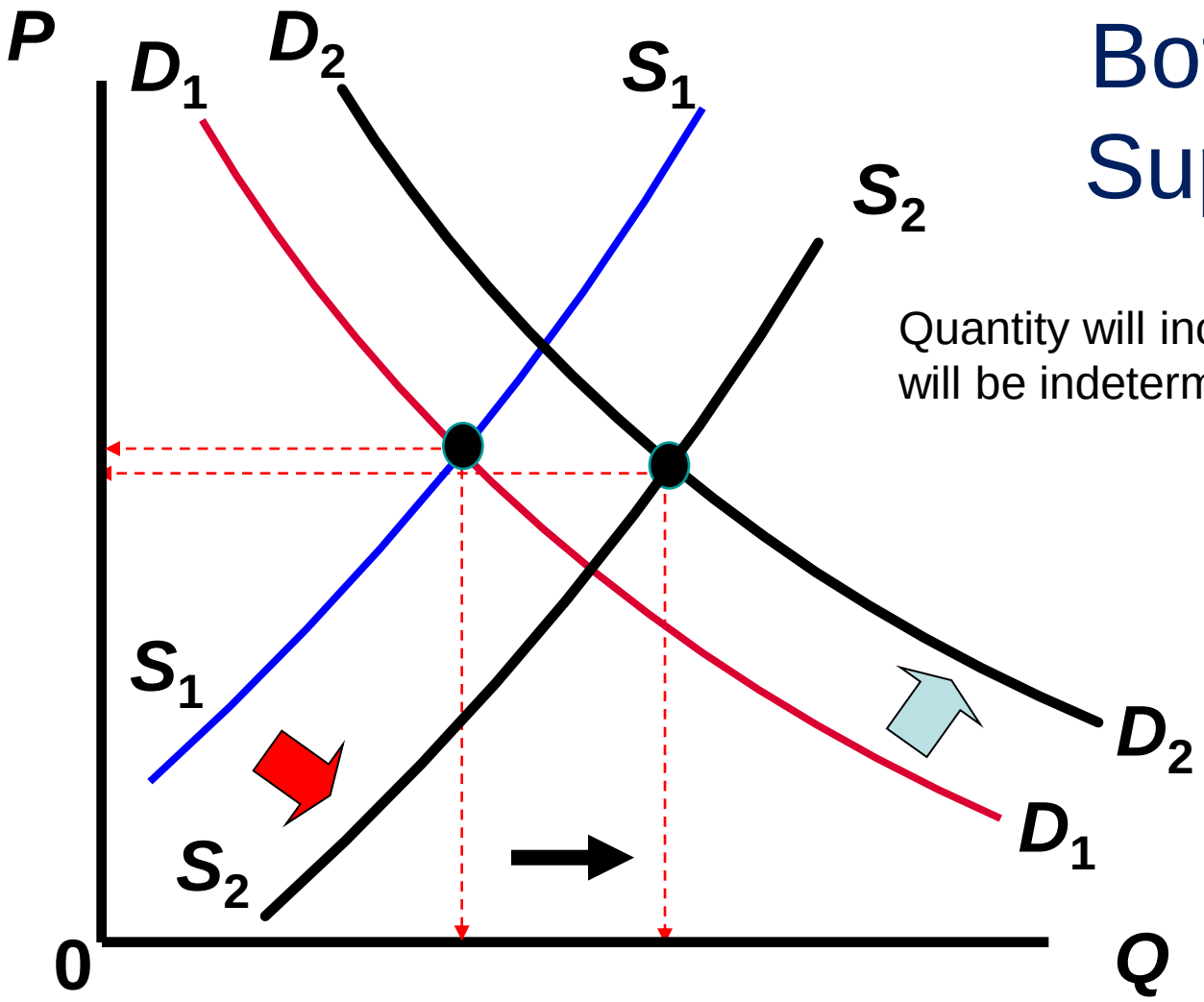
Market Equilibrium

Decrease in Supply



Equilibrium price rises & quantity falls

Market Equilibrium



Both Demand & Supply Increase

Quantity will increase but price change will be indeterminant

Economics

Economics

The word ***economy*** comes from the Greek word for "**one who manages a household**."

Economics

Economics is the study of how society **manages its scarce resources.**

Scarcity

The limited nature of society's resources

Cannot produce all the goods and services people wish to have.

Principles of Economics

How People Make Decisions

- ✓ People face tradeoffs
- ✓ The cost of something is what you give up to get it
- ✓ People respond to incentives

Principles of Economics

How People Interact

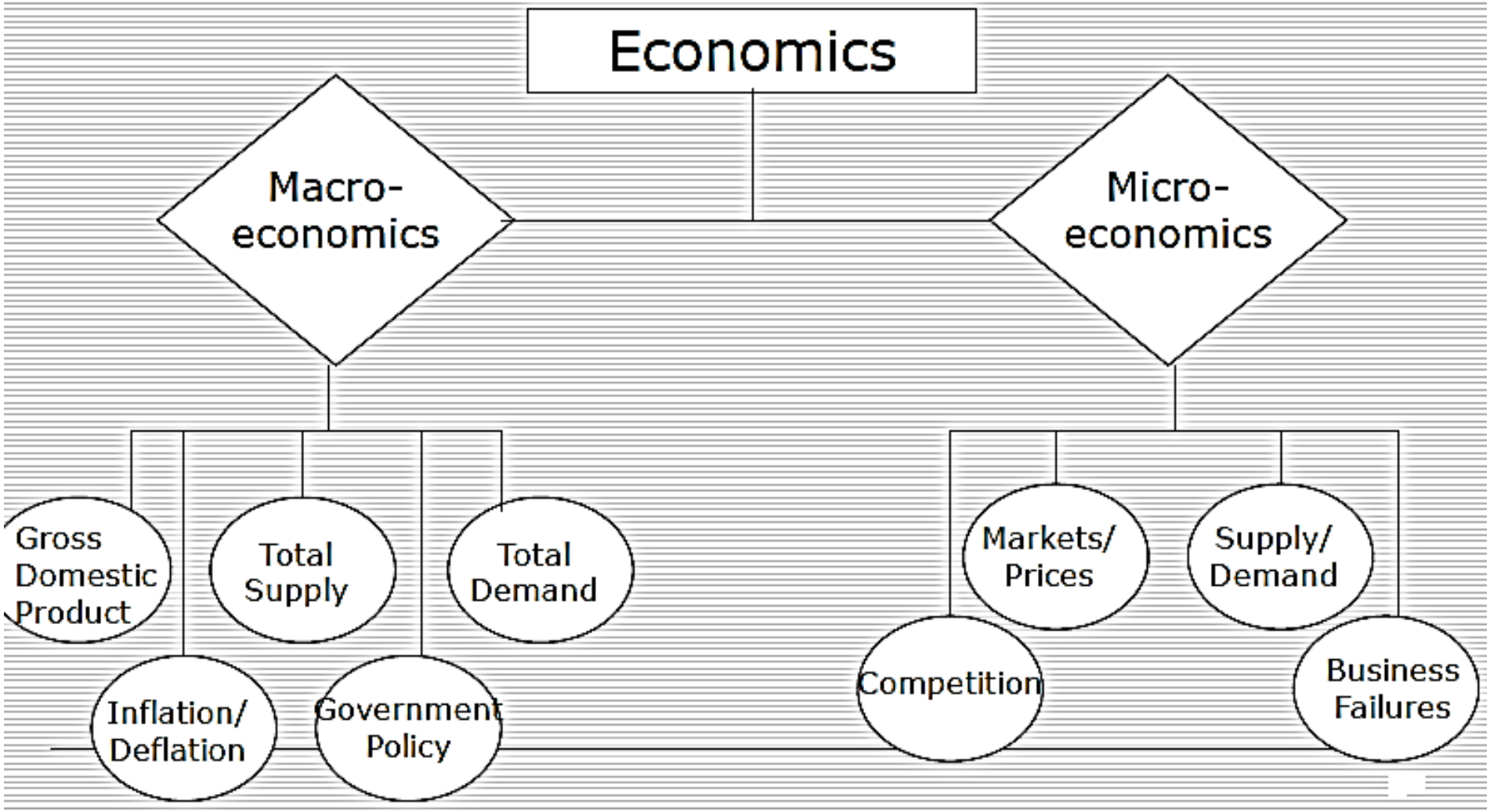
- ✓ Trade can make everyone better off
- ✓ Markets are usually a good way to organize economic activity
- ✓ Governments can sometimes improve market outcomes

Principles of Economics

How the economy as a whole works

- ✓ A Country's standard of living depends on its ability to produce goods and services
- ✓ Prices rise when the government prints too much money
- ✓ Society faces a short-run tradeoff between inflation and unemployment

Economics


Economics
Macro-economics
Micro-economics
Gross Domestic Product
Total Supply
Total Demand
Inflation/ Deflation
Government Policy
Markets/ Prices
Supply/ Demand
Competition
Business Failures

Macroeconomics

Macroeconomics is the study of economy-wide phenomena, including inflation, unemployment, and economic growth

Concepts related to Macroeconomics

Gross Domestic Product (GDP) is the market value of all goods and services produced within a country in one year

Concepts related to Macroeconomics

Total Supply is the total amount of goods and services produced during a defined period of time.

Concepts related to Macroeconomics

Total Demand is the total amount of spending on goods and services during a defined period of time.

Concepts related to Macroeconomics

Inflation is a sustained increase in the average price of goods and services within the entire economy

Concepts related to Macroeconomics

Deflation is a sustained decrease in the average price of goods and services within the entire economy

Concepts related to Macroeconomics

Governmental policy that relates to the amount of money (cash) available in the economy and design a policy that relates to taxes

GDP

GDP - Gross Domestic Product

GDP

GDP measures the total income of the nation

GDP

GDP measures two things at once:

The **total income** of everyone in the economy &

The **total expenditure** on the economy's output of goods and services

GDP

For an economy as a whole, **income must equal expenditure**

GDP

GDP is the market value of all final goods and services produced within a country in a given period of time

GDP

Gross domestic product (GDP) is the **market value** of all final goods and services produced within a country in a given period of time.

Market Value …

- Goods values at their market prices
- All goods are in the same units
- Things that don't have a market value are excluded

GDP

Gross domestic product (GDP) is the market value **of all** final goods and services produced within a country in a given period of time.

Of all …

Includes all items produced in the economy and sold legally in markets

GDP

Gross domestic product (GDP) is the market value of all **final** goods and services produced within a country in a given period of time.

Final …

- **Final Goods:** Intended for the end user
- **Intermediate Goods:** Used as components or ingredients in the production of other goods
- GDP only includes final goods – they already embody the value of the intermediate goods used in their production

GDP

Gross domestic product (GDP) is the market value of all final **goods and services** produced within a country in a given period of time.

Goods and Services …

GDP includes both

Tangible goods (food, clothing, cars) &

Intangible services (haircuts, housecleaning, doctor visits).

GDP

Gross domestic product (GDP) is the market value of all final goods and services **produced** within a country in a given period of time.

Produced…

GDP includes currently produced goods and not the goods produced in the past

GDP

Gross domestic product (GDP) is the market value of all final goods and services produced **within a country** in a given period of time.

Within a Country …

GDP measures the value of production within the geographic confines of a country.

GDP

Gross domestic product (GDP) is the market value of all final goods and services produced within a country **in a given period of time.**

In a given period of Time …

Specific interval of Time – year or a quarter (3 months)

Components of GDP

GDP (denoted as Y) is divided into 4 components:

- ✓ Consumption (*C*),
- ✓ Investment (*I*),
- ✓ Government purchases (*G*), &
- ✓ Net exports (*NX*)

$$Y = C + I + G + NX$$

Components of GDP

$$Y = C + I + G + NX$$

Consumption …

Spending by households on goods and services, with the exception of purchases of new housing

Components of GDP

$$Y = C + I + G + NX$$

Investment …

Spending on capital equipment, inventories, and structures, including household purchases of new housing

Components of GDP

$$Y = C + I + G + NX$$

Government Purchases …

spending on goods and services by local, state, and federal governments

Components of GDP

$$Y = C + I + G + NX$$

Net exports …

Spending on domestically produced goods by foreigners (exports) minus spending on foreign goods by domestic residents (imports)

Real GDP Vs Nominal GDP

Real GDP

The production of goods and services valued at ***Constant*** *prices*

Nominal GDP

The production of goods and services valued at ***Current*** *prices*

GDP Deflator

GDP deflator measures the current level of prices relative to the level of prices in the base year

$$\textbf{GDP Deflator} = \frac{\textbf{Nominal GDP}}{\textbf{Real GDP}} \textbf{ x 100}$$

Computing GDP

	2017 (Base Year)		2018		2019	
	A	B	A	B	A	B
Good X	$40	800	$43	900	$48	1100
Good Y	$120	200	$124	250	$130	400

Compute the following using the above data:

1. Nominal GDP in 2017

2. Real GDP in 2018

3. GDP deflator in 2019

Computing GDP

	2017 (Base Year)		2018		2019	
	A	B	A	B	A	B
Good X	$40	800	$43	900	$48	1100
Good Y	$120	200	$124	250	$130	400

Nominal GDP in 2017:

= 40 * 800 + 120 * 200 = $ 56000

Real GDP in 2018:

= 40 * 900 + 120 * 250 = $ 66000

Computing GDP

	2017 (Base Year)		2018		2019	
	A	B	A	B	A	B
Good X	$40	800	$43	900	$48	1100
Good Y	$120	200	$124	250	$130	400

GDP deflator in 2019

Nominal GDP in 2019 = 48 * 1100 + 130 * 400 = $ 1048000

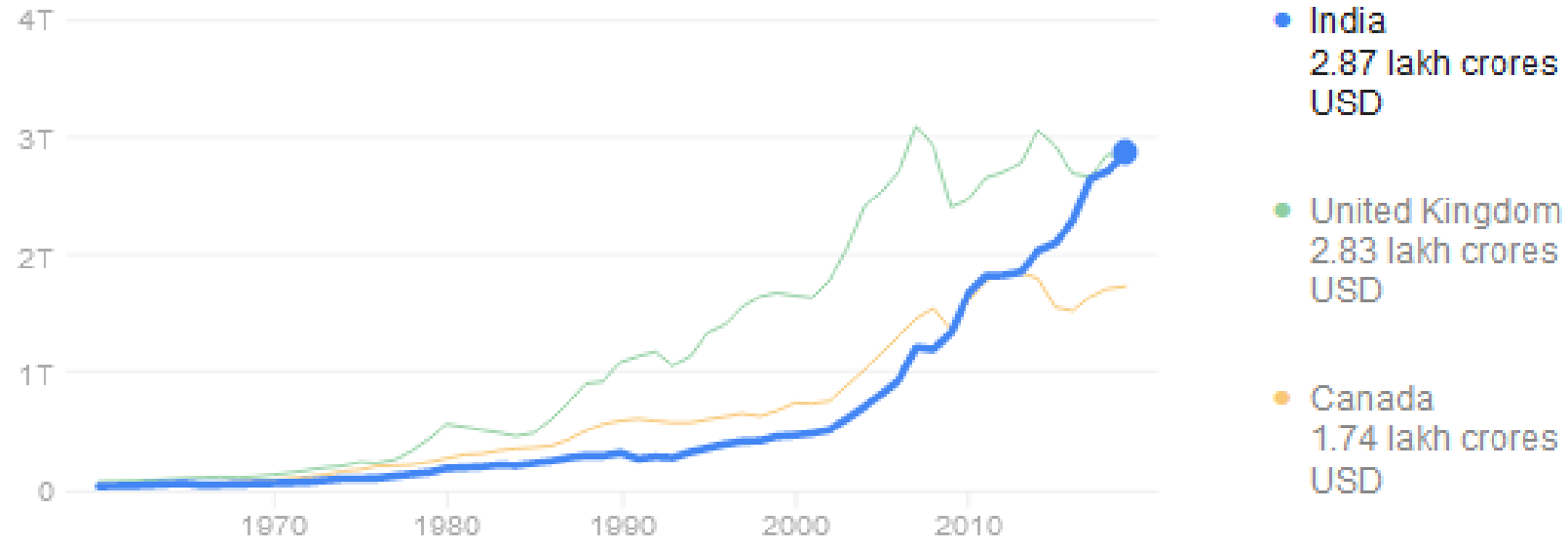
Real GDP in 2018 = 40 * 1100 + 120 * 400 = $ 92000

$$GDP\ Deflator = \frac{Nominal\ GDP}{Real\ GDP}\ x\ 100 = \frac{1048000}{92000}\ x\ 100 = 113.92$$

GDP Comparison

India / Gross domestic product

2.87 lakh crores USD (2019)



Sources include: World Bank

Feedback

Other Measures of Income

GNP – Gross National Product

Total income earned by a nation's permanent residents

Other Measures of Income

NNP – Net National Product

$$NNP = GNP - Depreciation$$

Other Measures of Income

National Income

$$National\ Income = NNP - Indirect\ Business\ Taxes + Business\ Subsidies$$

Other Measures of Income

Personal Income

Income that households and Non-corporate businesses receive

Microeconomics

Microeconomics *is the study of how households and firms make decisions and how they interact in markets*

Microeconomics

*It is the study of **Individuals***

Microeconomics

*Also called as **Price Theory** because it is primarily concerned with the determination of prices of individual commodities and factors*

Microeconomics

Concepts related to Microeconomics

Markets and **prices** give individuals the opportunity to buy and sell goods.

Concepts related to Microeconomics

Supply and demand is affected by business organizations and consumers. Governmental policies can sometimes affect supply and demand.

Concepts related to Microeconomics

Competition is determined by the number of buyers and sellers in particular markets

Concepts related to Microeconomics

Business failures occur due to inadequate competition, lack of access to reliable information, not enough demand for goods, and other reasons.

End of Module-1