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# **Economics**

## Lecture Notes

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January 9, 2025

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# Overview

<b>1 Scope and method of economics</b>	<b>19</b>
1.1 What is economics? . . . . .	19
1.2 Microeconomics vs. Macroeconomics . . . . .	21
1.3 The scope of economics in five questions . . . . .	23
1.4 The economic way of thinking . . . . .	27
1.5 International economics . . . . .	31
1.6 Methods of economics . . . . .	38
<b>2 Measuring the (macro)economy</b>	<b>45</b>
2.1 Measuring income and living standards . . . . .	45
2.2 Real Gross Domestic Product (GDP) . . . . .	50
2.3 Measuring prices and inflation . . . . .	51
2.4 Why inflation is bad . . . . .	56
2.5 The standard of living across countries . . . . .	56
2.6 Alternative measures of welfare . . . . .	56
<b>3 Economic growth in the long-run (Solow Model)</b>	<b>62</b>
3.1 Stylized facts . . . . .	63
3.2 Solow model . . . . .	68
3.3 The formal Solow model . . . . .	71
3.4 Summary . . . . .	76
<b>4 Microeconomic preliminaries</b>	<b>79</b>
4.1 Production functions . . . . .	79
4.2 Production possibility frontier curve . . . . .	80
4.3 Indifference curves and isoquants . . . . .	82
4.4 Budget constraint . . . . .	83

<b>5 Market</b>	<b>85</b>
5.1 Introduction: What is a market? . . . . .	85
5.2 Demand . . . . .	86
5.3 Supply . . . . .	90
5.4 Market equilibrium . . . . .	92
5.5 How markets allocate resources . . . . .	97
5.6 Summary . . . . .	100
5.7 Glossary . . . . .	101
<b>6 Managerial Economics</b>	<b>103</b>
<b>7 Consumption and production choices</b>	<b>104</b>
7.1 Decision making at the margin . . . . .	104
7.2 Consumption and production choices . . . . .	106
7.3 Consumption choice using the Lagrangian Multiplier . . . . .	111
<b>8 Elasticity</b>	<b>119</b>
8.1 How to measure an elasticity . . . . .	119
8.2 Midpoint method . . . . .	121
8.3 Elasticity and demand . . . . .	122
8.4 Responsiveness of demand to other factors . . . . .	123
8.5 Demand and revenue . . . . .	125
8.6 Elasticity and supply . . . . .	128
8.7 Summary . . . . .	129
<b>9 Market failure</b>	<b>130</b>
9.1 The perfect market . . . . .	130
9.2 Markets are not perfect . . . . .	131
9.3 When market are not free: Price controls . . . . .	132
9.4 Monopoly . . . . .	137
9.5 External effects . . . . .	143
9.6 Public goods . . . . .	146
9.7 Imperfect information . . . . .	148
<b>10 Business cycles and unemployment</b>	<b>153</b>
10.1 Unemployment . . . . .	153
10.2 Fluctuations in GDP . . . . .	159
10.3 Fluctuations in GDP and unemployment . . . . .	160

10.4 The reverse multiplier effect . . . . .	160
<b>11 Economies in the short run: The goods market</b>	<b>162</b>
11.1 Stylized facts . . . . .	162
11.2 Corona and how to fight an economic crisis . . . . .	165
11.3 Aggregate demand . . . . .	166
11.4 The goods market and the investment-savings (IS) relation . . . . .	172
11.5 Summary . . . . .	174
<b>12 Economies in the short run: The financial market</b>	<b>176</b>
12.1 Semantic traps: Money, income, and wealth . . . . .	176
12.2 The demand for money . . . . .	178
12.3 The supply of money and the equilibrium . . . . .	178
12.4 The derivation of the LM Curve . . . . .	179
12.5 Taylor rule . . . . .	181
<b>13 Goods and financial markets: The IS-LM model</b>	<b>182</b>
13.1 Putting the IS and the LM relations together . . . . .	182
13.2 Monetary policy . . . . .	183
13.3 Limitations of the IS-LM model . . . . .	186
<b>14 AS-AD Model</b>	<b>191</b>
14.1 The first lockdown at 23 March 2020... . . . . .	191
14.2 Value added and price level . . . . .	193
14.3 How did GDP fall while price levels remained roughly constant? . . . . .	194
14.4 Aggregated Demand (AD) . . . . .	195
14.5 Aggregated Supply (AS) . . . . .	195
14.6 International data . . . . .	198
<b>15 Negative interest rates policy</b>	<b>200</b>
15.1 My stamps taught me a lot . . . . .	201
15.2 Put money in a bank account and get rich . . . . .	201
15.3 European Central Bank . . . . .	202
<b>16 International economics</b>	<b>210</b>

<b>17 Financial mathematics</b>	<b>211</b>
17.1 Financial literacy . . . . .	211
17.2 Common investment mistakes . . . . .	213
17.3 Simple financial mathematics . . . . .	214
17.4 Net present value and internal rate of return . . . . .	215
17.5 Logarithmic and exponential function . . . . .	218
17.6 A note on growth rates and the logarithm . . . . .	220
17.7 Solutions . . . . .	223
<b>18 Game theory and behavioral economics</b>	<b>231</b>
18.1 Game theory . . . . .	231
18.2 Structure of games . . . . .	236
18.3 Representation of a game: The extensive-form . . . . .	236
18.4 Behavioral economics . . . . .	238
<b>Bibliography</b>	<b>248</b>

# Table of content

<b>1 Scope and method of economics</b>	<b>19</b>
1.1 What is economics? . . . . .	19
1.1.1 Production and productivity . . . . .	19
▣ Excercise — Production and Productivity . . . . .	19
1.1.2 Efficiency vs. effectiveness . . . . .	19
1.1.3 Economic topics in the news . . . . .	20
1.1.4 Definition . . . . .	20
1.2 Microeconomics vs. Macroeconomics . . . . .	21
▣ Excercise — A country is not a company . . . . .	23
1.3 The scope of economics in five questions . . . . .	23
1.3.1 What? . . . . .	23
1.3.2 How? . . . . .	23
1.3.3 For whom? . . . . .	24
1.3.4 Where? . . . . .	24
1.3.5 When is the pursuit of self-interest in the social interest? . . . . .	24
▣ Excercise — Do you act in self-interest and who decides? . . . . .	25
1.3.6 The magic of the price system in free markets . . . . .	25
Milton Friedman's pencil parable . . . . .	25
Adam Smith's invisible hand . . . . .	26
How markets allocate resources . . . . .	26
▣ Excercise — Magic of the price system . . . . .	27
⌚ Solution — Magic of the price system . . . . .	27
1.4 The economic way of thinking . . . . .	27
1.4.1 A choice is a tradeoff . . . . .	28
▣ Excercise — TANSTAAFL . . . . .	28
⌚ Solution — TANSTAAFL . . . . .	28
▣ Excercise — Tradeoffs . . . . .	29
1.4.2 Making a rational choice . . . . .	29
▣ Excercise — The businessman and the fisherman . . . . .	30
1.4.3 Benefit: What you gain . . . . .	30
1.4.4 Cost: What you must give up . . . . .	30
1.4.5 How much? Choosing at the margin . . . . .	30
1.4.6 Choices respond to incentives . . . . .	30
▣ Excercise — Marginal analysis . . . . .	31
1.5 International economics . . . . .	31
1.5.1 What is international trade? . . . . .	31
▣ Excercise — Trade and Putin . . . . .	31
1.5.2 What is international monetary economics? . . . . .	33
1.5.3 What is international trade policy? . . . . .	33
▣ Excercise — Free trade: good or bad? . . . . .	36
1.5.4 Important terms in international economics . . . . .	36
1.6 Methods of economics . . . . .	38

1.6.1	Theory and models . . . . .	38
1.6.2	Economic models . . . . .	38
1.6.3	Richard Feynman on scientific method (1964) . . . . .	38
1.6.4	The economic way of doing research . . . . .	41
	▣ Excercise — Positive or normative . . . . .	41
1.6.5	Cause and effect . . . . .	42
1.6.6	Common fallacies in economic research . . . . .	42
1.6.7	Why economists disagree . . . . .	43
<b>2</b>	<b>Measuring the (macro)economy</b>	<b>45</b>
2.1	Measuring income and living standards . . . . .	45
2.1.1	(Nominal) Gross Domestic Product (GDP) . . . . .	45
	▣ Excercise — Mankiw's definition . . . . .	46
2.1.2	Three equivalent ways to measure GDP . . . . .	46
	The expenditure approach . . . . .	46
	▣ Excercise — GDP explained . . . . .	46
	The income approach . . . . .	47
	The production approach . . . . .	49
2.1.3	Limitations of the nominal GDP . . . . .	49
	▣ Excercise — GDP as an imperfect measure . . . . .	50
	⌚ Solution — GDP as an imperfect measure . . . . .	50
2.2	Real Gross Domestic Product (GDP) . . . . .	50
2.3	Measuring prices and inflation . . . . .	51
	▣ Excercise — Global inflation . . . . .	52
2.3.1	Calculating the Consumer Price Index (CPI) in 5 Steps . . . . .	52
2.3.2	Calculating the inflation rate . . . . .	54
2.3.3	Real and nominal interest rates . . . . .	54
	▣ Excercise — The salary of teachers over time . . . . .	55
	⌚ Solution — The salary of teachers over time . . . . .	55
2.3.4	Challenges in measuring the cost of living using the CPI . . . . .	55
	▣ Excercise — CPI: relative weights . . . . .	55
2.4	Why inflation is bad . . . . .	56
2.5	The standard of living across countries . . . . .	56
2.6	Alternative measures of welfare . . . . .	56
	▣ Excercise — OECD better life index . . . . .	57
	▣ Excercise — How to measure GDP . . . . .	57
	▣ Excercise — What counts as GDP? . . . . .	57
	▣ Excercise — Nominal vs. real GDP and CPI . . . . .	58
	▣ Excercise — GDP and well-being . . . . .	58
	▣ Excercise — Various GDP . . . . .	58
	⌚ Solution — How to measure GDP . . . . .	59
	⌚ Solution — What counts as GDP? . . . . .	59
	⌚ Solution — Nominal vs. real GDP and CPI . . . . .	60
	⌚ Solution — GDP and well-being . . . . .	60
	⌚ Solution — Various GDP . . . . .	61
<b>3</b>	<b>Economic growth in the long-run (Solow Model)</b>	<b>62</b>
3.1	Stylized facts . . . . .	63
	▣ Excercise — Visualization of welfare . . . . .	63
3.2	Solow model . . . . .	68
3.2.1	Introduction to the Solow model of economic growth . . . . .	68
3.2.2	▶ <i>The Solow Model and the Steady State</i> . . . . .	69
3.2.3	▶ <i>The Solow Model and Ideas</i> . . . . .	70
	Solow's central question . . . . .	71

3.3	The formal Solow model . . . . .	71
3.3.1	Production . . . . .	71
	Constant returns to scale . . . . .	71
	Intensive form . . . . .	72
	Inada conditions . . . . .	72
	Cobb-Douglas function . . . . .	72
3.3.2	Evolution of production factors . . . . .	73
	L and A . . . . .	73
	K . . . . .	74
	Evolution of $k$ . . . . .	74
3.3.3	Steady-state, $k^*$ . . . . .	75
3.3.4	Consumption . . . . .	75
3.3.5	Golden Rule of consumption . . . . .	75
3.3.6	Long-run growth rates . . . . .	76
3.4	Summary . . . . .	76
	■ Excercise — Technological Progress . . . . .	76
	⌚ Solution — Technological Progress . . . . .	77
	■ Excercise — Solow Simplified . . . . .	78
<b>4</b>	<b>Microeconomic preliminaries</b>	<b>79</b>
4.1	Production functions . . . . .	79
4.2	Production possibility frontier curve . . . . .	80
	■ Excercise — Understanding production . . . . .	81
	⌚ Solution — Understanding production . . . . .	82
4.3	Indifference curves and isoquants . . . . .	82
	■ Excercise — Isoquants . . . . .	83
4.4	Budget constraint . . . . .	83
	■ Excercise — Cobb-Douglas PF . . . . .	84
<b>5</b>	<b>Market</b>	<b>85</b>
5.1	Introduction: What is a market? . . . . .	85
5.1.1	The problem of value: The Water-Diamond Paradox . . . . .	85
	■ Excercise — From moral to amoral theories of value . . . . .	85
5.1.2	Elements of a market . . . . .	85
5.2	Demand . . . . .	86
5.2.1	The law of demand . . . . .	86
	■ Excercise — Greed . . . . .	86
5.2.2	Demand schedule and demand curve . . . . .	86
5.2.3	Market demand versus individual demand . . . . .	87
	■ Excercise — Aggregate individual demand . . . . .	88
	⌚ Solution — Aggregate individual demand . . . . .	88
	Movements along the curve versus shifts . . . . .	88
	■ Excercise — Sources of demand . . . . .	89
	Movements along the demand curve . . . . .	89
	Shifts in the demand curve . . . . .	89
	■ Excercise — Three demand curves . . . . .	90
5.3	Supply . . . . .	90
5.3.1	The law of supply . . . . .	90
5.3.2	Supply schedule and supply curve . . . . .	90
5.3.3	Market supply versus individual supply . . . . .	91
	Movements along the curve versus shifts . . . . .	91
	Shifts in the supply curve . . . . .	91
	■ Excercise — Prices of Related Goods in Production . . . . .	92
	⌚ Solution — Prices of Related Goods in Production . . . . .	92

5.4	Market equilibrium . . . . .	92
	■ Excercise — Demand and Supply . . . . .	92
	⌚ Solution — Demand and Supply . . . . .	93
	Supply > Demand (Surplus / Excess) . . . . .	94
	Supply < Demand (Shortage) . . . . .	94
	■ Excercise — Effects of a new fertilizer . . . . .	95
	⌚ Solution — Effects of a new fertilizer . . . . .	96
	■ Excercise — Effects of a study on coffee . . . . .	96
	⌚ Solution — Effects of a study on coffee . . . . .	96
	■ Excercise — Housing market . . . . .	97
	⌚ Solution — Housing market . . . . .	97
	■ Excercise — Market of supply and demand . . . . .	97
5.5	How markets allocate resources . . . . .	97
5.5.1	Efficient allocation of resources . . . . .	98
5.5.2	Consumer and producer surplus . . . . .	98
	■ Excercise — Welfare and taxes . . . . .	100
	⌚ Solution — Welfare and taxes . . . . .	100
5.6	Summary . . . . .	100
5.7	Glossary . . . . .	101
<b>6</b>	<b>Managerial Economics</b>	<b>103</b>
<b>7</b>	<b>Consumption and production choices</b>	<b>104</b>
7.1	Decision making at the margin . . . . .	104
7.1.1	Total utility and diminishing marginal utility . . . . .	104
7.1.2	Calculating total utility . . . . .	105
7.1.3	Marginal utility per unit of money . . . . .	105
	■ Excercise — Error in table . . . . .	105
7.2	Consumption and production choices . . . . .	106
7.2.1	The role of income and budget . . . . .	106
7.2.2	The role of prices . . . . .	107
7.2.3	Substitution and income effect . . . . .	107
	■ Excercise — The graphical foundations of demand curves . . . . .	109
7.2.4	Consumption, production, and terms of trade . . . . .	109
	■ Excercise — Understanding indifference curves and budget constraints . . . . .	109
	⌚ Solution — Understanding indifference curves and budget constraints . . . . .	110
	■ Excercise — Utility maximization . . . . .	110
	■ Excercise — Burgers and drinks . . . . .	110
	⌚ Solution — Burgers and drinks . . . . .	111
7.3	Consumption choice using the Lagrangian Multiplier . . . . .	111
7.3.1	Lagrangian Multiplier Method . . . . .	111
	■ Excercise — Consumption Choice . . . . .	113
	⌚ Solution — Consumption Choice . . . . .	114
	■ Excercise — Derivation of Demand Function . . . . .	114
	■ Excercise — Cobb-Douglas and Demand . . . . .	114
	⌚ Solution — Derivation of Demand Function . . . . .	115
	⌚ Solution — Cobb-Douglas and Demand . . . . .	115
	⌚ Solution — Derivation of demand function using the Lagrangian multiplier . . . . .	116
	⌚ Solution — Cobb-Douglas and demand . . . . .	117
	■ Excercise — Labor and Machines . . . . .	117
	⌚ Solution — Labor and Machines . . . . .	118
<b>8</b>	<b>Elasticity</b>	<b>119</b>
8.1	How to measure an elasticity . . . . .	119

└ Excercise — How Rachel's demand reacts to changes in price . . . . .	120
└ Solution — How Rachel's demand reacts to changes in price . . . . .	120
└ Excercise — Check for Units of Measurement and Direction of Change . . . . .	120
└ Solution — Check for Units of Measurement and Direction of Change . . . . .	121
8.2 Midpoint method . . . . .	121
└ Excercise — Midpoint Method and the Direction of Change . . . . .	121
└ Solution — Midpoint Method and the Direction of Change . . . . .	121
8.3 Elasticity and demand . . . . .	122
8.3.1 Terms: Elastic, inelastic, perfect elastic, and perfect inelastic . . . . .	122
└ Excercise — Sketch Demand Curves . . . . .	122
8.3.2 Constant price elasticities . . . . .	123
8.3.3 Be careful not to confuse elasticity with slope. . . . .	123
8.4 Responsiveness of demand to other factors . . . . .	123
8.4.1 Income elasticity of demand . . . . .	123
8.4.2 Income elasticity of demand: Categorization . . . . .	123
└ Excercise — Income and Normal and Inferior Goods in Demand . . . . .	124
8.4.3 Cross-price elasticity of demand . . . . .	124
└ Excercise — Prices across Goods and Demand . . . . .	125
8.5 Demand and revenue . . . . .	125
8.5.1 The price elasticity of demand and revenue . . . . .	125
└ Excercise — Elasticity and total revenue . . . . .	126
└ Excercise — Prices and revenue . . . . .	126
└ Excercise — Prices elasticities and revenues . . . . .	126
└ Solution — Prices elasticities and revenues . . . . .	128
8.6 Elasticity and supply . . . . .	128
└ Excercise — Sketch supply curves . . . . .	128
8.6.1 Determinants of price elasticity of supply . . . . .	128
8.6.2 Examples for different price elasticities . . . . .	128
└ Excercise — Labor supply and labor demand . . . . .	129
8.7 Summary . . . . .	129
<b>9 Market failure</b>	<b>130</b>
9.1 The perfect market . . . . .	130
9.2 Markets are not perfect . . . . .	131
9.2.1 Should we care? . . . . .	131
9.2.2 Two fundamental theorems of welfare economics . . . . .	131
9.2.3 Types of imperfect market structures . . . . .	131
9.3 When market are not free: Price controls . . . . .	132
9.3.1 Maximum price . . . . .	132
9.3.2 Minimum price . . . . .	132
└ Excercise — Welfare and price controls . . . . .	133
9.3.3 Taxes . . . . .	133
└ Excercise — Tax Consumer . . . . .	134
└ Excercise — Laffer curve . . . . .	135
9.3.4 Subsidies . . . . .	135
└ Excercise — Exercise: Minimum Wage . . . . .	136
└ Excercise — Social Surplus . . . . .	136
└ Solution — Social Surplus . . . . .	136
└ Excercise — Markets Are Connected . . . . .	137
9.4 Monopoly . . . . .	137
9.4.1 Revenue function . . . . .	137
9.4.2 Revenue and price relationship . . . . .	137
9.4.3 Profit-maximizing level of output . . . . .	138
9.4.4 Price effect of a monopoly . . . . .	139

9.4.5	Welfare . . . . .	139
	■ Excercise — Marginal revenue and total revenue . . . . .	139
	? Solution — Marginal revenue and total revenue . . . . .	140
	■ Excercise — How to maximize profits . . . . .	140
	? Solution — How to maximize profits . . . . .	141
	■ Excercise — Monopolist optimal price . . . . .	141
	? Solution — Monopolist optimal price . . . . .	141
9.4.6	Monopoly and price discrimination . . . . .	141
9.5	External effects . . . . .	143
9.5.1	Introduction . . . . .	143
	■ Excercise — Positive and negative externalities . . . . .	143
9.5.2	Production externalities . . . . .	144
9.5.3	Consumption externalities . . . . .	144
9.5.4	Government interventions . . . . .	145
9.5.5	Private solutions to externalities . . . . .	145
9.6	Public goods . . . . .	146
9.7	Imperfect information . . . . .	148
9.7.1	Moral hazard . . . . .	148
9.7.2	Information asymmetry . . . . .	148
9.7.3	Adverse selection . . . . .	149
	■ Excercise — Market failure review . . . . .	149
	? Solution — Market failure review . . . . .	150
	■ Excercise — Externalities examples . . . . .	150
	? Solution — Externalities examples . . . . .	151
	■ Excercise — Tax a market failure . . . . .	152
	? Solution — Tax a market failure . . . . .	152
<b>10</b>	<b>Business cycles and unemployment</b> . . . . .	<b>153</b>
10.1	Unemployment . . . . .	153
10.1.1	Introduction . . . . .	153
10.1.2	Reasons for unemployment . . . . .	154
	■ Excercise — Perfect labor market . . . . .	155
10.1.3	Why is the wage not at a market-clearing level? . . . . .	156
	Minimum wage . . . . .	156
	Unions . . . . .	156
	■ Excercise — Unions as the source of market failure . . . . .	156
	? Solution — Unions as the source of market failure . . . . .	157
	Efficiency wages . . . . .	157
	■ Excercise — Wage increases can cut costs . . . . .	157
	Marx and the reserve army . . . . .	158
10.1.4	Types of unemployment . . . . .	158
	Frictional unemployment . . . . .	158
	Structural unemployment . . . . .	158
	Voluntary and involuntary unemployment . . . . .	158
	Cyclical unemployment . . . . .	158
	Natural unemployment . . . . .	159
	Full employment . . . . .	159
	■ Excercise — Can unemployment be good? . . . . .	159
	? Solution — Can unemployment be good? . . . . .	159
	■ Excercise — Unemployment in Niger and Qatar . . . . .	159
10.2	Fluctuations in GDP . . . . .	159
10.3	Fluctuations in GDP and unemployment . . . . .	160
10.4	The reverse multiplier effect . . . . .	160
	■ Excercise — The great depression vs. COVID crisis . . . . .	161

<b>11 Economies in the short run: The goods market</b>	<b>162</b>
11.1 Stylized facts . . . . .	162
11.2 Corona and how to fight an economic crisis . . . . .	165
11.3 Aggregate demand . . . . .	166
11.3.1 The composition of GDP . . . . .	166
Consumption, $C$ . . . . .	166
Investment, $I$ . . . . .	166
Government Spending, $G$ . . . . .	167
Imports, $IM$ . . . . .	167
Exports, $X$ . . . . .	167
11.3.2 Demand for Goods . . . . .	168
(1) Consumption . . . . .	168
(2) Investment . . . . .	168
(3) Government spending . . . . .	169
11.3.3 Equilibrium at the goods market . . . . .	169
The Determination of equilibrium output . . . . .	169
11.3.4 The model using algebra . . . . .	170
11.3.5 The model using graphs . . . . .	171
11.3.6 The model using words . . . . .	172
11.4 The goods market and the investment-savings (IS) relation . . . . .	172
11.4.1 The derivation of the IS curve . . . . .	173
■ Excercise — Determinants of investments . . . . .	173
? Solution — Determinants of investments . . . . .	173
11.4.2 Shifts of the IS curve . . . . .	173
■ Excercise — Shifting the IS curve . . . . .	173
11.4.3 Investment equals savings . . . . .	173
11.5 Summary . . . . .	174
<b>12 Economies in the short run: The financial market</b>	<b>176</b>
12.1 Semantic traps: Money, income, and wealth . . . . .	176
■ Excercise — Don't say I have a lot of money . . . . .	177
12.2 The demand for money . . . . .	178
■ Excercise — Money or bonds . . . . .	178
12.3 The supply of money and the equilibrium . . . . .	178
12.4 The derivation of the LM Curve . . . . .	179
12.4.1 Using algebra . . . . .	179
12.4.2 Using graphs . . . . .	180
12.5 Taylor rule . . . . .	181
■ Excercise — Taylor rule . . . . .	181
<b>13 Goods and financial markets: The IS-LM model</b>	<b>182</b>
13.1 Putting the IS and the LM relations together . . . . .	182
13.2 Monetary policy . . . . .	183
■ Excercise — Fiscal contraction . . . . .	184
? Solution — Fiscal contraction . . . . .	185
13.3 Limitations of the IS-LM model . . . . .	186
■ Excercise — Rap battle . . . . .	187
? Solution — Rap battle . . . . .	188
■ Excercise — IS-curve (0) . . . . .	188
■ Excercise — IS-curve again . . . . .	188
■ Excercise — IS-curve (1) . . . . .	188
■ Excercise — IS-curve (2) . . . . .	188
■ Excercise — Automatic Stabilizers . . . . .	189
■ Excercise — IS-LM . . . . .	189

└ Excercise — Foreign multiplier . . . . .	190
<b>14 AS-AD Model</b>	<b>191</b>
14.1 The first lockdown at 23 March 2020... . . . .	191
└ Excercise — Economic consequences . . . . .	191
└ Solution — Economic consequences . . . . .	192
14.2 Value added and price level . . . . .	193
14.3 How did GDP fall while price levels remained roughly constant? . . . . .	194
14.4 Aggregated Demand (AD) . . . . .	195
14.5 Aggregated Supply (AS) . . . . .	195
└ Excercise — Effects of the lockdown on equilibrium . . . . .	196
└ Solution — Effects of the lockdown on equilibrium . . . . .	197
14.6 International data . . . . .	198
14.6.1 Summary . . . . .	198
└ Excercise — Comparing the financial crisis to the Corona crisis . . . . .	199
└ Solution — Comparing the financial crisis to the Corona crisis . . . . .	199
<b>15 Negative interest rates policy</b>	<b>200</b>
15.1 My stamps taught me a lot . . . . .	201
15.2 Put money in a bank account and get rich . . . . .	201
15.3 European Central Bank . . . . .	202
15.3.1 Objective . . . . .	202
15.3.2 Monetary policy instruments . . . . .	202
15.3.3 Central bank interest/policy rate (CBPR) . . . . .	203
└ Excercise — Sparkassen CEO criticizes the ECB policy . . . . .	209
<b>16 International economics</b>	<b>210</b>
<b>17 Financial mathematics</b>	<b>211</b>
17.1 Financial literacy . . . . .	211
└ Excercise — How to measure financial literacy . . . . .	212
└ Excercise — The big three questions . . . . .	213
17.2 Common investment mistakes . . . . .	213
└ Excercise — Common investment mistakes . . . . .	214
17.3 Simple financial mathematics . . . . .	214
17.3.1 Simple Interest . . . . .	214
17.3.2 Compound interest . . . . .	214
17.3.3 Continuously compounded interest . . . . .	215
17.3.4 Present value . . . . .	215
17.4 Net present value and internal rate of return . . . . .	215
└ Excercise — Investment case . . . . .	216
└ Excercise — Present value . . . . .	216
└ Excercise — Invest in A or B . . . . .	216
└ Excercise — Net present value . . . . .	217
└ Excercise — Internal rate of return . . . . .	217
└ Excercise — Rule of 70 . . . . .	217
17.5 Logarithmic and exponential function . . . . .	218
17.5.1 Logarithmic function . . . . .	218
└ Excercise — Calculate with log . . . . .	218
17.5.2 Exponential function . . . . .	218
Definition . . . . .	218
The number $e$ . . . . .	219
17.6 A note on growth rates and the logarithm . . . . .	220
└ Excercise — Investments over time . . . . .	222

└─► Excercise — Exponential growth . . . . .	222
└─► Excercise — COVID and how to plot it . . . . .	223
17.7 Solutions . . . . .	223
└─► Solution — How to measure financial literacy . . . . .	223
└─► Solution — The big three questions . . . . .	223
└─► Solution — Common investment mistakes . . . . .	226
└─► Solution — Investment case . . . . .	226
└─► Solution — Present value . . . . .	227
└─► Solution — Invest in A or B . . . . .	227
└─► Solution — Net present value . . . . .	227
└─► Solution — Internal rate of return . . . . .	228
└─► Solution — Rule of 70 . . . . .	229
└─► Solution — Calculate with log . . . . .	229
└─► Solution — Investments over time . . . . .	229
└─► Solution — Exponential growth . . . . .	229
<b>18 Game theory and behavioral economics</b>	<b>231</b>
18.1 Game theory . . . . .	231
18.1.1 Introduction . . . . .	231
18.1.2 Representation of a game: the normal form . . . . .	232
18.1.3 Homo economicus . . . . .	232
18.1.4 Nash equilibrium . . . . .	233
John Forbes Nash Jr. (1928–2015) . . . . .	233
Identifying a Nash equilibrium . . . . .	233
1994 — Nobel Price award ceremony speech . . . . .	233
18.1.5 The prisoner’s dilemma . . . . .	235
18.2 Structure of games . . . . .	236
18.2.1 Elements of games . . . . .	236
18.2.2 Classes of games . . . . .	236
18.3 Representation of a game: The extensive-form . . . . .	236
└─► Excercise — Matching pennies (random and simultaneous version) . . . . .	236
└─► Excercise — Matching pennies (random version) . . . . .	237
└─► Excercise — Matching pennies (strategic version) . . . . .	237
└─► Solution — Matching pennies (random and simultaneous version) . . . . .	237
└─► Solution — Matching pennies (random version) . . . . .	238
└─► Solution — Matching pennies (strategic version) . . . . .	238
18.4 Behavioral economics . . . . .	238
18.4.1 Behavioral experiments . . . . .	238
Milgram experiment (starting 1961) . . . . .	239
18.4.2 Behavioral economic experiments . . . . .	239
Tversky and Kahneman’s judgment under uncertainty . . . . .	239
└─► Excercise — Should Lisa be worried? . . . . .	240
└─► Solution — Should Lisa be worried? . . . . .	240
18.4.3 Common biases in decision making . . . . .	240
Heuristics . . . . .	240
└─► Excercise — Heuristics can fail . . . . .	244
└─► Solution — Heuristics can fail . . . . .	245
18.4.4 The rational model of decision making . . . . .	245
18.4.5 System 1 and System 2 thinking . . . . .	246
└─► Excercise — Shepard tabletop illusion . . . . .	247
└─► Excercise — Kahnemann’s examples . . . . .	247
<b>Bibliography</b>	<b>248</b>

# Preface

- Questions, comments and suggestions are welcome. Especially, if you find any errors in the lecture notes or if you have difficulties with some contents, please let me know.
- You can contact (at every time) me in the lecture or via
  - phone (+49 221 973199-523),
  - e-mail [Stephan.Huber@hs-fresenius.de](mailto:Stephan.Huber@hs-fresenius.de),
  - in office, and
  - online. For making an appointment, you can use the online tool that you find on my private homepage: <https://hubchev.github.io/>
- Material such as slides and lecture notes can be found on ILIAS, Studynet, Lentera cloud, or my private homepage and GitHub Account.
- My teaching principle is **KISS** which stands for **keep it simple and straightforward**.

The KISS principle states that most systems work best if they are kept simple rather than complicated; therefore, simplicity should be a key goal in design, and unnecessary complexity should be avoided.

However, KISS does not mean that the course is easy! If you are not able to think logically or if you are not willing to work hard, you may have problems passing the course

Given your talent and mental capacities, I try to maximize your ability and self-confidence to solve future problems (in life and work).

- I am convinced that reading the lecture notes, preparing for class, taking actively part in class, and trying to solve the exercises without going straight to the solutions is the best method for students to
  - maximize leisure time and minimize the time needed to prepare for the exam, respectively,
  - getting long-term benefits out of the course,
  - improve grades, and
  - have more fun during lecture hours.
- **Literature:** This lecture just scratches the surface of many economic phenomena. For a deeper understanding, you should read a textbook. Any major economics textbook can be used for this lecture. I personally recommend
  - Mankiw, N. G. (2024). *Principles of Economics*. Cengage Learning, 10 edition,
  - Blanchard, O. and Johnson, D. R. (2013). *Macroeconomics*. Pearson, 6 edition,
  - Shapiro, D., MacDonald, D., and Greenlaw, S. A. (2022). *Principles of Economics*. OpenStax, 3 edition,

but you can also use

- Parkin, M. (2012). *Economics*. Addison-Wesley, 10 edition, Case2019Principles, , or
- Krugman, P. R. and Wells, R. (2018). *Economics*. Worth, 5 edition.

While it is always nice to have a more recent textbook, basically older copies are just as fine (and much cheaper). Also, there are good books that are freely available online such as

- Shapiro, D., MacDonald, D., and Greenlaw, S. A. (2022). *Principles of Economics*. OpenStax, 3 edition,
- Anon (2020). *Principles of Economics*. University of Minnesota Libraries Publishing,
- Goodwin, M. (2012). *Economix: How and Why Our Economy Works (and Doesn't Work) in Words and Pictures*. Abrams & Chronicle Books, and
- Klein, G. and Bauman, Y. (2010). *Cartoon Introduction to Economics: Volume One: Microeconomics*. Hill & Wang.

- I present international economics divided into three major branches:

**International trade** is concerned with the determination of relative prices and real incomes in international trade abstracting from the intervention of money. That means trade is considered as an exchange of goods with no financial transactions involved. Of course, this assumption is unrealistic. However, it helps to understand the driving forces of real-world problems.

**Monetary international economics** explicitly considers the meaning of the international financial transaction.

**International trade policy** is about how international economics is taken into action to build the world we live in.

- Of course, this lecture cannot cover all aspects of international economics. It's more like a curated collection of crucial concepts to grasp the fundamentals of global trade. For a deeper dive, I suggest exploring a standard international economics textbook of your preference. Below is a list of recommended books::

- [Suranovic \(2012\)](#): Suranovic, S. (2012). *International Economics: Theory and Policy*. Saylor Foundation, 1.0 edition
- [Krugman et al. \(2017\)](#): Krugman, P. R., Obstfeld, M., and Melitz, M. J. (2017). *International Economics: Theory and Policy*. Prentice Hall, 11 edition
- [Feenstra and Taylor \(2017\)](#): Feenstra, R. C. and Taylor, A. M. (2017). *International Economics*. Worth, 4 edition
- [Pugel \(2015\)](#): Pugel, T. A. (2015). *International Economics*. McGraw-Hill, 16 edition
- [Carbaugh \(2016\)](#): Carbaugh, R. (2016). *International Economics*. South-Western, 16 edition
- [van Marrewijk \(2012\)](#): van Marrewijk, C. (2012). *International Economics: Theory, Application, and Policy*. Oxford University Press, 2 edition
- ?:

- **Notes on Economic models:**

In the following sections, I introduce some mathematical economic models and concepts that are helpful to think about economics in a structured way. Moreover, knowledge on these concepts will allow you to read up-to-date textbooks and literature. Last but not least, the concepts, i.e., formulas and graphical visualizations of arguments can be helpful to understand, analyze, and memorize more complex situations of international trade.

Economic models are based on transparent assumptions and generally consist of a set of equations that describe a theory of economic behavior. A good model should provide useful insights into how rational agents behave and how the economy works. Unfortunately, sometimes students feel lost with these models as the models draw on mathematics and rigorous logical thinking. I often hear that there are less sophisticated ways to formulate the argument and that I act like the teacher of [Figure 1](#). While that may sometimes be true, I am deeply convinced that the formal way to introduce international economics is the best way in the medium and long term. Let me justify my conviction:

1. The narrative method, i.e., telling stories and listing bullet points, is an efficient way to quickly inform about different types of topics, but it also has drawbacks: Students easily get lost in intuitive-sounding anecdotes without learning to think critically and identify underlying general driving forces. Students tend to cram the information told just for the exam and quickly forget everything afterward.
2. Compared to an anecdote, a formal model is not necessarily true. However, they can provide more insight into a topic than an anecdote or other type of storytelling.
3. A formal model is usually more flexible compared to stories and anecdotes. Once students understand the underlying logic of a model and are able to interpret and evaluate its meaning, they can apply the findings to a variety of circumstances or problems. An anecdote, on the other hand, is just a story that may represent a limited view of a problem. Overall, drawing general conclusions and analogies from anecdotal evidence is problematic.
4. A mathematical economic model is like a proof of an argument. It states exactly under what assumptions an argument is true. In a narrative, it is often difficult to see the underlying assumptions and premises of an argument.
5. The formal way of reasoning about things is the standard in economic research, and therefore by knowing the basic concepts, students can read and understand the current literature to do research and solve problems in their professional lives.
6. Once students understand an economic model, they know the underlying relationships, which they are less likely to forget. In other words, **a formal model ensures that students are not just repeating the teacher's words, but are able to think and reason for themselves.**

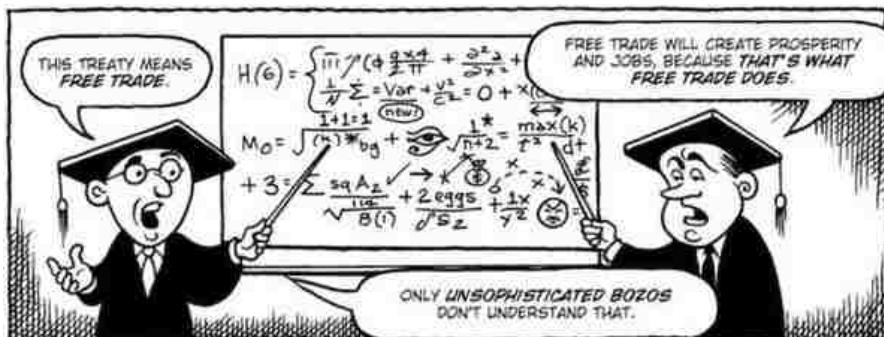
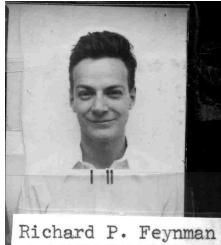


Figure 1: How to be a bad teacher of international economics

## How to prepare for the exam



Richard P. Feynman:

"I don't know what's the matter with people: they don't learn by understanding; they learn by some other way - by rote, or something. Their knowledge is so fragil!"



Stephan Huber:

I agree with Feynman: The key to learning is understanding. However, I believe that there is no understanding without practice, that is, solving problems and exercises by yourself with a pencil and a blank sheet of paper without knowing the solution in advance.

- Study the lecture notes, i.e., try to understand the exercises and solve them yourself.
- Study the exercises, i.e., try to understand the logical rules and solve the problems yourself.
- Test yourself with past exams that you will find online. .
- If you have the opportunity to form a group of students to study and prepare for the exam, make use of it. It is great to help each other, and it is very motivating to see that everyone has problems sometimes.
- If you have difficulties with some exercises and the solutions shown do not solve your problem, ask a classmate or contact me. I will do my best to help.

# Chapter 1

## Scope and method of economics

I recommend a reading of one of these two:

- [Shapiro et al. \(2022, ch. 1-3\)](#),
- [Mankiw \(2024, part I\)](#)

### Learning objectives

- Define economics and distinguish between microeconomics and macroeconomics
- Explain the big questions of economics
- Explain the key ideas that define the economic way of thinking
- Explain how economists go about their work as social scientists

### 1.1 What is economics?

It's important to note that economics encompasses a broad spectrum of interpretations. There isn't a single institution that definitively defines it. Nevertheless, certain definitions emerge frequently, and a degree of consensus exists regarding its meaning. The upcoming chapter is all about that.

#### 1.1.1 Production and productivity

Economics is the study of how to maximize welfare, production, consumption of goods and services, and whatever you may think of is good for an economy<sup>1</sup>.

##### Exercise 1.1 — Production and Productivity

(Solution → p. ??)

Discuss the meaning of the terms production and productivity.

#### 1.1.2 Efficiency vs. effectiveness

- However, in my point of view: Economics is pretty much about **EFFICIENCY** and **EFFECTIVENESS**.
- **Efficiency** is the ability to produce an intended result in the way that results in the least waste of time, effort, and resources.

<sup>1</sup> "An economy is an area of the production, distribution and trade, as well as consumption of goods and services. In general, it is defined as a social domain that emphasize the practices, discourses, and material expressions associated with the production, use, and management of scarce resources." Simplified you can say an economy is a system of providing living to people. [Wikipedia \(2022\)](#)

- **Efficiency** is about doing things in an optimal way, for example doing it the fastest or in the least expensive way. It could be the wrong thing, but it was done optimally.
- **Effectiveness** is the ability to produce a better result, one that delivers more value or achieves a better outcome.
- **Effectiveness** is about doing the right task, completing activities and achieving goals.

### 1.1.3 Economic topics in the news

You are studying economics at a time of **enormous change**. Some of the change is for the better, some of the change is for the worse. Studying economics will help you to **understand the powerful forces that are shaping and changing our world**.

- |   |  |
|---|--|
| <ul style="list-style-type: none"> <li>• COVID</li> <li>• Protectionism/trade war</li> <li>• Brexit</li> <li>• Euro crisis</li> <li>• Monetary policy</li> <li>• Refugees</li> <li>• Germany's trade surplus</li> </ul> | <ul style="list-style-type: none"> <li>• Greece's debt crisis</li> <li>• Real estate crisis</li> <li>• Global financial crisis in 2009</li> <li>• Economics of the Corona Crisis</li> <li>• Oil price fluctuations</li> <li>• US-Dollar strength</li> <li>• Economics of climate change</li> </ul> |
|---|--|

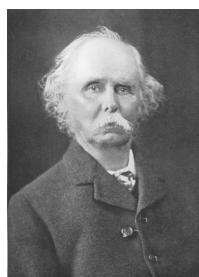
### 1.1.4 Definition

- All economic questions arise because we want more than we can get.
- Our inability to satisfy all our wants is called **scarcity**.
- Because we face scarcity, we must make **choices**.
- The choices we make depend on the **incentives** we face. An incentive is a reward that encourages or a penalty that discourages an action.

Economics is a social science, and as in all social sciences, many of the terms used in it are poorly defined. For example, the term *economy* can be defined understood differently as the following quotes demonstrate:



**John Maynard Keynes (1883-1946):** “The theory of economics does not furnish a body of settled conclusions immediately applicable to policy. It is a method rather than a doctrine, an apparatus of the mind, a technique of thinking, which helps its possessors to draw correct conclusions.” ([Keynes, 1921](#))



**Alfred Marshall (1842-1924):** “Economics is a study of mankind in the ordinary business of life; it examines that part of individual and social action which is most closely connected with the attainment and with the use of the material requisites of wellbeing.” ([Marshall, 2009](#), p. 1)



**James Duesenberry (1918-2009)** “Economics is all about how people make choices. Sociology is about why there isn’t any choice to be made.” ([Duesenberry, 1960](#), p. 233)

[Colander](#) (2006, p. 4): “Economics is the study of how human beings coordinate their wants and desires, given the decision-making mechanisms, social customs, and political realities of the society.”

[Parkin](#) (2012, p. 2): “Economics is the social science that studies the choices that individuals, businesses, governments, and entire societies make as they cope with scarcity and the incentives that influence and reconcile those choices.”

[Gwartney et al.](#) (2006, p. 5): “[E]conomics is the study of human behavior, with a particular focus on human decision making.”

[Backhouse and Medema](#) (2009, p. 222): “[E]conomics is apparently the study of the economy, the study of the coordination process, the study of the effects of scarcity, the science of choice, and the study of human behavior.”

[Greenlaw and Shapiro](#) (2022, ch. 1): Economics seeks to solve the problem of scarcity, which is when human wants for goods and services exceed the available supply. A modern economy displays a division of labor, in which people earn income by specializing in what they produce and then use that income to purchase the products they need or want. The division of labor allows individuals and firms to specialize and to produce more for several reasons: a) It allows the agents to focus on areas of advantage due to natural factors and skill levels; b) It encourages the agents to learn and invent; c) It allows agents to take advantage of economies of scale. Division and specialization of labor only work when individuals can purchase what they do not produce in markets. Learning about economics helps you understand the major problems facing the world today, prepares you to be a good citizen, and helps you become a well-rounded thinker.

[Backhouse and Medema](#) (2009, p. 222): “Perhaps the definition of economics is best viewed as a tool for the first day of principles classes but otherwise of little concern to practicing economists.”



**Jacob Viner (1892-1970):** “Economics is what economists do.” ([Backhouse and Medema](#), 2009, p. 222)

Although many textbook definitions are quite similar in many ways, the lack of agreement on a clear-cut definition of economics does not really matter and does not necessarily pose a problem as

“[E]conomists are generally guided by pragmatic considerations of what works or by methodological views emanating from various sources, not by formal definitions.” ([Backhouse and Medema](#), 2009, p. 231)

## 1.2 Microeconomics vs. Macroeconomics

[Parkin](#) (2012, p. 2): “**Microeconomics** is the study of the choices that individuals and businesses make, the way these choices interact in markets, and the influence of governments. [...] **Macroeconomics** is the study of the performance of the national economy and the global economy.”

Microeconomics and macroeconomics are two different perspectives on the economy. The microeconomic perspective focuses on parts of the economy:

- individuals,
- firms, and

- industries.

The term macro stems from the Greek word *makros*, i.e., large. Thus, it studies groups or the entire economy with aggregate measures that have something to do with welfare and the standards of living such as

- national income,
- money,
- total (un)employment,
- aggregate demand and supply,
- total savings,
- inflation,
- general price level,
- international trade, etc.

Macroeconomics employs two key policy approaches to pursue these objectives: monetary policy and fiscal policy.

- Fiscal policy pertains to the regulation of government revenue, expenditures, and debt to generate positive impacts while averting negative effects on income, output, and employment.
- Monetary policy involves controlling money supply and credit to stimulate business activities, foster economic growth, stabilize price levels, attain full employment, and achieve balance of payments equilibrium.
- Some examples of microeconomic questions are: Why are people downloading more movies? How would a tax on e-commerce affect eBay?
- Some examples of macroeconomic questions are: Why is the U.S. unemployment rate so high? Can the Federal Reserve make our economy expand by cutting interest rates?

**Why a separate Macro- and Microeconomics?** Certainly, events occurring at the micro-level can provide insights into phenomena observed at the macro-level, and vice versa. Thus, there is an interdependence of these disciplines. Nevertheless, there remains value in distinguishing them because:

1. What is good at the micro level don't have to be good for the economy as a whole.
2. Macroeconomic problems can be comprehended and solved only through macro level policy actions and programs.

### Exercise 1.2 — A country is not a company

(Solution → p. ??)

- a) Read [Krugman \(1996\)](#) which is also available online:  
<https://hbr.org/1996/01/a-country-is-not-a-company>

🔗 <https://hbr.org/1996/01/a-country-is-not-a-company>



### Trump calls for New York Times to fire economist Paul Krugman in the latest escalation of their longtime feud

Connor Perrott Jan 26, 2020, 7:04 PM



Source: [www.businessinsider.com](http://www.businessinsider.com)

Discuss why Trump may don't like Krugman's expertise on international trade and comment on Krugman's quote:

"The next time you hear business people propounding their views about the economy, ask yourself. Have they taken the time to study this subject? Have they read what the experts write? If not, never mind how successful they have been in business. Ignore them, because they probably have no idea what they are talking about."

- b) Discuss the following quote from the article *What Do Undergrads Need to Know About Trade?* from Nobel Laureate Paul Krugman (1993, p.25)

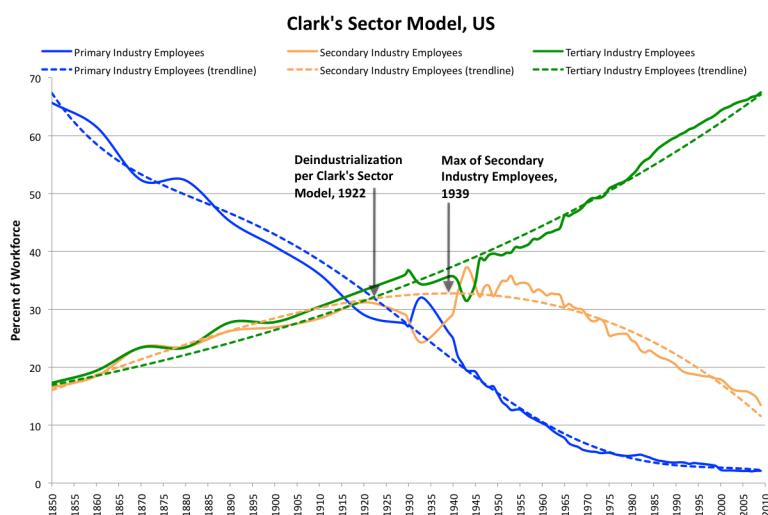
"It should be possible to emphasize to students that the level of employment is a macroeconomic issue, depending in the short run on aggregate demand and depending in the long run on the natural rate of unemployment, with microeconomic policies like tariff shaving little net effect. Trade policy should be debated in terms of its impact on efficiency, not in terms of phony numbers about jobs created or lost."

## 1.3 The scope of economics in five questions

- How do choices end up determining **what, where, how, and for whom** goods and services get produced?
- When do choices made in the pursuit of **self-interest** also promote the **social interest**?

### 1.3.1 What?

What we produce changes over time.<sup>2</sup>



### 1.3.2 How?

Goods and services are produced by using productive resources that economists call factors of production, i.e.,

**Land** aka *natural ressources* are the *gifts of nature* that we use to produce goods and services.

**Labor** is the work time and effort that people devote to production. The quality of labor depends on *human capital*, which is the knowledge and skill that people obtain from education, on-the-job training, and work experience.

<sup>2</sup>Source: [https://upload.wikimedia.org/wikipedia/commons/b/bb/Clark%27s\\_Sector\\_model.png](https://upload.wikimedia.org/wikipedia/commons/b/bb/Clark%27s_Sector_model.png)

**Capital** The tools, instruments, machines, buildings, and other constructions that are employed in the production process.

**Entrepreneurship** The human resource that organizes labor, land, and capital can be called *entrepreneurship*. Entrepreneurs come up with new ideas about what and how to produce, make business decisions, and bear the risks that arise from these decisions.

What determines the quantities of factors of production that are used to produce goods and services is a typical economic question.

### 1.3.3 For whom?

Who gets the goods and services depends on the incomes that people earn. People earn their incomes by selling the services of the factors of production they own:

- Land earns **rent**.
- Labor earns **wages**.
- Capital earns **interest**.
- Entrepreneurship earns **profit**.

Why is the distribution of income so unequal? Why do women and minorities earn less than white males?

### 1.3.4 Where?

We all know *the World is not flat*: The placement of land, labor, capital and entrepreneurs in space is important. In particular, **Regional Science** considers that importance.

“No other discipline can claim such a wide scope of interest and relevance to today’s rapidly changing World. Thus, contrary to the claims of the ‘end of geography’, the process of globalisation is making geography more important than ever.” ([Sokol, 2011](#), p. 36)

Unfortunately, the main microeconomic and macroeconomic textbooks usually refrain from discussing the question *Where?*. One reason for this could be that the introduction of space into the theory is not trivial. Ignoring the existence of regional differences and transport is accompanied by a lack of reality and may lead to wrong conclusions.

### 1.3.5 When is the pursuit of self-interest in the social interest?

7,800,000,000 people make economic choices every day that result in *What*, *How*, and *For Whom* goods and services get produced.

- Do we produce the right things in the right quantities?
- Do we use our factors of production in the best way?
- Do the goods and services go to those who benefit most from them?

Well it depends if we consider self-interest or social-interest:

**self-interest** A choice is in your *self-interest* if you think that choice is the best one available for you. You use your time and other resources in the ways that make the most sense to you.

**social-interest** A choice is in the social interest if it leads to an outcome that is the best for society as a whole. The social interest has two dimensions: efficiency and equity (or fairness). What is best for society is an efficient and fair use of resources.

### Exercise 1.3 — Do you act in self-interest and who decides?

(Solution → p. ??)

- a) Are you acting in your own interest or are you acting in the interest of a third party? And, do you have freedom of choice?
- b) Who decides *what*, *how*, and *for whom*? Discuss.
- c) Is it possible that when each of us makes decisions that are in our own best interest, it also turns out that those decisions are also in society's best interest?
- d) Do public ownership and central planning do a better job than private corporations and free markets?
- e) Don't corporate scandals show that large corporations work against society's interest?
- f) Should pharmaceutical companies be forced to provide HIV/AIDS drugs (or others) to poor people at low cost?
- g) Why are we destroying the environment?
- h) Why don't all people have jobs?

#### 1.3.6 The magic of the price system in free markets

##### Milton Friedman's pencil parable



Milton Friedman (1912–2006) one of the great economists (and teachers) of the 20th century had a 10-hour PBS broadcast series in 1980 called *Free to Choose*. In this show, he presented his vision of how free markets work. In a clip from the show he distills his arguments into a parable about a pencil:<sup>3</sup>

Watch: [www.youtube.com/watch?v=67tHtpac5ws](https://www.youtube.com/watch?v=67tHtpac5ws), or read

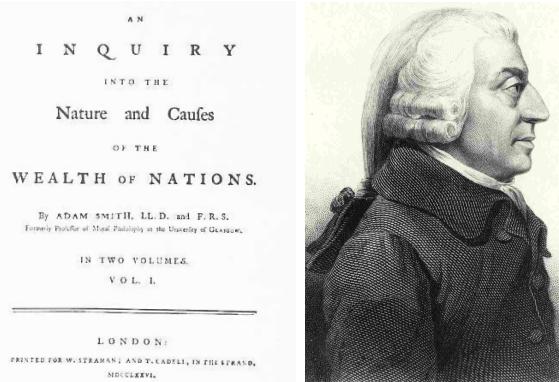
the transcript of the video:

Look at this lead pencil. There's not a single person in the world who could make this pencil. Remarkable statement? Not at all. The wood from which it is made, for all I know, comes from a tree that was cut down in the state of Washington. To cut down that tree, it took a saw. To make the saw, it took steel. To make steel, it took iron ore. This black center—we call it lead but it's really graphite, compressed graphite—I'm not sure where it comes from, but I think it comes from some mines in South America. This red top up here, this eraser, a bit of rubber, probably comes from Malaya, where the rubber tree isn't even native! It was imported from South America by some businessmen with the help of the British government. This brass ferrule? [Self-effacing laughter.] I haven't the slightest idea where it came from. Or the yellow paint! Or the paint that made the black lines. Or the glue that holds it together. Literally thousands of people co-operated to make this pencil. People who don't speak the same language, who practice different religions, who might hate one another if they ever met! When you go down to the store and buy this pencil, you are in effect trading a few minutes of your time for a few seconds of the time of all those thousands of people. What brought them together and induced them to cooperate to make this pencil? There was no commissar sending ... out orders from some central office. It was the magic of the price system: the impersonal operation of prices that brought them

<sup>3</sup>Actually, the parable goes back to Leonard E. Read, see: <https://fee.org/resources/i-pencil/>

together and got them to cooperate, to make this pencil, so you could have it for a trifling sum. That is why the operation of the free market is so essential. Not only to promote productive efficiency, but even more to foster harmony and peace among the peoples of the world.

### Adam Smith's invisible hand



“It is not from the benevolence of the butcher, the brewer, or the baker that we expect our dinner, but from their regard to their own interest” [Smith \(1776\)](#)

In perhaps the most influential book in economics ever written, *An Inquiry into the Nature and Causes of the Wealth of Nations*, Adam [Smith \(1776\)](#) argued that the pursuit of self-interest in a marketplace would promote the general interest. He said resources would be guided, as if by an **invisible hand**, to their best uses. That invisible hand was the **marketplace**. In particular, he wrote:

“Every individual necessarily labours to render the annual revenue of the society as great as he can [...] He is in this, as in many other ways, led by an invisible hand to promote an end which was no part of his intention [...] By pursuing his own interest he frequently promotes that of the society more effectually than when he really intends to promote it”

### How markets allocate resources

Markets use prices as signals to allocate resources to their highest valued uses. Consumers will pay higher prices for goods and services that they value more highly. Producers will devote more resources to the production of goods and services that have higher prices, other things being equal. And other things being equal, workers will provide more hours of labor to jobs that pay higher salaries.

This allocation principle applies both to product markets for items such as cars, houses, and haircuts and to resource markets for items such as labor, land, and equipment. Households play two important roles in an economy—they demand goods and services and supply resources. Businesses also have dual roles—they supply goods and services and demand resources. The interaction of demand and supply in product and resource markets generates prices that serve to allocate items to their highest valued alternatives. Factors that interfere with the workings of a competitive market result in an inefficient allocation of resources, causing a reduction in society’s overall well-being.

**Milton Friedmann:** “*There was no commissar sending out orders from some central office. It was the magic of the price system: the impersonal operation of prices that brought them together and got them to cooperate, to make this pencil, so you could have it for a trifling sum.*”

Further explanations can be found here:

- ▶ [Coordination Through Prices](https://youtu.be/j_awx6F6z-U) by Daniel Russell
- ▶ [What If There Were No Prices?](https://youtu.be/zkPGfTEZ_r4) by Howard Baetjer Jr.

✍ Explain in your own words what Friedman means when he talks about the *magic of the price system*. How is this different from Adam Smith's *invisible hand*? Can you think of situations where the *magic of the price system* does not work properly? Can you think of necessary conditions that must be met for the “magic” to become reality?

### Solution to Exercise 1.4 — Magic of the price system

(Exercise → p. 27)

The *magic of the price system* actually requires markets to be perfect. The assumptions of perfect markets and perfect competition, respectively, are:

1. **Many buyers and sellers:** In a perfectly competitive market, there are numerous buyers and sellers, none of whom have a significant influence over market price. Each participant is a price taker, meaning they have no control over the price at which goods or services are exchanged.
2. **Homogeneous products:** The products offered by all firms in a perfectly competitive market are identical or homogeneous. Consumers perceive no differences between the goods or services provided by different sellers. As a result, buyers base their purchase decisions solely on price.
3. **Perfect information:** All buyers and sellers in a perfectly competitive market have complete and accurate information about prices, quality, availability, and other relevant factors. This assumption ensures that market participants can make rational decisions and respond efficiently to changes in market conditions.
4. **Free entry and exit:** Firms can freely enter or exit the market in response to profits or losses. There are no barriers to entry or exit, such as legal restrictions or substantial costs, that prevent new firms from entering the market or existing firms from leaving it.
5. **Perfect mobility of factors of production:** The resources used in production, such as labor and capital, can move freely between different firms and industries. There are no constraints on the mobility of factors of production, allowing firms to allocate resources efficiently.
6. **Profit maximization:** All firms in a perfectly competitive market are profit maximizers. They aim to maximize their profits by adjusting their output levels based on prevailing market conditions. If firms can increase their profits, they will expand production, and if they incur losses, they will reduce output or exit the market.
7. **No externalities and no transaction costs:** There are assumed to be no externalities, that is no external costs or benefits to third parties not involved in the transaction.

These assumptions collectively define perfect competition and form the foundation of its analysis. If all conditions are fulfilled, there is no need for government regulation. Welfare is maximized and no pareto-improvement can be achieved.

Perfect competition is never found in the real world. However, it is a useful theoretical model that serves as a reference point for analyzing real-world markets. It provides valuable insights into market functioning and informs policymakers on how to address instances of market failure, where at least one assumption of perfect markets is not met. Usually, in real markets these conditions are not given. However, that does not mean that such imperfect markets fail or perform worse compared to centrally planned economies, for example.

## 1.4 The economic way of thinking

The questions that economics attempts to answer tell us something about the scope of economics, but they do not tell us (1) how economists think and (2) how economists conduct research to find answers.

### 1.4.1 A choice is a tradeoff

Before discussing how economists do research, let's look at six key concepts that define the economic way of thinking:

1. A choice is a **tradeoff**.
2. People make **rational decisions** by comparing benefits and costs.
3. **benefit** is what you get out of something.
4. **cost** is what you have to give up to get something.
5. Most choices are *how-much* choices made **at the margin**.
6. Choices respond to **incentives**.

#### Exercise 1.5 — TANSTAAFL

(Solution → p. 28)



\$24 on <https://libertymaniacs.com>

A friend gives you a shirt as a gift. You like it, however you want to find out what the acronym TANSTAAFL means before you put it on. So find out what kind of message goes along with the imprint of the shirt.

#### Solution to Exercise 1.5 — TANSTAAFL

(Exercise → p. 28)

See  [https://en.wikipedia.org/wiki/No\\_such\\_thing\\_as\\_a\\_free\\_lunch](https://en.wikipedia.org/wiki/No_such_thing_as_a_free_lunch)

Because we face scarcity, we must make choices. And when we make a choice, we select from the available alternatives. You can think about every choice as a tradeoff—an exchange—giving up one thing to get something else.

The questions what, how, and for whom become sharper when we think in terms of tradeoffs:

**What?** Tradeoffs arise when people choose how to spend their incomes, when governments choose how to spend their tax revenues, and when businesses choose what to produce.

**How?** Tradeoffs arise when businesses choose among alternative production technologies.

**For Whom?** Tradeoffs arise when choices change the distribution of buying power across individuals. Government redistribution of income from the rich to the poor creates the *big tradeoff*—the tradeoff between equality and efficiency.

**Choices bring change** What, how, and for whom goods and services get produced changes over time and the quality of our economic lives improve. At least if we are able to take wise decisions. The quality of our decisions depend on choices that involve tradeoffs.

**Example:** We face three tradeoffs between enjoying current consumption and leisure time and increasing future production, consumption, and leisure time.

- If we save more, we can buy more productive capital, i.e., machines, and increase our production.
- If we take less leisure time, we can educate and train ourselves to become more productive.
- If businesses produce less and devote resources to research and developing new technologies, they can produce more in the future.
- The choices we make in the face of these tradeoffs determine the pace at which our economic condition improves.

### Exercise 1.6 — Tradeoffs

(Solution → p. ??)

- a) Name choices that involve tradeoffs.
- b) Give some examples for choices without tradeoffs.

#### 1.4.2 Making a rational choice

Economists view the choices that people make as **rational**. A rational choice is one that compares **costs and benefits** and achieves the greatest benefit over cost for the person making the choice.

### Exercise 1.7 — The businessman and the fisherman

(Solution → p. ??)

A classic tale that exist in different version <sup>a</sup> goes like this:

One day a fisherman was lying on a beautiful beach, with his fishing pole propped up in the sand and his solitary line cast out into the sparkling blue surf. He was enjoying the warmth of the afternoon sun and the prospect of catching a fish.

About that time, a businessman came walking down the beach, trying to relieve some of the stress of his workday. He noticed the fisherman sitting on the beach and decided to find out why this fisherman was fishing instead of working harder to make a living for himself and his family. “You aren’t going to catch many fish that way,” said the businessman to the fisherman.

“You should be working rather than lying on the beach!”

The fisherman looked up at the businessman, smiled and replied, “And what will my reward be?”

“Well, you can get bigger nets and catch more fish!” was the businessman’s answer. “And then what will my reward be?” asked the fisherman, still smiling. The businessman replied, “You will make money and you’ll be able to buy a boat, which will then result in larger catches of fish!”

“And then what will my reward be?” asked the fisherman again.

The businessman was beginning to get a little irritated with the fisherman’s questions.

“You can buy a bigger boat, and hire some people to work for you!” he said.

“And then what will my reward be?” repeated the fisherman.

The businessman was getting angry. “Don’t you understand? You can build up a fleet of fishing boats, sail all over the world, and let all your employees catch fish for you!”

Once again the fisherman asked, “And then what will my reward be?”

The businessman was red with rage and shouted at the fisherman, “Don’t you understand that you can become so rich that you will never have to work for your living again! You can spend all the rest of your days sitting on this beach, looking at the sunset. You won’t have a care in the world!”

The fisherman, still smiling, looked up and said, “And what do you think I’m doing right now?”

Who is acting rationally here? The fishermen or the businessmen? What are the costs and benefits of both?

<sup>a</sup>This one stems from [thestorytellers.com](http://thestorytellers.com). A famous version stems from Paulo Coelho see <https://paulocoelhoblog.com>

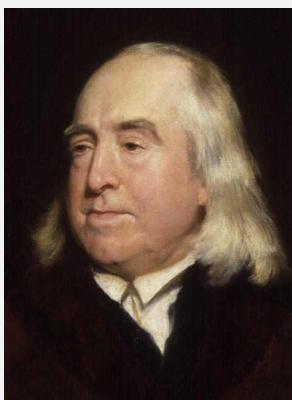
### 1.4.3 Benefit: What you gain

The utility of a thing is the gain or pleasure it brings and is determined by **preferences**. That is, what a person likes or dislikes, and the intensity of those feelings. Economists measure utility as the most a person **is willing to give up to get something**.

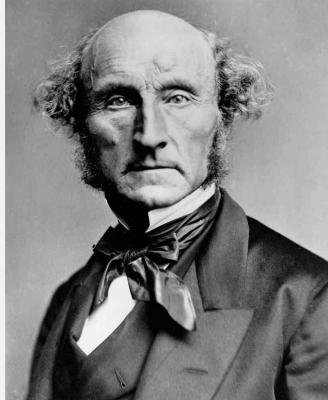
### 1.4.4 Cost: What you must give up

Thinking about a choice as a tradeoff emphasizes cost as an opportunity forgone. The **opportunity cost** of something is the highest-valued alternative that must be given up to get it.

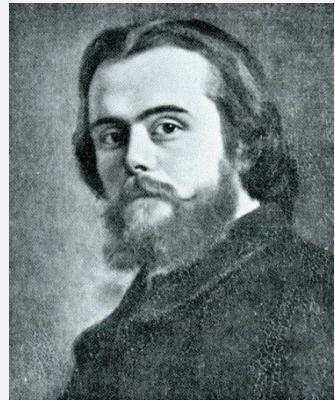
#### Utility as a general measure



Jeremy Bentham (1748-1832)



John Stuart Mill (1806-1873)



Léon Walras (1834-1910)

Within economics, the concept of utility is used to model worth or value. Its usage has evolved significantly over time. The term was introduced initially as a measure of pleasure or happiness within the theory of utilitarianism by moral philosophers such as Jeremy Bentham and John Stuart Mill. Later on it was popularized by Léon Walras. In Microeconomics it usually represents the satisfaction or pleasure that consumers receive for consuming a bundle of goods and services, respectively.

### 1.4.5 How much? Choosing at the margin

- Choosing between studying or watching Netflix is usually not a *all or nothing* decision. Instead, you think about how many minutes to allocate to each activity. To make this decision, you compare the benefit of a little bit more study time with its cost, i.e., you make your choice **at the margin**.
- People make choices at the margin, which means that they evaluate the consequences of making incremental changes in the use of their resources.
- The benefit from pursuing an incremental increase in activity is its marginal benefit. The opportunity cost of pursuing an incremental increase in activity is its marginal cost.

### 1.4.6 Choices respond to incentives

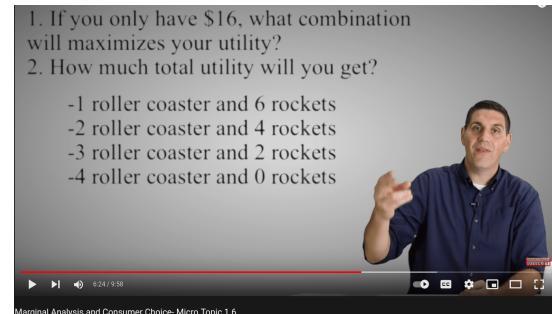
- For any activity, if the marginal benefit exceeds marginal cost, people have an incentive to do more of that activity

- If the marginal cost exceeds the marginal benefit, people have an incentive to do less of that activity.
- Incentives are also the key to reconciling self-interest and social interest.
- Economists take human nature as given and view people as acting in their self-interest.
- Please note, self-interested actions are not necessarily selfish actions.
- But if human nature is given and people pursue self-interest, how can the social interest be served? Economists answer this question by emphasizing the role of institutions in creating incentives to behave in the social interest.

### Exercise 1.8 — Marginal analysis

(Solution → p. ??)

Watch  <https://youtu.be/1exopH0l1jo> and solve the problems therein.



1. If you only have \$16, what combination will maximizes your utility?  
 2. How much total utility will you get?  
 -1 roller coaster and 6 rockets  
 -2 roller coaster and 4 rockets  
 -3 roller coaster and 2 rockets  
 -4 roller coaster and 0 rockets

## 1.5 International economics

### 1.5.1 What is international trade?

International trade is the exchange of capital, goods, and services across international borders or territories.

#### Questions of international trade:

- Why do nations trade?
- What do they trade?
- What is the effect of trade policies on trade and welfare?
- Can trade in goods substitute for factor mobility?
- Is free trade better than autarky?
- What are the effects of trade on income distribution?
- If there are winners and losers of trade liberalization, can the former compensate the latter?
- If nations gain from trade, how are the gains distributed?
- What are the welfare effects of various trade policies?

### Exercise 1.9 — Trade and Putin

(Solution → p. ??)

Discuss the following quote in the context of the war of Russia against the Ukraine.

“International trade and international capital flows link national economies. Although such links are considered to be beneficial for the most part, they produce an interdependence that occasionally has harmful effects. In particular, shocks that emanate in one country may negatively impact trade partners.” —Helpman and Itskhoki (2010)

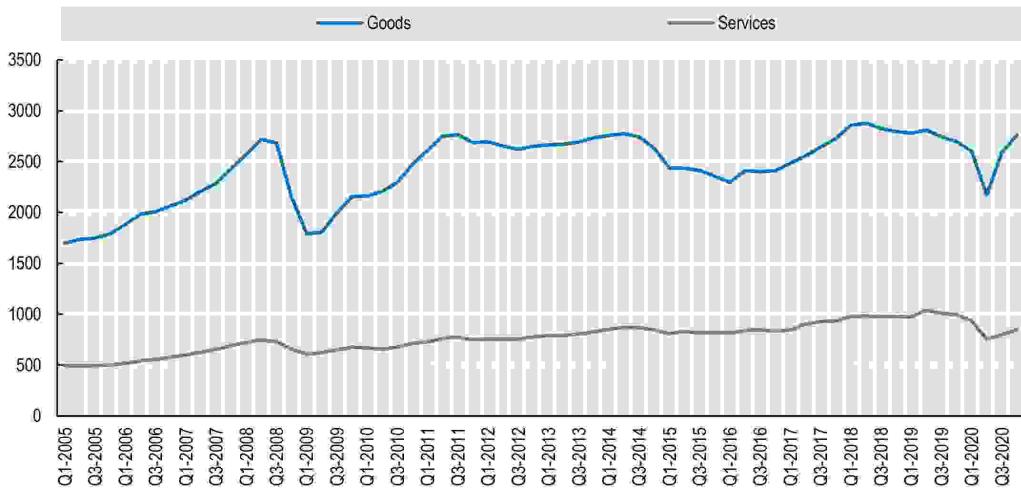


Figure 1.1: Imports and exports in USD billion, OECD countries

Source: [Arriola et al. \(2021\)](#)

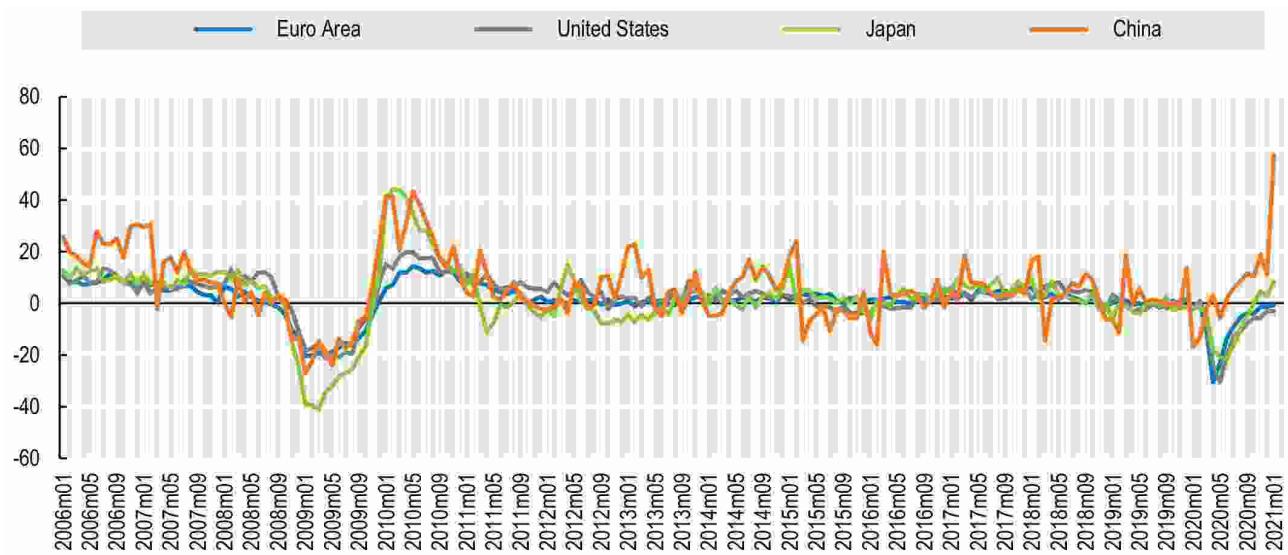


Figure 1.2: Year-on-year growth rates of export volumes

Source: [Arriola et al. \(2021\)](#)

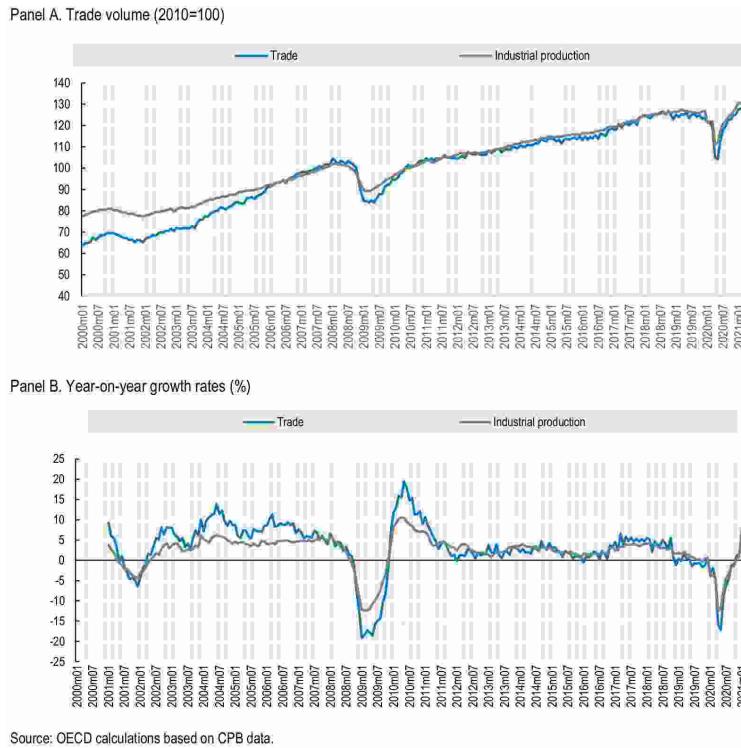


Figure 1.3: World merchandise trade and industrial production volumes  
2010=100, seasonally adjusted  
Source: [Arriola et al. \(2021\)](#)

## 1.5.2 What is international monetary economics?

International monetary economics is about the financial aspects of international trade. It studies the flows of money across countries and the resulting effects on their economies as a whole.

Date: October 2021

**Lira Tumbles to Record Low After Central Bank Cuts Rates Again**

By Burhan Yıldırım Follow  
21 October 2021, 13:08 MEZ

A customer exchanges U.S. dollars at a currency exchange bureau in Istanbul. (Photographer: Murat Kula/Bloomberg)

Source: [Bloomberg.com](#)

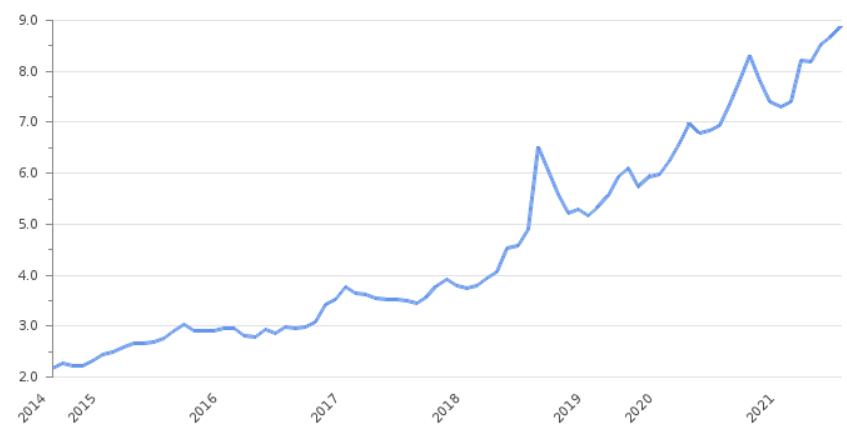


Figure 1.4: TRY to USD rate ( $\text{₺}/\$$ )  
Source: [take-profit.org](#)

## 1.5.3 What is international trade policy?

International trade policy encompasses the interplay of national interests affecting trade across national borders. The assumption here is that a country's international trade policy serves the interests of its citizens and companies.

Date: 03/03/2018

## Juncker responds to Trump's trade tariffs: 'We can also do stupid'

 COMMENTS

By Euronews · Updated 03/03/2018

European Commission chief Jean-Claude Juncker has vowed to fight back against US President Donald Trump's threat of a 25% tariff on steel and 10% on aluminium imports.

"So now we will also impose import tariffs. This is basically a stupid process, the fact that we have to do this. But we have to do it. We will now impose tariffs on motorcycles, Harley Davidson, on blue jeans, Levis, on Bourbon. We can also do stupid. We also have to be this stupid," he said in Hamburg on Friday evening.

While Trump may be comfortable with the idea of a trade war, it wasn't just across the Atlantic where the leader's plans ruffled feathers.

"We are impressing upon the American administration the unacceptable nature of these proposals that are going to hurt them every bit as much as they will hurt us," said Canadian Prime Minister Justin Trudeau.

The warnings from leaders around the world mirrored those of the International Monetary Fund, which said Trump's plan would cause damage both internationally and within America itself.

Trump however remains defiant, insisting that trade wars are good and easy to win."

Source:  [euronews.com](#)

Date: 7/25/2018

## Donald Trump and Jean-Claude Juncker talk trade tariffs

The leaders agreed to work toward "zero tariffs" between the US and the EU, which would decisively reverse the slew of trade tariffs imposed recently. The deal involves the EU purchasing natural gas from the US.

Source:  [YouTube](#)



Source:  [dw.com](#)

### Exercise 1.10 — Free trade: good or bad?

(Solution → p. ??)

Please consider the following figures as well as the short video/text below and discuss whether trade is something 'good' or 'bad'.

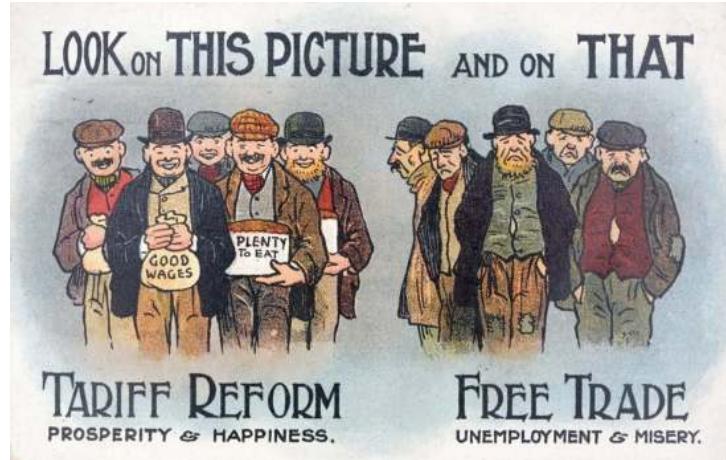


Figure 1.5: Tariffs for prosperity and happiness

Source: [https://cdn.shopify.com/s/files/1/0895/0864/products/42-26642856\\_1024x1024.jpeg?v=1451729228](https://cdn.shopify.com/s/files/1/0895/0864/products/42-26642856_1024x1024.jpeg?v=1451729228)



Figure 1.6: Support tariff reform

Source: <https://i.redd.it/7ede6gxpos131.png>



"You drive a Japanese car, drink French wine, eat Chinese food, own an American computer, buy Canadian lumber and vacation in Mexico. How can you be AGAINST free trade?!"

Figure 1.7: How can we be against free trade?

Source: [https://www.cartoonstock.com/directory/f/free\\_trade.asp](https://www.cartoonstock.com/directory/f/free_trade.asp)

Donald J. Trump  @realDonaldTrump

Follow v

When a country (USA) is losing many billions of dollars on trade with virtually every country it does business with, trade wars are good, and easy to win. Example, when we are down \$100 billion with a certain country and they get cute, don't trade anymore-we win big. It's easy!

5:50 AM - 2 Mar 2018

22,716 Retweets 100,775 Likes



29K 23K 101K

Figure 1.8: Trump thinks trade wars are easy to win  
Source: Twitter



Figure 1.9: Free trade at last  
Source: <https://otherwords.org/wp-content/uploads/2015/03/Free-trade-at-last.jpg>



Figure 1.10: Trump's trad policy could backfire  
Source: <https://fee.org/media/30172/backfire.png>

#### 1.5.4 Important terms in international economics

**trade:** Trade involves the transfer of goods or services from one person or entity to another often in exchange for money. Economists refer to a system or network that allows trade as a market.

**international trade:** International trade is the exchange of capital, goods, and services across international borders or territories.

**export** An export in international trade is a good or service produced in one country that is bought by someone in another country. The seller of such goods and services is an exporter; the foreign buyer is an importer

**import** An import in the receiving country is an export from the sending country. Importation and exportation are the defining financial transactions of international trade.

**balance of trade** The balance of trade, commercial balance, or net exports (sometimes symbolized as NX), is the difference between the monetary value of a nation's exports and imports over a certain time period.

**trade deficit/surplus** If a country exports a greater value than it imports, it has a trade surplus or positive trade balance, and conversely, if a country imports a greater value than it exports, it has a trade deficit or negative trade balance. ‘

**balance of payments** The balance of payments, also known as balance of international payments and abbreviated B.O.P. or BoP, of a country is the record of all economic transactions between the residents of the country and the rest of the world in a particular period of time (e.g., a quarter of a year). These transactions are made by individuals, firms and government bodies. Thus the balance of payments includes all external visible and non-visible transactions of a country. It is an important issue to be studied, especially in international financial management field, for a few reasons.

**trade barrier** Trade barriers are government-induced restrictions on international trade.

**tariff** A tariff is a tax on imports or exports between sovereign states. It is a form of regulation of foreign trade and a policy that taxes foreign products to encourage or safeguard domestic industry. Traditionally, states have used them as a source of income. Now, they are among the most widely used instruments of protectionism, along with import and export quotas.

**trade war** A trade war is an economic conflict resulting from extreme protectionism in which states raise or create tariffs or other trade barriers against each other in response to trade barriers created by the other party.

**protectionism** Protectionism is the economic policy of restricting imports from other countries through methods such as tariffs on imported goods, import quotas, and a variety of other government regulations.

**autarky** Autarky is the characteristic of self-sufficiency; the term usually applies to political states or to their economic systems. Autarky exists whenever an entity survives or continues its activities without external assistance or international trade.

**closed economy** If a self-sufficient economy also refuses to conduct any trade with the outside world then economists may term it a 'closed economy'.

**production–possibility frontier curve** A production–possibility frontier (PPF) or production possibility curve (PPC) is a curve which shows various combinations of the amounts of two goods which can be produced within the given resources and technology/a graphical representation showing all the possible options of output for two products that can be produced using all factors of production, where the given resources are fully and efficiently utilized per unit time.

**indifference curve** In economics, an indifference curve connects points on a graph representing different quantities of two goods, points between which a consumer is indifferent. That is, any combinations of two products indicated by the curve will provide the consumer with equal levels of utility, and the consumer has no preference for one combination or bundle of goods over a different combination on the same curve.

**utility** Within economics, the concept of utility is used to model worth or value. Its usage has evolved significantly over time. The term was introduced initially as a measure of pleasure or satisfaction within the theory of utilitarianism by moral philosophers such as Jeremy Bentham and John Stuart Mill. The term has been adapted and reapplied within neoclassical economics, which dominates modern economic theory, as a utility function that represents a consumer's preference

ordering over a choice set. It is devoid of its original interpretation as a measurement of the pleasure or satisfaction obtained by the consumer from that choice.

## 1.6 Methods of economics

### 1.6.1 Theory and models

Economists analyze problems differently than other professionals. The main tools economists use are (economic) models. A **model** is not an illustration of the answer to a problem. Rather, a model is a tool to understand the essential core of an issue, explain it, and use it to determine an answer. Models usually simplify the real world and try to capture theoretical concepts so that we can analyze and empirically test certain aspects of a theory. This can be done with an empirical model that explains how data are used. A **theory** can be understood as a generalized consideration or conclusion of something that is a consequence of an analysis. It must be possible to prove a theory true or false. Otherwise it would be just an assertion of how things work.

### 1.6.2 Economic models

“All theory depends on assumptions which are not quite true. That is what makes it theory. The art of successful theorizing is to make the inevitable simplifying assumptions in such a way that the final results are not very sensitive.” — Robert M. Solow (1956, p. 65)

- An **economic model** is a description of some aspect of the economic world that includes only those features of the world that are needed for the purpose at hand.
- Economic models reduce the real world complexity aiming to understand the world a bit better. They help to focus on key variables and to examine their interactions.
- **Example:** to understand how consumers make their purchasing decisions, it may be helpful to start by assuming that there are only two different goods.
- The art of scientific thinking is deciding which **assumptions** to make.
- Once we understand the basic model we can begin to relax and/or add some assumptions.
- An economic model is built to address one or a few particular questions.
- A model contains basically **endogenous variables** whose value is determined within the model and **exogenous variables** whose value is determined outside the model.

### 1.6.3 Richard Feynman on scientific method (1964)

Richard Phillips Feynman (\*1918-1988) was an American theoretical physicist. At the age of 25 he was a group leader of the Manhattan Project in Los Alamos, he received the Nobel Prize in Physics in 1965, wrote one of the most famous science books of our time (*Surely You're Joking, Mr. Feynman!*), and is still a hero for nerds and teachers.



Figure 1.11: Feynman's ID badge in Las Alamos and the Feynman bus

*On Feynman's bus you see the so-called Feynman diagrams. The bus appears in the The Big Bang Theory episode 3, season 9.*



Watch <https://youtu.be/EYPapE-3FRw> Here is a transcript of his lecture:

Now, I'm going to discuss how we would look for a new law. In general, we look for a new law by the following process. First, we guess it.

Then we— well, don't laugh. That's really true. Then we compute the consequences of the guess to see what— if this is right, if this law that we guessed is right, we see what it would imply, and then we compare those computation results to nature. Or we say, compare to experiment or experience. Compare it directly with observation to see if it works.

If it disagrees with experiment, it's wrong. And that simple statement is the key to science. It doesn't make a difference how beautiful your guess is. It doesn't make a difference how smart you are, who made the guess, or what his name is, if it disagrees with experiment, it's wrong. That's all there is to it.

It's therefore not unscientific to take a guess, although many people who are not in science think it is. For instance, I had a conversation about flying saucers some years ago with laymen.

Because I'm scientific. I know all about flying saucers. So I said, I don't think there are flying saucers. So the other— my antagonist said, is it impossible that there are flying saucers? Can you prove that it's impossible? I said, no, I can't prove it's impossible. It's just very unlikely.

That, they say, you are very unscientific. If you can't prove an impossible, then why— how can you say it's likely, that it's unlikely? Well, that's the way— that it is scientific. It is scientific only to say what's more likely and less likely, and not to be proving all the time possible and impossible.

To define what I mean, I finally said to them, listen, I mean that from my knowledge of the world that I see around me, I think that it is much more likely that the reports of flying saucers are the result of the known irrational characteristics of terrestrial intelligence, rather than the unknown rational effort of extraterrestrial intelligence.

It's just more likely, that's all. And it's a good guess. And we always try to guess the most likely explanation, keeping in the back of the mind the fact that if it doesn't work, then we must discuss the other possibilities.

[...]

Now, you see, of course, that with this method, we can disprove any definite theory. We have a definite theory, a real guess from which you can really compute consequences which could be compared to experiment, and in principle, we can get rid of any theory. You can always prove any definite theory wrong. Notice, however, we never prove it right.

Suppose that you invent a good guess, calculate the consequences, and discover every consequence that you calculate agrees with the experiment. Your theory is then right? No, it is simply not proved wrong. Because in the future, there could be a wider range of experiments, you compute a wider range of consequences, and you may discover, then, that the thing is wrong.

That's why laws like Newton's laws for the motion of planets lasts such a long time. He guessed the law of gravitation, calculated all kinds of consequences for the solar system and so on, compared them to experiment, and it took several hundred years before the slight error of the motion of Mercury was developed.

[...]

I must also point out to you that you cannot prove a vague theory wrong. If the guess that you make is poorly expressed and rather vague, and the method that you used for figuring

out the consequences is rather a little vague— you're not sure. You say, I think everything is because it's all due to [INAUDIBLE], and [INAUDIBLE] do this and that, more or less. So I can sort of explain how this works. Then you see that that theory is good, because it can't be proved wrong.

If the process of computing the consequences is indefinite, then with a little skill, any experimental result can be made to look like— or an expected consequence. You're probably familiar with that in other fields. For example, A hates his mother. The reason is, of course, because she didn't caress him or love him enough when he was a child. Actually, if you investigate, you find out that as a matter of fact, she did love him very much, and everything was all right. Well, then, it's because she was overindulgent when he was [INAUDIBLE]. So by having a vague theory— it's possible to get either result. [APPLAUSE]

Now, wait. Now, the cure for this one is the following. It would be possible to say, if it were possible to state ahead of time how much love is not enough, and how much love is overindulgent exactly, and then there would be a perfectly legitimate theory against which you can make tests. It is usually said when this is pointed out how much love is and so on, oh, you're dealing with psychological matters, and things can't be defined so precisely. Yes, but then you can't claim to know anything about it. [APPLAUSE]

Now, I want to concentrate for now on— because I'm a theoretical physicist, and more delighted with this end of the problem— as to what goes— how do you make the guesses? Now, it's strictly, as I said before, not of any importance where the guess comes from. It's only important that it should agree with experiment, and that it should be as definite as possible.

But, you say, that is very simple. We set up a machine— a great computing machine— which has a random wheel in it that makes a succession of guesses. And each time it guesses a hypotheses about how nature should work, computes immediately the consequences, and makes a comparison to a list of experimental results it has at the other end. In other words, guessing is a dumb man's job.

Actually, it's quite the opposite, and I will try to explain why.[...]

### Theory vs. anecdotes:

In the following sections, I introduce some mathematical economic models and concepts that are helpful to think about international trade in a structured way. Moreover, knowledge on these concepts will allow you to read up-to-date textbooks and literature in the field of economics. Last but not least, the concepts, i.e., formulas and graphical visualizations of arguments can be helpful to understand, analyze, and memorize more complex situations of international trade. Economic models are based on transparent assumptions and generally consist of a set of equations that describe a theory of economic behavior. A good model should provide useful insights into how rational agents behave and how the economy works. Unfortunately, sometimes students feel lost with these models as the models draw on mathematics and rigorous logical thinking. I often hear that there are less sophisticated ways to formulate the argument. While that may sometimes be true, I am deeply convinced that the formal way to introduce economics is the best way in the medium and long term. Let me justify my conviction:

1. The narrative method, i.e., telling stories and listing bullet points, is an efficient way to quickly inform about different types of topics, but it also has drawbacks: Students easily get lost in intuitive-sounding anecdotes without learning to think critically and identify underlying general driving forces. Students tend to cram the information told just for the exam and quickly forget everything afterward.
2. Compared to an anecdote, a formal model is not necessarily true. However, they can provide more insight into a topic than an anecdote or other type of storytelling as it aims to discuss the essential forces that drives a result.

3. A formal model is usually more flexible compared to stories and anecdotes. Once students understand the underlying logic of a model and are able to interpret and evaluate its meaning, they can apply the findings to a variety of circumstances or problems. An anecdote, on the other hand, is just a story that may represent a limited view of a problem. Overall, drawing general conclusions and analogies from anecdotal evidence is problematic.
4. A mathematical economic model is like a proof of an argument. It states exactly under what assumptions an argument is true. In a narrative, it is often difficult to see the underlying assumptions and premises of an argument.
5. The formal way of reasoning about things is the standard in economic research, and therefore by knowing the basic concepts, students can read and understand the current literature to do research and solve problems in their professional lives.
6. Once students understand an economic model, they know the underlying relationships, which they are less likely to forget. In other words, **a formal model ensures that students are not just repeating the teacher's words, but are able to think and reason for themselves.**

#### 1.6.4 The economic way of doing research

- When economists are trying to...
  - ...change the world, they are **policy advisors**.
  - ...explain the world, they are **scientists**.
- Economics is a social science.
- Economists distinguish between two types of statement:
  - A **positive** statement attempts to describe the world as it is and it can be tested by checking it against facts. In other words, a positive statement deals with assumptions about the state of the world and some conclusions. The validity of the statement is verifiable or testable in principle, no matter how difficult it might be.
  - A **normative** statement claims how the world should be and cannot be tested. In other words, normative statements often contain words such as *have to*, *ought to*, *must*, *should* or non-quantifiable adjectives such as *important*, that cannot be objectively measured. Accordingly, normative statements cannot be verified or falsified by scientific methods.

##### Exercise 1.11 — Positive or normative

(Solution → p. ??)

- An increase in the minimum wage will cause a decrease in employment among the least-skilled.
- Higher federal budget deficits will cause interest rates to increase.
- Nobody should be paid less because of their gender, race, age, or religion.
- The task of economic science is to discover positive statements that are consistent with what we observe in the world and that enable us to understand how the economic world works. This task is large and breaks into three steps:
  1. Observation and measurement:  
Economists observe and measure economic activity, keeping track of such things as: quantities of resources, wages and work hours, prices and quantities of goods and services produced, taxes and government spending, volume and price of traded goods.
  2. Model building
  3. Testing models

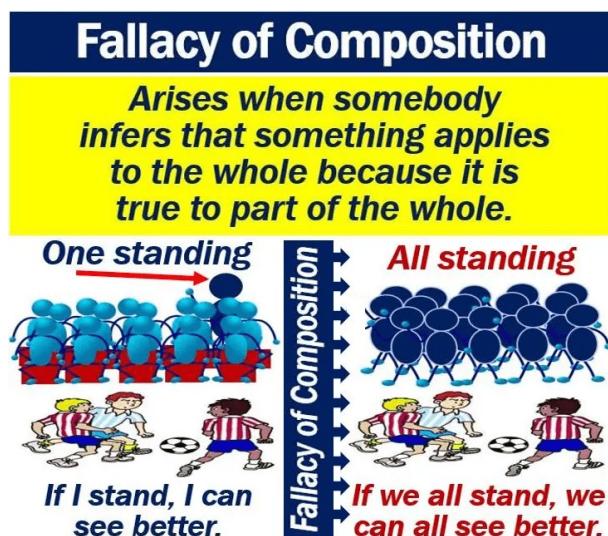
- Research methodologies in economics often blend the inductive and deductive approaches. Inductive reasoning builds theories, while deductive reasoning tests existing ones. It's a methodical dance between creation and scrutiny in the realm of economic research.

### 1.6.5 Cause and effect

- Economists aim to **unscrambling cause and effect**.
- Economists are interested in positive statements about cause and effect. Are computers getting cheaper because people are buying them in greater quantities? Or are people buying computers in greater quantities because they are getting cheaper? Or is some third factor causing both the price of a computer to fall and the quantity of computers bought to increase? To answer such questions, economists create and test economic models.
- Unfortunately, economists cannot easily do experiments and most economic behavior has many simultaneous causes. To isolate the effect of interest, economists use the logical device called *ceteris paribus* or *other things being equal*. That means, economists try to isolate cause-and-effect relationship by changing only one variable at a time, holding all other relevant factors unchanged.

### 1.6.6 Common fallacies in economic research

- The **fallacy of composition**, which is the false statement that what is true for the parts is true for the whole or what is true for the whole is true for the parts.



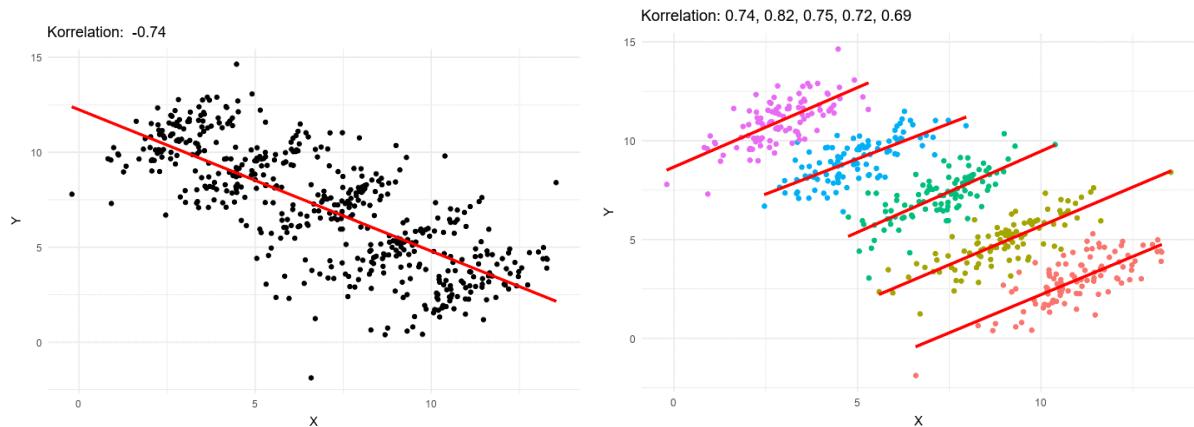
Source: [marketbusinessnews.com](http://marketbusinessnews.com)

- The **post hoc fallacy** which is the error of reasoning that a first event causes a second event because the first occurs *before* the second.

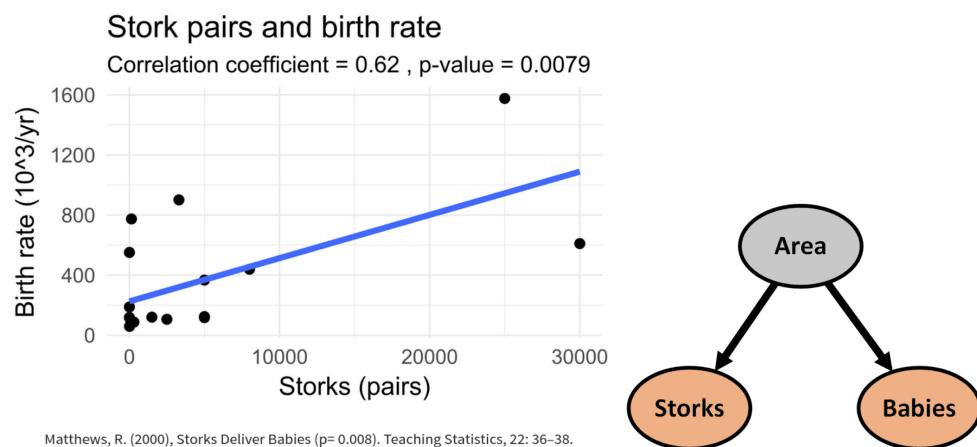


Source: <https://clalliance.org/wp-content/uploads/2016/12/post-hoc-ergo-propter-hoc.png>

- The **Simpson's paradox** is a phenomenon in probability and statistics in which a trend appears in several groups of data but disappears or reverses when the groups are combined.



- Correlation does not imply causation



Thus, we need to control for other effects that may have an impact on both variables of interest. These so-called control variables are usually variables that you are not particularly interested in, but that are related to the dependent variable. You want to remove their effects from the equation. This can be done within a regression analysis.

If you are interested in how to do research and *find out something* you may consider reading my lecture notes of the course *Quantitative Methods*. You find the notes here: <https://hubchev.github.io/>

### 1.6.7 Why economists disagree

Economists are often accused of contradicting each other. In contrast to the popular image, economists find much common ground on a wide range of issues. However, let's discuss why economists disagree: Economists may...

- ... disagree about the validity of alternative positive theories about how the world works.
- ... have different values and, therefore, different normative views about which policy should be implemented.

More information about how economists think and act, can be found in chapter 2 of [Mankiw \(2024\)](#).

**Rubinstein (2006, p. ix)** (Lecture Notes in Microeconomic Theory)<sup>a</sup>:

“As a new graduate student, you are at the beginning of a new stage of your life. In a few months you will be overloaded with definitions, concepts, and models. Your teachers will be guiding you into the wonders of economics and will rarely have the time to stop to raise fundamental questions about what these models are supposed to mean. It is not unlikely that you will be brainwashed by the professional-sounding language and hidden assumptions. I am afraid I am about to initiate you into this inevitable process. Still, I want to use this opportunity to pause for a moment and alert you to the fact that many economists have strong and conflicting views about what economic theory is. Some see it as a set of theories that can (or should) be tested. Others see it as a bag of tools to be used by economic agents, and yet others see it as a framework through which professional and academic economists view the world.

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<sup>a</sup>Also see:  <http://assets.press.princeton.edu/rubinstein/front.pdf>

# Chapter 2

## Measuring the (macro)economy

Required readings:

- [Shapiro et al. \(2022, ch. 19\)](#)
- [Mankiw \(2024, ch. 24\)](#)

Recommended readings:

- [Shapiro et al. \(2022, ch. 22, 23\)](#)
- [Mankiw \(2024, pt. VIII, ch. 32\)](#)

### In this chapter, we learn...

- ...the importance of gross domestic product (GDP), and how it is measured.
- ...the composition of GDP, and how it has changed over time.
- ...that GDP is the sum of consumption, investment, government spending, inventory investment, and exports minus imports.
- ...how to use GDP to measure the evolution of living standards over time.
- ...how to use GDP to measure differences in living standards across countries.
- ...how to measure a consumer price index.
- ...why the balance of trade is balanced.

### 2.1 Measuring income and living standards

“While the GDP and the rest of the National Income and Product Accounts (NIPA) may seem to be arcane concepts, they are truly among the great inventions of the twentieth century. Much as a satellite in space can survey the weather across an entire continent, so can the GDP give an overall picture of the state of the economy. Since their first construction by Simon Kuznets, who won the Nobel prize in Economics for his contributions to national income accounting, enormous strides have been taken in developing and improving indexes of economic welfare.”

William D. [Nordhaus \(2002\)](#) (and Paul A. Samuelson)

#### 2.1.1 (Nominal) Gross Domestic Product (GDP)

The **Gross Domestic Product (GDP)** “is the market value of all final goods and services produced within a country in a given period of time” ([Mankiw, 2024, ch. 24](#)).

This definition has four parts:

- **Market value:** The items in GDP are valued at their market values, that is, at their prices.
- **Final goods and services:** A final good is an item that is bought by its final user. It contrasts with an intermediate good, which is an item that is produced by one firm, bought by another

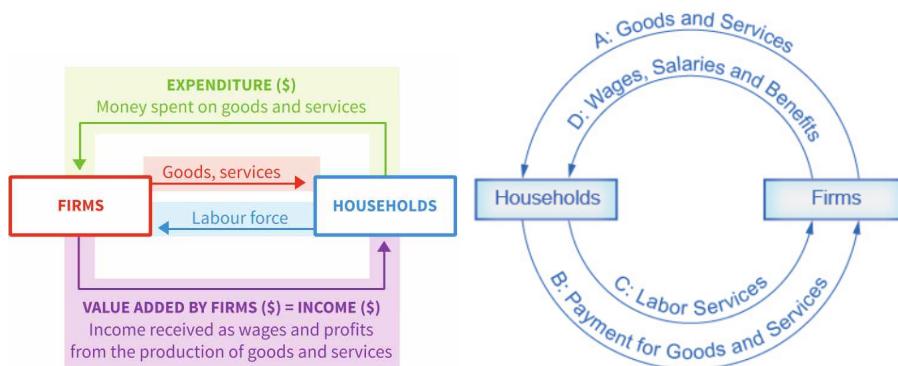


Figure 2.1: Two circular flow diagrams

firm, and used as a component of a final good or service. To avoid double counting, GDP includes only final goods and services (no intermediate goods and services are directly counted).

- **Produced within a country:** Only the goods and services produced within a country are counted.
- **In a given time of period:** GDP is measured over a period of time, typically a quarter of a year or a year.

#### Exercise 2.1 — Mankiw's definition

(Solution → p. ??)

Read [Mankiw \(2024, ch. 24\)!](#)

### 2.1.2 Three equivalent ways to measure GDP

GDP can be quantified through three methods, each expected to yield equivalent outcomes, and the circular flow diagrams in [Figure 2.1](#) and [Figure 2.2](#) can aid in understanding this concept.

1. Total spending on domestic products and services (expenditure approach)
2. Total domestic income
3. Total domestic production (measured as value added)

All three approaches theoretically should come to the same result.

#### The expenditure approach

##### Exercise 2.2 — GDP explained

(Solution → p. ??)

Watch:

- *What is Gross Domestic Product (GDP)?* <https://youtu.be/mjJmo5mN5yA>
- *Nominal vs. Real GDP* <https://youtu.be/rGqhTQyY6g4>
- *Real GDP Per Capita and the Standard of Living* <https://youtu.be/Z0qHA93o0Sc>
- *Measuring Inflation* <https://youtu.be/0jJKjgE3qfE>

The expenditure approach measures GDP as the sum of consumption expenditure,  $C$ , investment,  $I$ , government expenditure on goods and services,  $G$ , and net exports of goods and services,  $(X - M)$ . So

$$GDP = C + I + G + (X - M)$$

or, for the USA in 2020 and in billions of dollars,  $\$14,145 + \$3,605 + \$3,831 + (-\$645) = \$20,936$ .

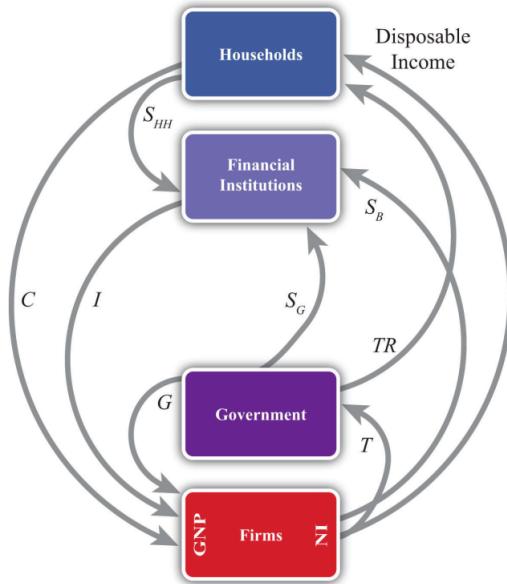


Figure 2.2: The circular flow in a closed economy  
The diagram was taken from Suranovic (2016, p. 54).

Table 2.1: Decomposition of GDP in 2013 for the US, the Eurozone, and China.

	US	Eurozone (19 countries)	China
Consumption (C)	68.4%	55.9%	37.3%
Government spending (G)	15.1%	21.1%	14.1%
Investment (I)	19.1%	19.5%	47.3%
Change in inventories	0.4%	0.0%	2.0%
Exports (X)	13.6%	43.9%	26.2%
Imports (M)	16.6%	40.5%	23.8%

Source: World Bank (2015). I took it from <https://www.core-econ.org/the-economy/book/text/13.html>

Aggregate expenditure equals GDP because all the goods and services that are produced are sold to households, firms, governments, or foreigners. (Goods and services not sold are included in investment as inventories and hence are “sold” to the producing firm.)

### GDP Decomposition

$$\text{GDP} = C + I + G + X - M$$

- Consumption (C) → Expenditure on all consumer goods
- Investment (I) → Expenditure on newly produced capital goods
- Government spending (G) → Government expenditure on goods and services (excluding transfers)
- Net exports (trade balance) → Exports (X) minus imports (M) Please consider Table 2.1, Figure 2.3, and Figure 2.4. They show different features of the GDP composition.

### The income approach

The income approach measures GDP as the sum of compensation of employees, net interest, rental income, corporate profits, and proprietors' income. This sum equals net domestic income at factor costs. To obtain GDP, indirect taxes (which are taxes paid by consumers when they buy goods and services) minus subsidies plus depreciation are included. Finally any discrepancy between the expenditure approach and income approach is included in the income approach as statistical discrepancy.

**Figure 2.1**  
**Composition of U.S. GDP, 1929–2005**

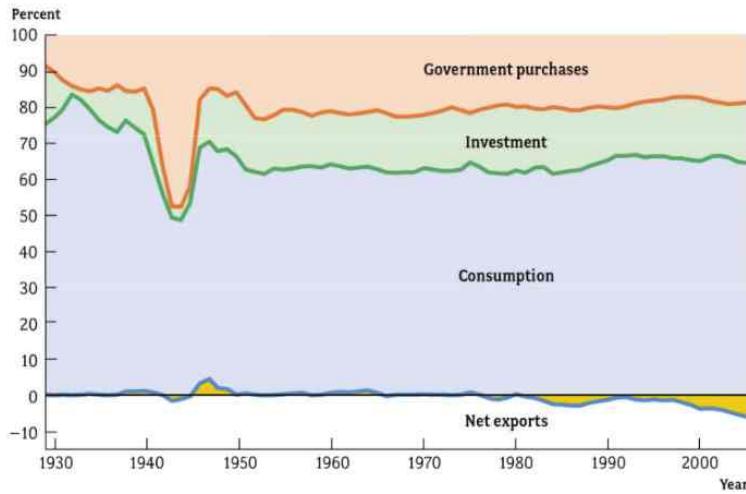


Figure 2.3: Composition of US GDP, 1929-2005

Source: [Jones \(2008\)](#)

**Figure 2.2**  
**Expenditure Shares of U.S. GDP, 1970–2005**

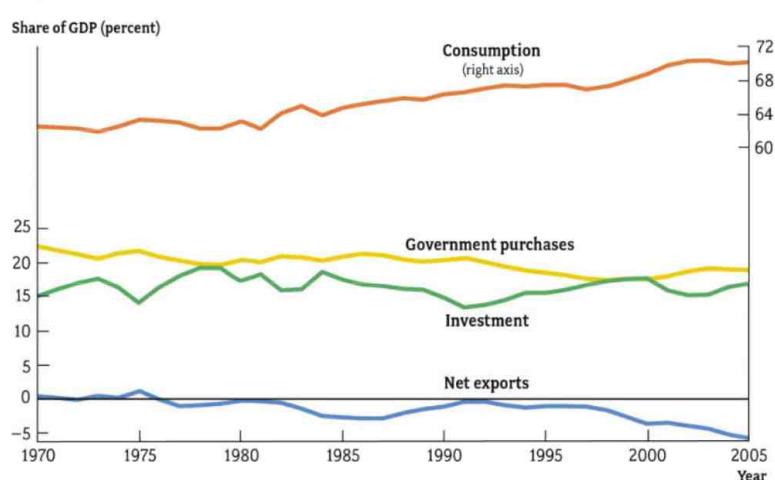


Figure 2.4: Expenditure shares of U.S. GDP, 1970-2005

Source: [Jones \(2008\)](#)

## The production approach

It calculates how much value is contributed at each stage of production. (Gross value added = gross value of output - value of intermediate consumption.)

### FAQ:

- **Are Government transfer payments part of the GDP?** Government transfer payments, such as Social Security payments, are **not** part of government expenditures because government expenditures include only funds used by the government to buy goods and services. Transfer payments are not buying a good or service for the government and so are not included in government expenditures.
- **How do we account for international transactions?** For example, foreign production is domestic consumption (imports); or domestic production is foreign consumption (exports).  
→ We include exports and exclude imports, so that GDP includes value added, income from, or consumption of, domestic production.
- **How do we incorporate government?** → Treat it as another producer where public services are *bought* via taxes.
- **Why “Domestic” and Why “Gross”?**
  - Depreciation is the decrease in the stock of capital that results from wear and tear and obsolescence. The total amount spent on purchases of new capital and on replacing depreciated capital is called **gross investment**. The amount by which the stock of capital increases is **net investment**. Net investment = Gross investment - Depreciation.
  - The “Gross” in gross domestic product reflects the fact that the investment in GDP is gross investment and so part of it goes to replace depreciating capital. Net domestic product subtracts depreciation from GDP.

### 2.1.3 Limitations of the nominal GDP

GDP is an imperfect measure of production. It ignores part of the production in an economy. For example, black market activity, private production, and production that is not traded in a market. It is often used to measure a country's welfare or people's well-being, happiness, and the like. However, GDP ignores things that can be considered important in these concepts, which are themselves difficult to define.

#### Exercise 2.3 — GDP as an imperfect measure

(Solution → p. 50)

- Watch <https://youtu.be/77IdKFqXbUY> or read the speech of Robert Kennedy below and discuss what factors that influence the standard of living are not part of GDP and how that may have an impact on GDP.



“Gross National Product counts air pollution and cigarette advertising, and ambulances to clear our highways of carnage. It counts special locks for our doors and the jails for the people who break them. It counts the destruction of the redwood and the loss of our natural wonder in chaotic sprawl. It counts napalm and counts nuclear warheads and armored cars for the police to fight the riots in our cities. It counts Whitman’s rifle and Speck’s knife, and the television programs which glorify violence in order to sell toys to our children. Yet the gross national product does not allow for the health of our children, the quality of their education or the joy of their play. It does not include the beauty of our poetry or the strength of our marriages, the intelligence of our public debate or the integrity of our public officials. [...] it measures everything in short, except that which makes life worthwhile.”

**Senator Robert F. Kennedy (1925-1968)**

Source: [Kennedy \(1968\)](#)

### Solution to Exercise 2.3 — GDP as an imperfect measure

(Exercise → p. 49)

*Some of the factors that influence the standard of living are not part of GDP. Omitted from GDP are:*

- **Non-market transactions:** Household production like services, such as childcare are not part of the GDP. As more services, such as childcare, are provided in the marketplace, the measured growth rate overstates development of all economic activity.
- **Black-market:** If the underground economy is a reasonably stable proportion of all economic activity, though the level of GDP will be too low, the growth rate will be accurate.
- **Leisure Time:** Increases in leisure time lower the economic growth rate, but people may value their leisure time and are better off with it.
- **Environmental Quality:** Pollution does not directly lower the economic growth rate while it may reduce living standards.
- **Inequality:** GDP fails to account for (income) inequality in society
- **Sustainability:** GDP fails to indicate the sustainability of economic growth.
- **Health and environment:** GDP fails to account for human health and the health of the environment in general.
- **Depreciation replacement:** GDP does not take into account how much capital (tangible goods) has been depreciated. For example, GDP measures the production of new bridges, but does not take into account bridges that have been decommissioned. It is not a balance sheet of prosperity, but a measure of the inflow of new production.

## 2.2 Real Gross Domestic Product (GDP)

Watch the video *Nominal vs. Real GDP* of the Marginal Revolution University <https://youtu.be/rGqhTQyY6g4>

- **Nominal GDP** is the value of the final goods and services produced in a given year valued at the prices that prevailed in that same year.
- The market value of production and hence GDP can increase either because the production of goods and services are higher or because the prices of goods and services are higher.

- **Real GDP** allows the quantities of production to be compared across time. Real GDP is the value of final goods and services produced in a given year when valued at the prices of a reference base year.

$$GDP^{\text{real}} = \frac{GDP^{\text{nominal}}}{P}$$

- The nominal GDP is the GDP usually reported and not corrected for prices. Whereas real GDP refers to the actual quantity of goods and services.
- **Definition taken from [www.investopedia.com](http://www.investopedia.com):** Real gross domestic product (GDP) is an inflation-adjusted measure that reflects the value of all goods and services produced by an economy in a given year (expressed in base-year prices) and is often referred to as constant-price GDP, inflation-corrected GDP, or constant dollar GDP.
- **Definition taken from Wikipedia (2020):** Real gross domestic product (real GDP for short) is a macroeconomic measure of the value of economic output adjusted for price changes (i.e. inflation or deflation). This adjustment transforms the money-value measure, nominal GDP, into an index for quantity of total output.

**Example A:** Suppose the economy produces one product only.

	Year	Number	price in Euro
Production and prices are as follows:	2010	500	1
	2011	500	1.1
	2012	500	1.2

Nominal GDP:

$$GDP_{2010}^{\text{nominal}} = 500 \cdot 1 = 500\text{€}$$

$$GDP_{2011}^{\text{nominal}} = 500 \cdot 1,1 = 550\text{€}$$

$$GDP_{2012}^{\text{nominal}} = 500 \cdot 1,2 = 600\text{€}$$

Real GDP with a base year 2010:

$$GDP_{2010}^{\text{real}, \text{base}=2010} = 500 * 1 = 500\text{€}$$

$$GDP_{2011}^{\text{real}, \text{base}=2010} = 500 * 1 = 500\text{€}$$

$$GDP_{2012}^{\text{real}, \text{base}=2010} = 500 * 1 = 500\text{€}$$

**Example B:** Suppose the economy produces one product only.

	Year	Number	price in Euro
Production and prices are as follows:	2010	500	1
	2011	600	1.1
	2012	700	1.2

Nominal GDP:

$$GDP_{2010} = 500 \cdot 1 = 500\text{€}$$

$$GDP_{2011} = 600 \cdot 1,1 = 660\text{€}$$

$$GDP_{2012} = 700 \cdot 1,2 = 840\text{€}$$

Real GDP with a base year 2010:

$$GDP_{2010}^{\text{base}=2010} = 500 * 1 = 500\text{€}$$

$$GDP_{2011}^{\text{base}=2010} = 600 * 1 = 600\text{€}$$

$$GDP_{2012}^{\text{base}=2010} = 700 * 1 = 700\text{€}$$

## 2.3 Measuring prices and inflation

- The price level is the average level of prices. The average level of prices can be rising, falling, or stable.
- **Inflation** occurs when the price level persistently **rises**.

- **Deflation** occurs when the price level persistently **falls**.
- The inflation rate is the percentage change in the price level from the previous period.
- Unexpected inflation or deflation is a problem for society because they redistribute income and wealth. Unexpected inflation benefits workers and borrowers; unexpected deflation benefits employers and lenders. They motivate people to divert resources from producing goods and services to forecasting and protecting themselves from the inflation or deflation.
- Unexpected deflation hurts businesses and households that are in debt (borrowers) who in turn cut their spending. A fall in total spending brings a recession and rising unemployment.
- Hyperinflation is an inflation rate of 50 percent a month or higher

#### Exercise 2.4 — Global inflation

(Solution → p. ??)

- Check inflation rate of selected countries online to get a feeling for international differences and global trends. Tip: <https://data.oecd.org/price/inflation-cpi.htm>
- Price levels tend to be lower during recessions (high unemployment). What do you think will this hold be true in the current Corona-crisis?

- To calculate the price level and hence the real GDP of a country if there is more than one good, we need to calculate a **Consumer Price Index (CPI)**.
- The Consumer Price Index (CPI) is a measure of the average of the prices paid by urban consumer for a fixed *basket* of consumer goods and services.
- The CPI is usually defined to equal 100 for a period called the reference base period. For example, suppose the current reference base period is 1982-1984 with an average CPI during that period of 100. In May 2021, the CPI was 269.2. Thus, since 1982-84, prices increased by 169.2 percent.
- An informative graphical representation of the basket of goods purchased by the representative consumers in Germany is presented here: <https://service.destatis.de/Voronoi/PriceKaleidoscope.svg>
- **Figure 2.5** illustrates that the relationship between oil prices and GDP growth is not a recent phenomenon.
- **Figure 2.6** illustrates that inflation is not a new phenomena and was on average much worse in the past.

#### 2.3.1 Calculating the Consumer Price Index (CPI) in 5 Steps

1. **Fix the Basket:** Determine what prices are most important to the typical consumer.<sup>1</sup>
2. **Find the Prices:** Find the prices of each of the goods and services in the basket for each point in time.
3. **Compute the Basket's Cost:** Use the data on prices to calculate the cost of the basket of goods and services at different times.
4. **Choose a Base Year and Compute the Index:**
  - Designate one year as the base year, making it the benchmark against which other years are compared.
  - Compute the index by dividing the price of the basket in one year by the price in the base year and multiplying by 100.

$$CPI = \frac{\text{cost of basket in current year}}{\text{cost of basket in base year}} \cdot 100$$

<sup>1</sup>The National Statistics agencies identify a market basket of goods and services the typical consumer buys and conducts regular consumer surveys to set the weights for the prices of those goods and services.

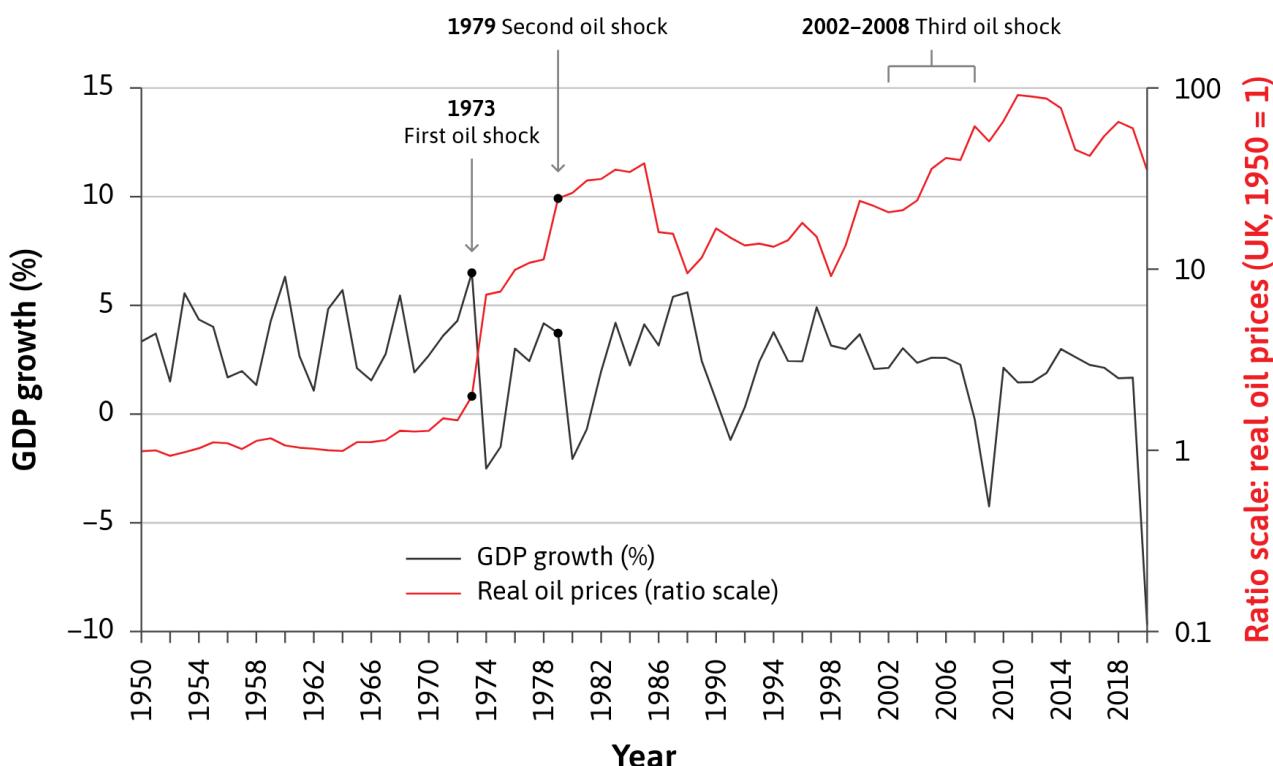


Figure 2.5: UK GDP growth and real oil prices (1950–2020)

Source: <https://www.core-econ.org/the-economy/book/text/15.html>

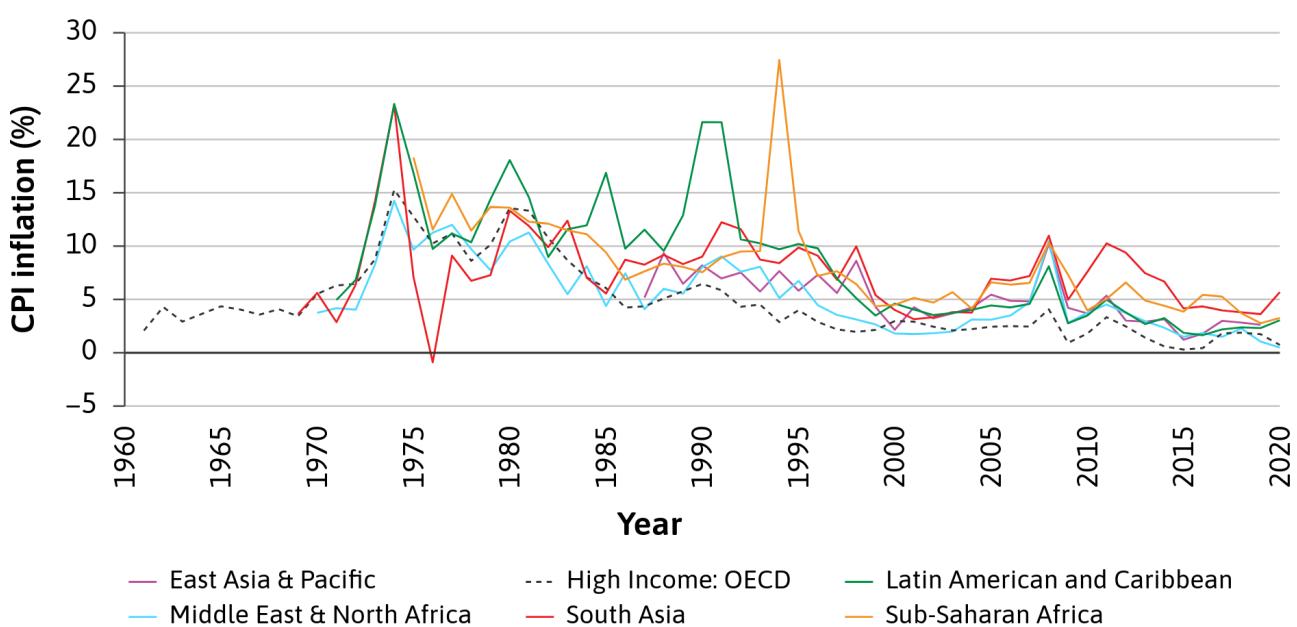


Figure 2.6: Inflation levels and volatility in high- and low-income economies

Source: <https://www.core-econ.org/the-economy/book/text/13.html>

5. **Compute the Inflation Rate:** The inflation rate is the percentage change in the price index from the preceding period.

$$\text{Inflation rate in } t=2 = \frac{CPI_{t=2} - CPI_{t=1}}{CPI_{t=1}} \cdot 100$$

### Calculating the CPI: An Example

**Step 1:** 4 salads and 2 hamburgers

**Step 2:**

Year	Price of Salads	Price of Hamburgers
2016	1	2
2017	2	3
2018	3	4

**Step 3:**

Year	Basket cost
2016	8
2017	14
2018	20

**Step 4 and 5:**

With base year = 2016:	Year	CPI	Inflation Rate
	2016	100	na
	2017	175	75%
	2018	250	43%

### 2.3.2 Calculating the inflation rate

The inflation rate is the percentage change in the price level from one year to the next. In a formula,

$$h_t = \left( \frac{CPI_t - CPI_{t-1}}{CPI_{t-1}} \cdot 100, \right)$$

where  $h_t$  denotes the inflation rate at time  $t$  (this year),  $CPI_t$  and  $CPI_{t-1}$  denotes the Consumer Price Index at time  $t$  and the  $t-1$  (last year).

In May 2021, the CPI was 261.0. In May 2020, the CPI was 257.9. Using the formula, between 2021 and 2020, the inflation rate was 1.2%.

### 2.3.3 Real and nominal interest rates

The nominal interest rate is the interest rate usually reported and not corrected for inflation. It is the interest rate that a bank pays. The real interest rate is the nominal interest rate that is corrected for the effects of inflation. **Example:**

- Assume you store €1,000 at your bank account for one year.
- Nominal interest rate (investment rate): 15%.
- During the year, inflation amounted to 10%.

$$\begin{aligned} \text{Real interest rate} &= \text{Nominal interest rate} - \text{Inflation} \\ &= 15\% - 10\% = 5\% \end{aligned}$$

#### Exercise 2.5 — The salary of teachers over time

(Solution → p. 55)

- In 1947 teachers earned 1000€.
- In 2015 teachers earned 74,000€. That means they earn in 2015 nominally 74 times as much as in 1947. Can teachers buy more or less now as compared to 1947 if you consider

that prices have risen since 1947 as follows:

- CPI in 1947 = 28.9
- CPI in 2015 = 1018.6

### Solution to Exercise 2.5 — The salary of teachers over time

(Exercise → p. 54)

*Converting teachers salaries in 1947 to 2022 values:*

$$\text{salary}_{2022} = \text{salary}_{1947} \cdot \frac{\text{CPI}_{2022}}{\text{CPI}_{1947}} = €1000 \cdot \frac{1018.6}{28.9} \cdot €35,246$$

*That means, 1000€ in 1947 had the same purchasing power as 35,246€ in 2022. As teachers earn 74,000€ in 2022, they can buy more with their salary than in 1947.*

### 2.3.4 Challenges in measuring the cost of living using the CPI

The CPI is an accurate measure of the selected goods (that make up the typical bundle), but it is not a perfect measure of the cost of living. Here are three key issues that cause the CPI to overstate the true cost of living if the basket is held fixed over time:

#### 1. Substitution bias

- The basket does not change to reflect consumer reaction to changes in relative prices.
- Consumers substitute toward goods that have become relatively less expensive.
- The index overstates the increase in cost of living by not considering consumer substitution.

#### 2. Introduction of new goods

- The basket does not reflect the change in purchasing power brought on by the introduction of new products.
- New products result in greater variety, which in turn makes each euro more valuable.
- Consumers need less money to maintain any given standard of living.

#### 3. Unmeasured quality changes

- If the quality of a good rises from one year to the next, the value of a euro rises, even if the price of the good stays the same.
- If the quality of a good falls from one year to the next, the value of a euro falls, even if the price of the good stays the same.
- The ONS tries to adjust the price for constant quality, but such differences are hard to measure.

### Exercise 2.6 — CPI: relative weights

(Solution → p. ??)

Analyze the weighing schemes of the Federal Statistics Office Germany (destatis) and the U.S. Bureau of Labor Statistics with respect to the relative importance of housing and energy in their consumer price indices. Here are links to the data:

- <https://www.bls.gov/cpi/tables/relative-importance/home.htm>
- <https://www.destatis.de/DE/Themen/Wirtschaft/Preise/Verbraucherpreisindex/Methoden/Downloads/waegungsschema-2015.pdf>

## 2.4 Why inflation is bad

Central banks and politicians try to keep inflation low because it has negative implications for an economy due to various reasons:

**Menu costs** When inflation is high, businesses have to keep changing their prices, which costs time and money.

**Purchasing power loss** Inflation affects different people in different ways. Low wage earners and people with a nominal fixed income lose purchasing power.

**Redistribution of wealth and income** As we discussed in subsection 2.3.3, real interest rates decrease as inflation rises. Consequently, borrowers need to pay a lower real interest rate, while lenders receive a smaller real interest rate in return. The redistribution occurs because debt is generally expressed in nominal terms, and during inflation, the actual value of a fixed sum of money diminishes.

**Distorted Price Signals** Inflation disrupts the accuracy of prices as signals for resource allocation. Prices typically convey vital information about supply and demand, aiding good decisions. Inflation blurs these signals, making it challenging to distinguish genuine changes in value from general price increases. Thus, the magic of the prices to guide the market is disturbed.

**Uncertainties** High and fluctuating inflation introduces uncertainty about future prices. Businesses and consumers become unsure about the real value of money, which can deter long-term planning, saving, and investment. Moreover, it can lead to economic instability.

In summary, high inflation generates menu costs, disproportionately affects income distribution, distorts price signals, breeds uncertainty, and erodes savings.

## 2.5 The standard of living across countries

To compare living standards across countries with the real GDP, we need to face some challenges:

1. The real GDP of one country must be converted into the **same currency** unit as the real GDP of the other country. Once we have the exchange rates, this is straight forward. However, these rates often fluctuate a lot and hence the GDP of countries. We may tend to have a biased view on the GDP when spotting it in times when the exchange rate peaks. Moreover, if the prices of goods and services differ significantly, the difference between the two GDP does not only stem from living standard differences.
2. The goods and services in both countries must be valued at the **same prices**. Relative prices in countries will differ, so goods and services should be weighted accordingly. For example, if more prices are lower in China than in the United States, China's prices put a lower value on China's production than would U.S. prices. If all the goods and services produced in China are valued using U.S. prices, then a more valid comparison can be made of real GDP in the two countries. This comparison using the same prices is called purchasing power parity (PPP) prices.

## 2.6 Alternative measures of welfare

**Disposable income** (= Total income – taxes + government transfers) is the income that households and non-corporate businesses have left after satisfying all their obligations to the government. GDP includes the goods and services produced by the government such as schooling, national defence, and law enforcement. These things contribute to well-being but are not included in disposable income. In this respect, GDP per capita is a better measure of living standards than disposable income.

**Gross national product (GNP)** is the total income earned by a nation's citizens domestically and abroad.

**Net national product (NNP)** is the total income of a nation's residents (GNP) minus losses from depreciation. Depreciation is the wear and tear on the economy's stock of equipment and structures, such as lorries rusting and computers becoming obsolete.

**World Happiness Report** primarily uses data from the Gallup World Poll and it is collected from people in over 150 countries (see: <https://worldhappiness.report/>). Each variable measured reveals a populated-weighted average score on a scale running from 0 to 10 that is tracked over time and compared against other countries. These variables currently include:

- real GDP per capita
- social support
- healthy life expectancy
- freedom to make life choices
- generosity
- perceptions of corruption

**Human Development Index (HDI)** is a composite index of life expectancy, education (mean years of schooling completed and expected years of schooling upon entering the education system), and per capita income indicators, which are used to rank countries into four tiers of human development. A country scores a higher HDI when the lifespan is higher, the education level is higher, and the gross national income GNI (PPP) per capita is higher. (see: <https://hdr.undp.org/en/content/human-development-index-hdi>)

#### Exercise 2.7 — OECD better life index

(Solution → p. ??)

Vist  <https://www.oecdbetterlifeindex.org/> and create your own index by weighting certain things that are important for life. Then, explore what matters on average the most for people in your home country.

#### Exercise 2.8 — How to measure GDP

(Solution → p. 59)

Explain in one sentence the three equivalent ways to measure GDP.

#### Exercise 2.9 — What counts as GDP?

(Solution → p. 59)

By how much does GDP rise in each of the following scenarios? Explain.<sup>a</sup>

- a) You spend \$4,000 on college tuition this semester.
- b) You buy a used car from a friend for \$2,500.
- c) The government spends \$ 100 million to build a dam.
- d) Foreign graduate students work as teaching assistants at the local university and earn \$5,000 each.

<sup>a</sup>This exercise is taken from Jones (2008, p. 34f).

#### Exercise 2.10 — Nominal vs. real GDP and CPI

(Solution → p. 59)

In this exercise, you calculate nominal and real GDP for a simple economy. You then calculate real GDP growth using two base years and discuss the differences. Suppose than an economy consists of only two types of products: computers and automobiles. Sales and price data for these two products for two different years are as shown below:

Year	No. of PCs	Price per PC (in €)	No. of cars sold	Price per car (in €)
1990	500,000	6000	1,000,000	12,000
2000	5,000,000	2000	1,500,000	20,000

- a) Nominal GDP in any year is calculated by multiplying the quantity of each final product sold by its price and summing over all final goods and services. Assuming that all computers and automobiles are final goods, calculate nominal GDP in 1990 and in 2000.
- b) Real GDP in any year is calculated by multiplying that year's quantities of goods and services by their prices in some base year. Calculate real GDP in 1990 and 2000, using 1990 as the base year.
- c) Calculate the percentage change in real GDP between 1990 and 2000 using 1990 as the base year.
- d) Calculate real GDP in 1990 and 2000, using 2000 as the base year.
- e) Calculate the percentage change in real GDP between 1990 and 2000 using 2000 as the base year.
- f) Explain why your answers to parts c and e are different. Do you feel there is one that more accurately measures the true growth in GDP? Which one, and why?
- g) Calculate the Consumer Price Index (CPI) and inflation for the economy using 1990 as the base year.
- h) Calculate the Consumer Price Index (CPI) and inflation for the economy using 2000 as the base year.
- i) Compare the CPI results from above. Can you explain the results?

### Exercise 2.11 — GDP and well-being

(Solution → p. 60)

Assume that two countries have the same nominal GDP (measured in the same currency and according to the same accounting rules). Explain four reasons (which you consider to be the most important) why you cannot assume that citizens in both countries enjoy roughly the same level of economic well-being.

### Exercise 2.12 — Various GDP

(Solution → p. 60)

- a) To estimate GDP you add the value of all the goods and services produced, both final and intermediate goods. Is this procedure correct? Why?
- b) What is the relationship between aggregate income and aggregate production? Why does this relationship exist?
- c) Does my purchase of a domestically produced Ford automobile that was manufactured in 2020 add to the current U.S. GDP? Why? How about my purchase of a domestically produced, newly produced Ford? Why?
- d) Does my purchase of 100 shares of stock in Meta add to the nation's GDP? Why?
- e) If a homeowner cuts his or her lawn, is the value of this work included in real GDP? Suppose that the homeowner hires a neighborhood kid to cut the lawn. Is this activity included in real GDP? Comment on your answers.
- f) In 1900, the average work week was 65 hours; today it is approximately 35 hours. How did this change affect real GDP within the United States? How did it affect the standard of living within the United States? Comment on your answers.
- g) In the United States, many children receive day-care from commercial providers. In Africa, this is unknown; children are almost all cared for by relatives. How would this difference affect comparisons of GDP per person?

### Solution to Exercise 2.8 — How to measure GDP

(Exercise → p. 57)

- In the expenditure approach, GDP is calculated as the sum of all expenditure on final products.
- In the income approach, GDP is calculated as the sum of all income.
- In the value-added approach, GDP is calculated as the sum of all value added in all production units.

### Solution to Exercise 2.9 — What counts as GDP?

(Exercise → p. 57)

- GDP rises by the \$4,000 amount of your tuition payment. This is purchase of a service (education) that is produced this semester.
- The purchase of used goods does not involve new production. This example is just the transfer of an existing good, so GDP is unchanged. If you bought the used car from a used-car dealer, the service of selling the car would represent new production—so something like \$200 of the \$2,500 might be included in GDP.
- The new dam is new production, and the government spending of \$100 million is counted as GDP. Notice that if the spending were spread over several years, then the flow of new production (and GDP) would also be spread over time.
- Foreign graduate students working in the United States contribute to production that occurs within the United States, and this is included in GDP. So GDP goes up by \$5,000 for each student.

### Solution to Exercise 2.10 — Nominal vs. real GDP and CPI

(Exercise → p. 57)

- 1990: 15,000,000,000 €  
2000: 40,000,000,000 €
- 1990: 15,000,000,000 €  
2000: 48,000,000,000 €
- 220% increase
- 1990: 21,000,000,000 €  
2000: 40,000,000,000 €
- 90%
- Answers differ because base-year prices are different. Neither measure is clearly superior, but notice that real GDP growth is radically different between the two. Notice that there are ten times as many computers in 2000 compared with 1990, and 50% more cars. So something between 50% and 1000% is appropriate. But how to weight each increase – that's where prices come in.

g)

$$500' \cdot 6' + 1000' \cdot 12' = 15''$$

$$500' \cdot 2' + 1000' \cdot 20' = 21'''$$

$$CPI_{base=1990} = 1.4$$

Prices increased from 1990 to 2000 by 40% using 1990 as the base year.

h)

$$5000' \cdot 6' + 1500' \cdot 12' = 48''$$

$$5000' \cdot 2' + 1500' \cdot 20' = 40'''$$

$$CPI_{base=2000} \approx 0.8\bar{3}$$

Prices decreased from 1990 to 2000 by 16 $\frac{2}{3}$ % using 2000 as the base year.

- i) The CPI calculation provided above yields contradictory results. This discrepancy arises from the utilization of distinct goods baskets. With 2000 as the base year, considerable weight is attributed to PCs, which have experienced a decline in price over the years. Conversely, when employing 1990 as the base year, a substantial emphasis is placed on cars, which have seen an increase in price over the years.

### Solution to Exercise 2.11 — GDP and well-being

(Exercise → p. 58)

Some possible, but not all, explanations include:

- different price levels in the two countries would result in different amounts of real GDP, i.e., different quantities of goods and services available in each country;
- different-sized populations could result in different quantities of goods and services available per person in each country;
- different levels of nonmarket production in the two countries would alter the quantity of goods and services available in each country;
- different amounts of leisure time available (not captured in nominal GDP figures) would cause economic well-being to differ in the two countries;
- different distributions of income in the two countries could alter the quantity of goods and services available to the typical citizen in each country.
- different quantities of both positive and negative externalities associated with producing GDP, such as pollution and congestion, which are not measured in GDP, would cause the different levels of economic well-being between the two countries.

### Solution to Exercise 2.12 — Various GDP

(Exercise → p. 58)

- a) Adding all the goods and services produced is incorrect because it will lead to significant double counting. Intermediate goods and services will be double counted. For instance, if a CPU produced by Intel and then used in a Dell computer is counted both as a CPU from Intel and as part of the computer from Dell, the CPU has been double counted.
- b) Aggregate income equals aggregate production. The circular flow shows this result: The flow of production out of business firms equals the flow of expenditure into business firms. The flow of expenditure into business firms equals the flow of costs out of business firms. And the flow of costs out of business firms is the same as the flow of aggregate income to households.
- c) The purchase of the used Ford does not add to the current U.S. GDP though it did add to U.S. GDP in 2020 when the car was newly produced. GDP measures production within a given time period and the used Ford was not produced within the current year. A new Ford automobile, however, is counted in current U.S. GDP because it was produced in the current year.
- d) Purchasing shares of stock does not add to the nation's GDP. GDP measures production. Shares of stock are not the production of a good or service and therefore are not included in GDP.
- e) The homeowner's work around his or her home is not included in GDP because home production is excluded. Hiring a neighborhood kid to cut the lawn is, in theory, included in GDP because it is a service that has been sold in a market. This difference in the treatment of these two activities shows a flaw in how GDP is computed. In both cases the precise same lawn is mowed. But in one case GDP is unaffected and in the other GDP increases. It is paradoxical that the effect on GDP of producing the same service depends on who produces the service.
- f) The decrease in the average work week decreases real GDP from what it would have been if the work week had remained at 65 hours because less time is spent at production of goods and services. Taken by itself, the decrease in real GDP means that the standard of living within the United States is lower. However the fall in the average work week also means a significant increase in people's leisure time, which raises the standard of living. For many people it

*is likely the case that their standard of living is higher with the shorter work week—and hence lower level of real GDP—that it would be with the longer work week because they value their leisure more than the goods and services that would have been produced. But at the least, looking only at the change in real GDP as the sole measure of the standard of living is incorrect because that view ignores the gain in the standard of living from the increased leisure.*

- g) *This difference means that U.S. GDP per person is biased higher than GDP per person in African countries. In both the United States and in Africa children are cared for so the same service is produced in both regions. But in the United States this service is included in GDP because it is purchased in a market; however, in Africa the service is not included in GDP because it is performed as household production.*

# Chapter 3

## Economic growth in the long-run (Solow Model)

### In this chapter, we learn...

- ... how capital accumulates over time, helping us understand economic growth.
- ... the role of the diminishing marginal product of capital in explaining differences in growth rates across countries.
- ... the principle of transition dynamics: the farther below its steady state a country is, the faster the country will grow.
- ... the limitations of capital accumulation, and how it leaves a significant part of economic growth unexplained.

Required readings:

■ [Blanchard and Johnson \(2013, Chapter 11\)](#).

Recommended readings:

■ [Blanchard and Johnson \(2013, Chapter 10-12\)](#)

■ [Romer \(2006, p. 5-29\)](#).

This chapter focuses on the determinants of economic growth **in the long run**. In particular, we present a growth model developed independently by [Solow \(1956\)](#) (see [Figure 3.1](#)) and [Swan \(1956\)](#) that is called the *Solow-Swan growth model*, the *neoclassical growth model*, or simply the *Solow model*.

**Long run** means that we are not talking about cyclical movements. Rather, we are talking about long-term trajectories that span decades. Long-term growth models are about real income or real

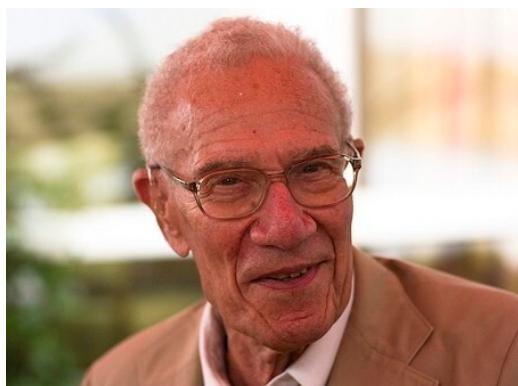


Figure 3.1: Robert M. Solow: Winner of the Nobel Memorial Prize in Economic Sciences in 1987  
Source: [Storbeck \(2020\)](#)

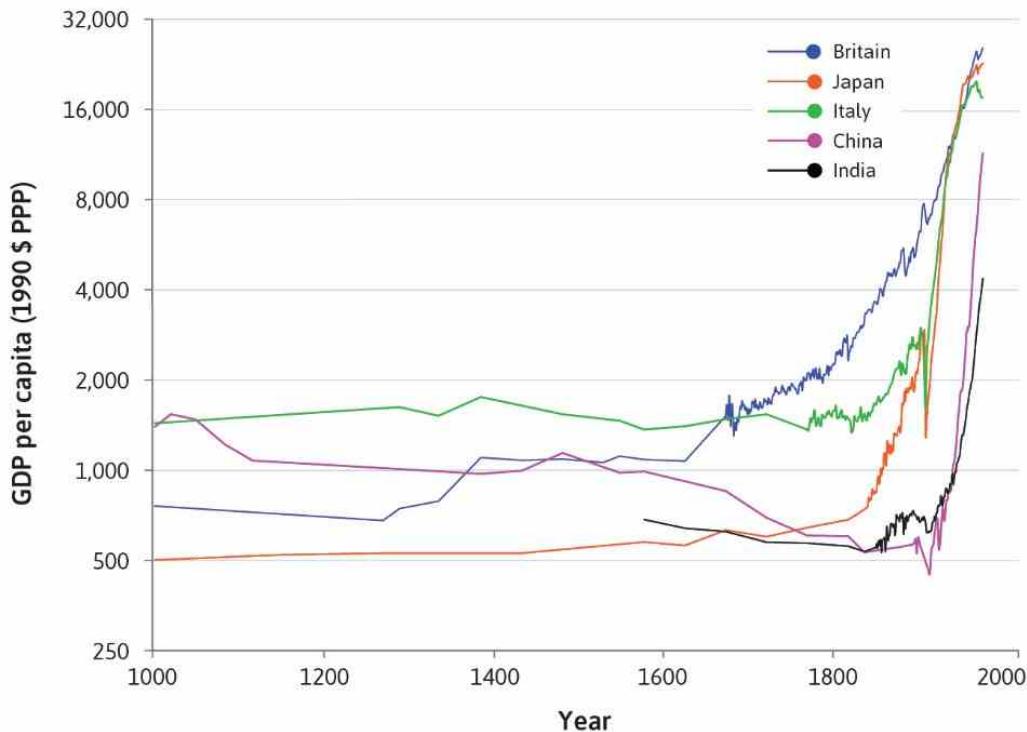


Figure 3.2: GDP per capita over time

Source: [www.core-econ.org](http://www.core-econ.org)

output, and we ignore things that matter a lot in the short run, like inflation or demand.

### 3.1 Stylized facts

#### Exercise 3.1 — Visualization of welfare

(Solution → p. ??)

- Watch *Hans Rosling's 200 Countries, 200 Years, 4 Minutes - The Joy of Stats - BBC Four*: <https://youtu.be/jbkSRLYSojo>
- Visit <https://livingcost.org/cost/germany/indonesia> and
- <https://data.worldbank.org/indicator/NY.GDP.PCAP.KD.ZG?end=2022&locations=ID&start=1961&view=chart>.

Please discuss about what led to Indonesia's impressive catch-up growth. Also speculate when this rapid growth might slow down. Moreover, do you think it is possible for Indonesia to attain a GDP per capita similar to that of a Mid-European country like Germany?

**Timing of growth** In Figure 3.2, it's evident that numerous countries have witnessed a form of *hockey-stick* growth. Growth take-off occurred at different points in time for different countries: Britain was the first country to experience sustained economic growth. It began around 1650. In Japan, it occurred around 1870. The kink for China and India happened in the second half of the 20th century. In some economies, substantial improvements in people's living standards did not occur until they gained independence from colonial rule or interference by European nations.

**The Industrial Revolution** The Industrial Revolution, also called the Technological Revolution, was a transformative era from the late 18th to 19th centuries. It brought technological advances, like machinery and steam power, that revolutionized manufacturing and led to urbanization. This period reshaped economies, labor, and society, shaping the modern world.

**Technology** is the process that uses inputs to produce an output. For example, a technology for making a cake can be described by the recipe that specifies the combination of inputs (ingredients such as flour, labor activities such as stirring, the oven, and the energy) needed to create the

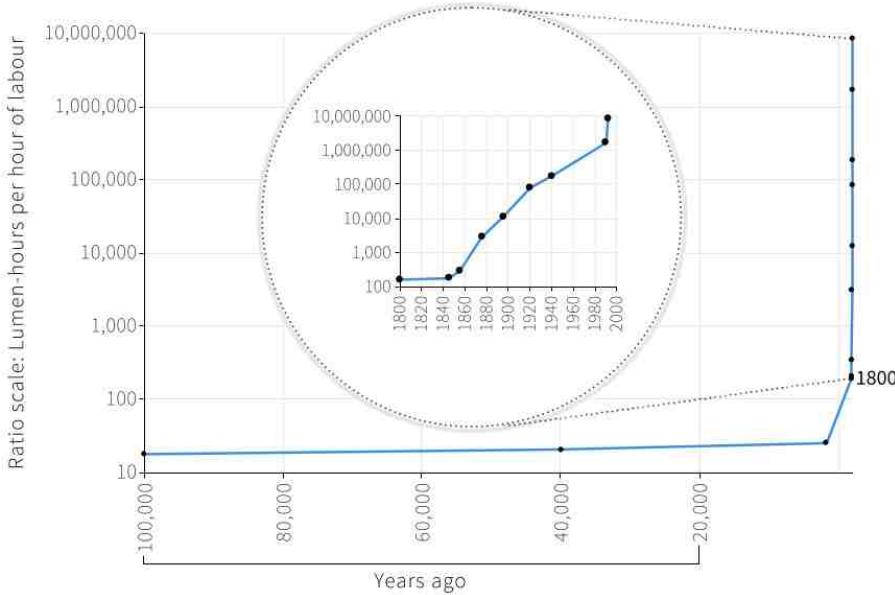


Figure 3.3: Lumen-hours per hour of labor

Source: [www.core-econ.org](http://www.core-econ.org)

output (the cake).

By reducing the amount of work time it takes to produce things, technological changes allowed significant increases in living standards. Figures 3.3, 3.4, and 3.5 show the fast development in technology in some areas that play a role in the production process and have an impact on welfare.

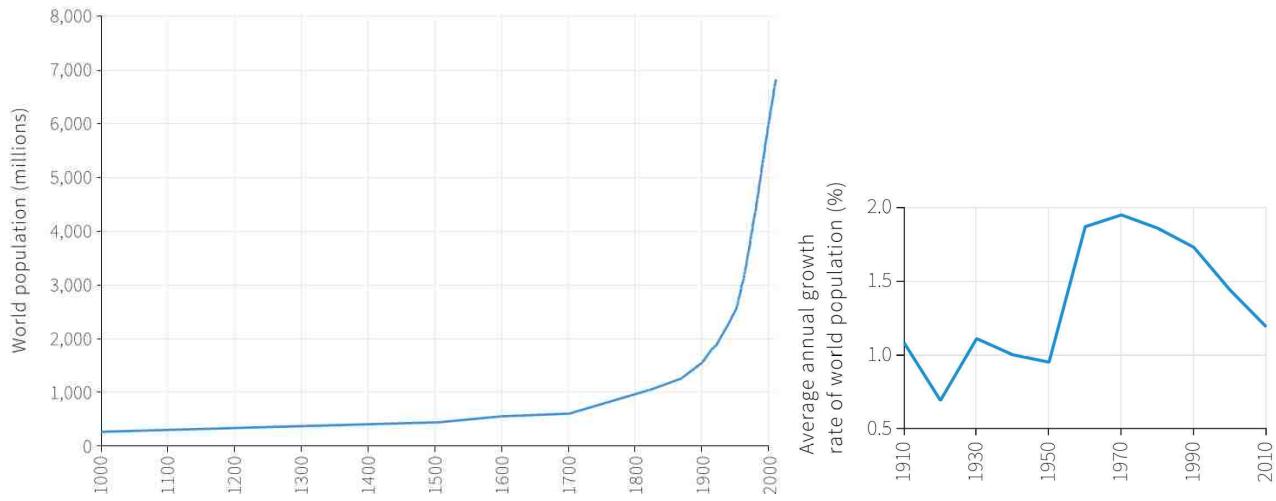


Figure 3.6: World population over time

Source: [www.core-econ.org](http://www.core-econ.org)

**Economic cycles** Figure 3.7 illustrates the long-term GDP growth of the UK, highlighting its fluctuations and indicating the most severe crisis.

**Population growth** • Population has also experienced *hockey-stick* growth, see Figure 3.6

- Growth is slowing down due to the demographic transition  
(fall in birth rates > fall in death rates)

**Environmental consequences** The consequences on the environment stem from heightened production and population growth. This impact manifests globally through climate change and locally through increased pollution in urban areas as well as deforestation. Nevertheless, it's important

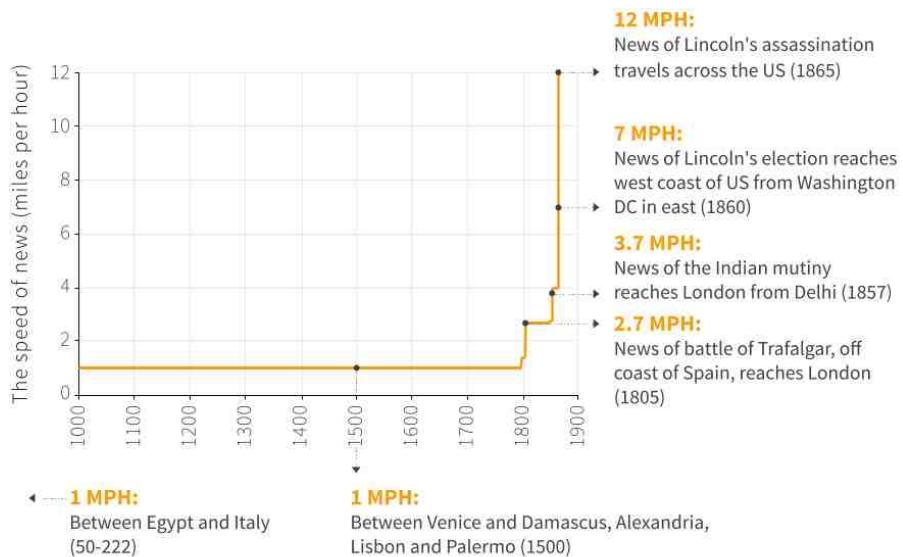


Figure 3.4: A connected World  
Source: [www.core-econ.org](http://www.core-econ.org)

to recognize that new technologies could potentially hold solutions to these issues. Figure 3.8 shows some important environmental measures.

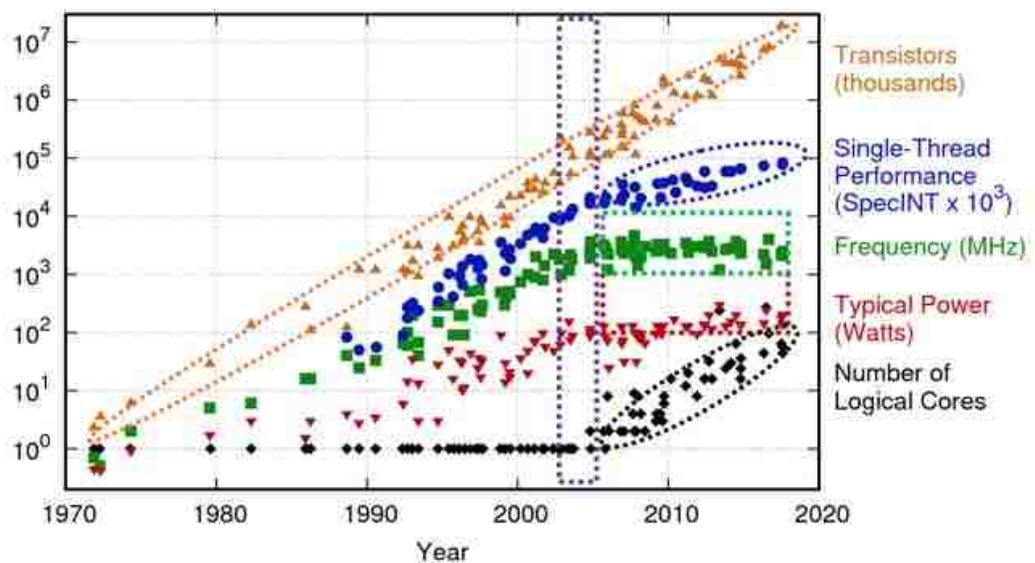


Figure 3.5: 42 Years of microprocessor trend data

Source: [Rusanovsky et al. \(2019\)](#)

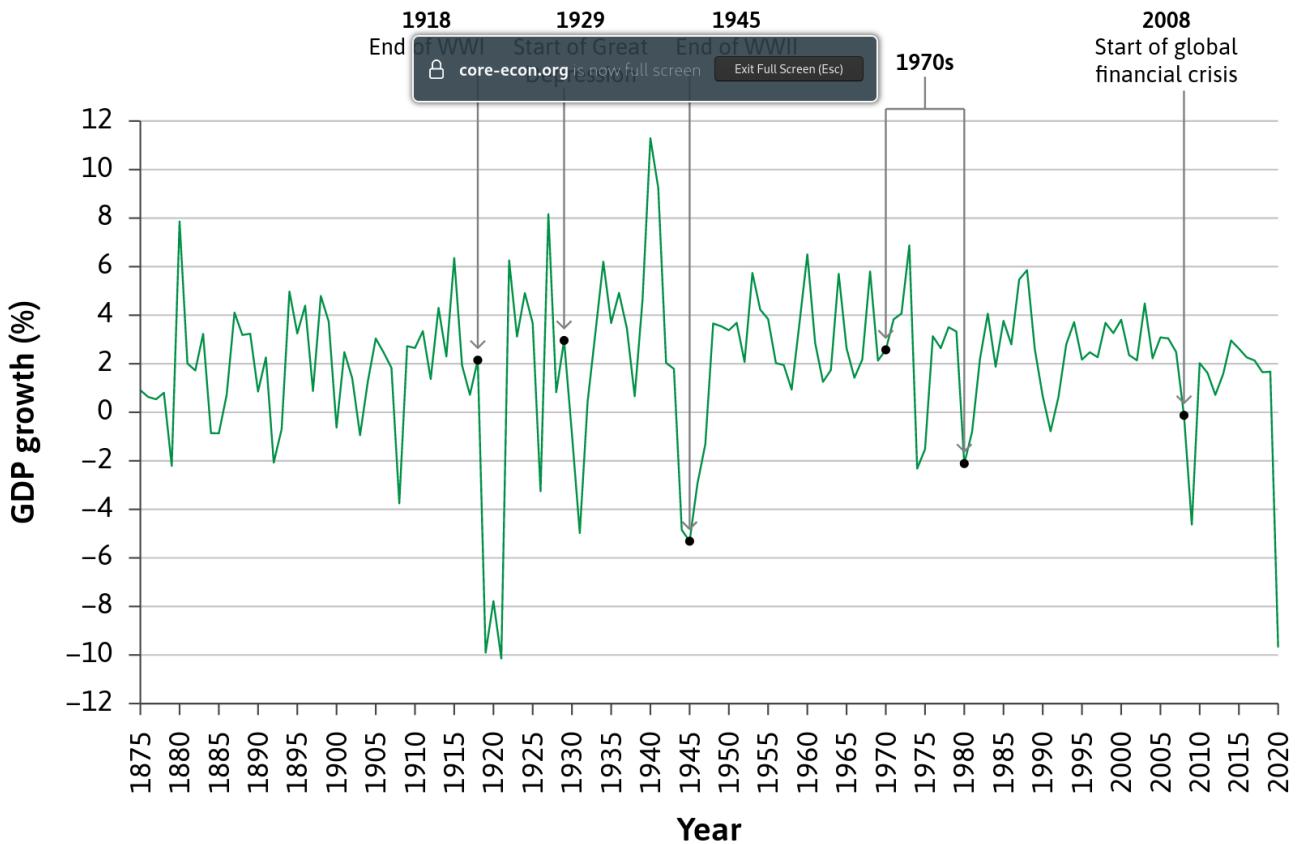


Figure 3.7: UK GDP growth (1875–2020)

Source: <https://www.core-econ.org/the-economy/book/text/13.html>

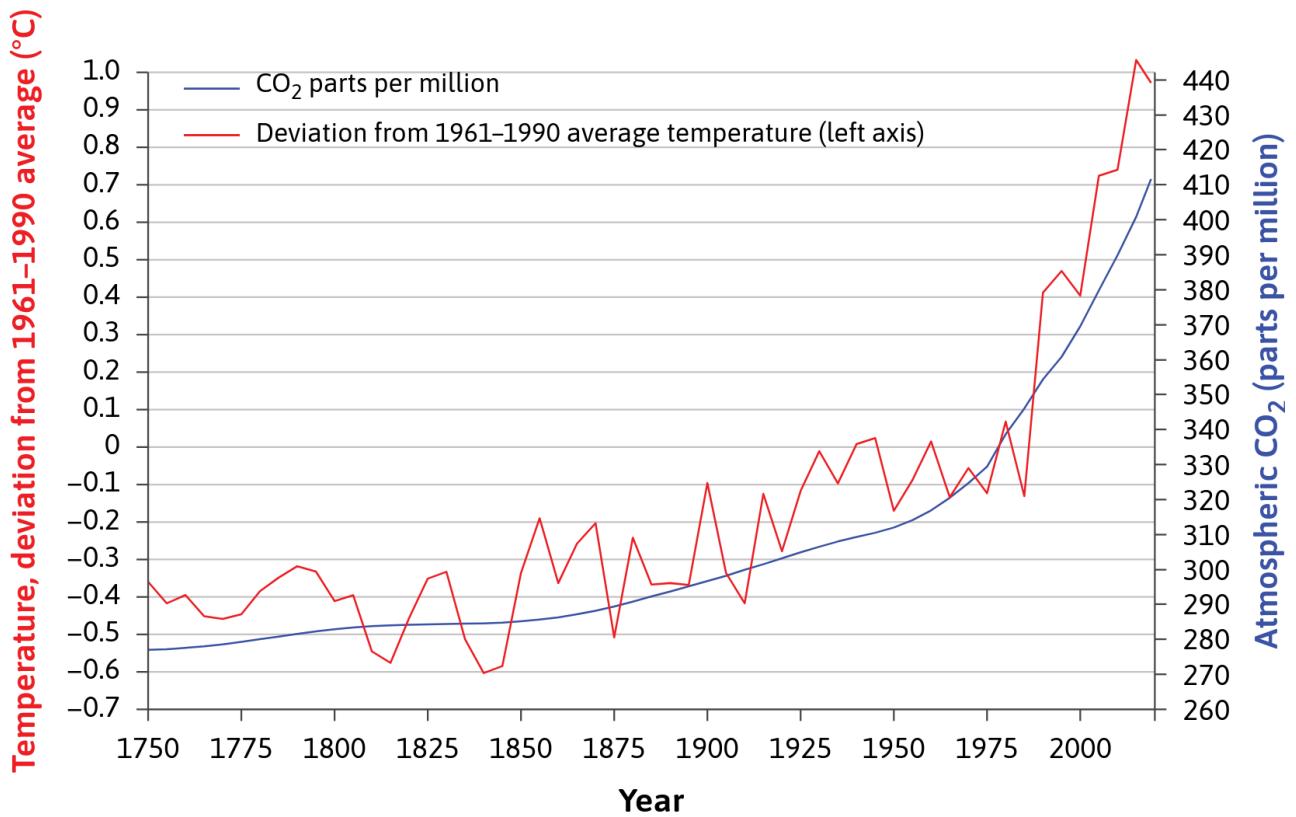


Figure 3.8: Global atmospheric concentration of carbon dioxide and global temperatures (1750–2019)

Source: <https://www.core-econ.org/the-economy/book/text/20.html>

## 3.2 Solow model

### 3.2.1 Introduction to the Solow model of economic growth

Watch  <https://youtu.be/eVAS-t83Tx0>

The nicely animated video is discussing counterintuitive economic growth situations and presents two puzzles: Germany and Japan's rapid growth after World War II despite heavy losses, and China's astonishing growth compared to advanced economies despite having better institutions and more capital. The Solow Model of Economic Growth is introduced to help understand these dynamics and distinguish between "catching up" and "cutting edge" growth. The model simplifies growth factors: labor ( $L$ ), human capital ( $L \cdot e$ ), physical capital ( $K$ ), and ideas ( $A$ ). These inputs work together in a production function to generate output. The production function's abstraction will be further simplified in upcoming videos, starting with an exploration of how capital contributes to economic growth.

Here is a transcript of the video:

Here's a fact about economic growth that might seem counterintuitive. During World War II, Germany and Japan suffered heavy losses. Millions of people were killed. Entire cities were flattened. Roads, bridges, factories, and other resources critical to an economy were destroyed. Yet, following World War II, Germany and Japan both grew quickly. In fact, they grew much faster than did the United States. Many people wondered what was going on. Why were the losers of the war growing faster than the winners? Here's another puzzle. In the past several decades, China has been growing at astonishing rates of growth – 7 to 10 % per year. Remember, at those rates, the standard of living – it's doubling every 7 to 10 years. In contrast, in the advanced economies, like the United States, Canada, or France, they're growing around 2% per year, doubling only once every 35 years. So here's the puzzle. In the previous talks, we said that the way to get a high standard of living and economic growth is to have good institutions, like property rights, honest government, political stability, a dependable legal system, and competitive and open markets. But in each one of these cases, there's no question that the advanced economies have better institutions than does China. Plus, the advanced economies – they've got more human and physical capital. So if the advanced economies have got better institutions and more capital, why are they growing slower than China? To solve these puzzles, we're going to be drawing on an important economic model the Solow Model of Economic Growth, named for Robert Solow, who won the Nobel Prize. The Solow Model will help us to better understand the dynamics of growth. The Solow Model is also going to help us to draw a distinction between two types of growth catching up growth and cutting edge growth. As we'll see, catching up can be much faster than growing on the cutting edge. Now, you might ask, "What's an economic model?" An economic model is a simplified framework that helps us to understand a more complex reality. We're going to be using a super simple version of the Solow Model that boils economic growth down to just a few key variables and some basic mathematics. Now, although it's simple, the Solow Model can provide us with some deep insights into the causes of growth. A key part of the model is a production function – a simplified description of how resources, inputs, are used to produce output. So let's take a look at some of the inputs into our production function. The first key input is us, people. We use the letter  $L$  to represent labor. The more educated people are, the more effective their labor. So we can multiply  $L$  by  $e$  for education. Together, these two variables represent human capital. Next is physical capital, represented by the letter  $K$ .  $K$  is all of our factories, and tools, and so forth. Last, but certainly not least, is ideas, represented by the letter  $A$ .  $A$  represents all of our knowledge about how to combine capital and labor to produce valuable output. Everything from how to transport stuff without carrying it on your back, to how to keep diseases from spreading, to how to add up, numbers in a

fraction of a second.  $A$  is ideas, and better ideas mean that we can get more bang for our buck, more output from the same inputs of capital and labor. We can think of human capital, physical capital, and ideas being used together to produce output. That's the idea of our production function. Now, right now our production function is very abstract. But in future videos, we're going to boil it down even more and make our production function concrete. We're going to start in the next video by taking a closer look at how capital – machines, factories, roads, and so forth – how capital contributes to economic growth. Let's dig in.

### 3.2.2 **The Solow Model and the Steady State**

Watch  <https://youtu.be/LQR7r0-I96A>

Transcript of the video:

Let's continue our exploration of the Solow Growth Model. In our last video, we covered how physical capital faces the iron logic of diminishing returns. Now let's turn to another unfortunate aspect of physical capital: capital rusts. Roads get potholes and need to be repaired, tools wear out, trucks break down. In short, we say that capital depreciates. Now let's put the amount of capital on the horizontal axis and the amount of depreciation on the vertical axis. We can then model the relationship like this. Depreciation increases at a constant rate as the capital stock increases. The more capital you have, the more capital depreciation you have. Now let's add a new aspect to our model. Where does the money for capital accumulation come from? From savings and investment. When we create economic output, we can either consume it or save it. What we don't consume can be saved and invested in new capital. So suppose we invest a constant fraction of our output. Let's say we devote of every units of output or 30% of output to investment. We can now add an investment curve to our graph. It'll mimic the shape of the output line since investment is just a constant fraction of output. Notice that our first units of capital – they're very productive and so they create a lot of output and thus also a lot of investment. But as we add more and more units of capital, we get less output and also less investment. That's the iron logic of diminishing returns once again. Now let's put investment and depreciation on the same graph. Depreciation is growing at the same rate as the capital stock grows. Each new unit of capital creates an equal amount of depreciation. Now notice that when investment is greater than depreciation, that means the capital stock must be growing. We're adding more units of capital than are depreciating. But as the capital stock grows – investment and depreciation – they're on a crash course to intersect. When this happens, we've reached what is called the Steady-State Level of Capital. The steady-state is the key to understanding the Solow Model. At the steady-state, an investment is equal to depreciation. That means that all of investment is being used just to repair and replace the existing capital stock. No new capital is being created. Now remember, we've assumed that all the other variables in the model – they're not changing. So if the capital stock isn't growing, nothing is growing. In other words, when we reach the Steady-State Level of Capital we've also reached the Steady-State Level of Output. Now suppose you ended up on the other side of the steady-state point – over here. You'd find that depreciation is greater than investment. That means some of the capital stock needs repair, but there isn't enough investment to do all of the needed repairs, so the capital stock shrinks, pushing you back towards the steady state. So to the left of the steady-state we have investment greater than depreciation and the capital stock is growing. To the right of the steady-state we have the opposite – depreciation is greater than investment, and the capital stock – it's shrinking. Either way, we always end up moving towards the steady-state. Let's go back to our earlier example of Germany after the end of World War II. Since the capital stock is low, it's also very productive and we get a lot of output from the first new roads and factories after the war. We've already mentioned that point. But in addition, we now see that when the capital stock is very productive and producing a lot of output, we will also

be producing a lot of investment. So in the next period the capital stock will be even bigger than before and we'll get even more output. Plus, since the capital stock is low, we don't have much depreciation to take care of. So with the investment, it will mostly be generating new capital, not replacing old capital. Now over time, however, both of these forces – they weaken. The returns to capital diminish and depreciation eats up more and more of investment. A country with a lot of roads, and bridges and factories – it's doing well, but it also has to invest a lot just to maintain all those roads and bridges and factories. And this is exactly what we saw in Germany and Japan after World War II. Growth rates started out very high, but as those countries caught up, growth rates declined. Now perhaps our friend  $K$  still has one more trick up his sleeve to get the economy growing. What if we started to save more of our output? A higher savings rate shifts the investment curve up like this. Now investment is higher than depreciation, so we're adding to the capital stock and the economy is back to growing. However, you can see that the same dynamic exists as before. The iron logic of diminishing returns means that we'll again end up at a new steady-state level of capital. The higher savings rate – it spurs growth for a time and it does increase the steady-state level of output. But, at the new steady-state, investment once again equals depreciation and we get zero economic growth. Accumulation of physical capital can only generate temporary growth. In our next video, we'll take a look at how human capital influences growth.

### 3.2.3 *The Solow Model and Ideas*

Watch  <https://youtu.be/-yPDlowSL1w>

Transcript of the video:

We've covered a lot of the Super Simple Solow Model. We've looked at the dynamics of capital accumulation, how changes in savings rates influence growth, and we've looked at some of the predictions of the Solow Model. One thing we've learned is that the model seems to inevitably predict that we end up in a steady state with no growth. Now, however, we're going to turn to the last of our variables ideas. Can ideas keep us growing? Better ideas mean that we get more bang for our buck, more output from the same inputs of capital and labor. Alternatively, we can think about this as increasing our productivity. Henry Ford, for example, took ideas from lots of other industries, like meatpacking, bicycle making, and brewing, and he combined them in a way that had never before been used in the manufacturing of automobiles. This novel combination of ideas sparked a dramatic increase in productivity that transformed the world. The same types of processes – they're continuing today, and in all industries, increasing output per worker across the economies. So let's go back to our previous graph of capital and output. We can now add ideas as a multiplier. Better ideas multiply the output from the same capital stock. So, if  $A$  increases from 1 to 2, that's a doubling of our productivity. And that shifts the output curve up. When output doubles, so does investment. Now, once again, investment is greater than depreciation. So we begin accumulating capital once again. And that further boosts our output. So better ideas spur more output, which creates more investment, which leads to capital accumulation. So better ideas lead to growth in two ways. The increased productivity of a given capital stock, and the increased investment, which increases capital accumulation. Now imagine that ideas are constantly improving. You'd have continual shifts upward of the output curve. And that means continual shifts upward of the investment curve. We'd always stay to the left of the steady state, and there, we'd continually grow. So growth at the cutting edge – it's determined by how fast new ideas are formed, and how much those new ideas increase our productivity. So that's our super simple Solow Model. It combines a model of catching up growth due to capital accumulation, with a model of cutting edge growth due to idea accumulation.

## Solow's central question

Can capital accumulation lead to long-term growth and perpetual improvements in living standards? Formally speaking, can the following circular relationship last forever and lead to sustainable growth in production:  $Y \uparrow \rightarrow S \uparrow \rightarrow I \uparrow \rightarrow K \uparrow \rightarrow Y \uparrow \dots$

Robert M. Solow's answer is: No, capital accumulation can boost growth only for some time. The only long-term key to growth is technological progress.

**“Whether you like it or not, history is on our side. We will bury you!”**

This is a quote of Soviet First Secretary Nikita Khrushchev while addressing Western ambassadors at a reception at the Polish embassy in Moscow on November 18, 1956 ([Time Magazine, 1956](#)).

In the 1950s, the Soviet Union launched a growth offensive with extremely high investments, primarily in heavy industry. History was not really on his side as far as we can judge that.

## 3.3 The formal Solow model

There are many different versions of the Solow model out there. Each comes with its unique way of writing things down, which might puzzle newcomers who are trying to understand it.

To make your reading of research easier, let me introduce you to the approach taken by [Romer \(2006, p. 5-29\)](#). In his widely-recognized book for graduate students, he presents the classic form of the model. Despite its challenging aspects, it's designed to be quite comprehensible.

### 3.3.1 Production

The heart of any theory of growth is a production function (PF) as it describes how output is made out of different factors of production. Production in the Solow model takes the form

$$Y(t) = f(K(t), A(t)L(t)) \quad (3.1)$$

where  $Y$  is output,  $K$  is the input of physical capital (buildings and machines),  $L$  is the input of labor, and  $A$  is *knowledge* or the *effectiveness of labor*. Time  $t$  does not enter production directly, but only through  $A$ ,  $K$ , and  $L$ . As  $A$  and  $L$  enters multiplicatively,  $AL$  is usually interpreted jointly as *effective labor*.

For convenience, the time argument  $(t)$  will henceforth be dropped and the PF can rewritten:

$$Y = F(K, AL) \quad (3.2)$$

#### Constant returns to scale

If output changes by the factor  $c$  when every production factor is multiplied by  $c$ , then the production function has constant returns to scale (CRS). Production in the Solow model is assumed to take place at constant returns to scale:

$$f(c \cdot K, c \cdot AL) = c \cdot f(K, AL) \quad \text{for all } c \geq 0 \quad (3.3)$$

## Intensive form

CRS allows us to work with the PF in *intensive form*<sup>1</sup> setting  $c$  to be  $\frac{1}{AL}$ :

$$f\left(\frac{1}{AL} \cdot K, \frac{1}{AL} \cdot AL\right) = \frac{1}{AL} \cdot f(K, AL) \quad (3.4)$$

$$\Leftrightarrow f\left(\underbrace{\frac{K}{AL}}_k, 1\right) = \underbrace{\frac{Y}{AL}}_y \quad (3.5)$$

$$F(k) = y, \quad (3.6)$$

where  $k$  is defined as  $\frac{K}{AL}$  and denotes the amount of capital per unit of effective labor and  $y$  is defined as  $\frac{Y}{AL}$  and denotes the output per unit of effective labor.

## Inada conditions

The intensive form PF is assumed to satisfy<sup>2</sup>

$$f(0) = 0, \quad (3.7)$$

$$f'(k) > 0, \quad (3.8)$$

$$f''(k) < 0. \quad (3.9)$$

A PF that satisfying these assumptions is shown in figure [Figure 3.9](#). A nice series of lecture units explaining the Solow model can be found here:  <https://youtu.be/b5Yi-ZhFwKw>

## Cobb-Douglas function

The function

$$f(K, AL) = K^\alpha (AL)^{1-\alpha} \quad (3.10)$$

is a well-received PF named after [Cobb and Douglas \(1928\)](#) that

1. can be written in the intensive form by dividing both inputs by  $AL$ :

$$f(k) = f\left(\frac{K}{AL}, 1\right) = \left(\frac{K}{AL}\right)^\alpha = k^\alpha \quad (3.11)$$

---

<sup>1</sup>**Why do we need the intensive form here?**: The intensive form is just a special way to look at a production function and to analyze its factors of production. Here, we simply re-write the PF into the *intensive form* so that we only need to consider only one factor of production, that is, the capital per unit of effective labor  $\frac{K}{AL}$ . That will be very useful in the further course of the analysis. Of course, the new variables  $y = \frac{Y}{AL}$  and  $k = \frac{K}{AL}$  are not of interest in their own right. Rather, they are tools for learning about the variables we are interested in. As we will see, the easiest way to analyze the model is to focus on the behavior of  $k$  rather than to consider directly the behavior of the two arguments of the production function,  $K$  and  $AL$ .

To see the intuition behind the intensive form, think of dividing the economy into  $AL$  small economies, each with 1 unit of effective labor and  $\frac{K}{AL}$  units of capital. Since the production function has constant returns, each of these small economies produces  $\frac{1}{AL}$  as much as is produced in the large, undivided economy. Thus, the amount of output per unit of effective labor depends only on the quantity of capital per unit of effective labor, and not on the overall size of the economy. ([Romer, 2006](#))

<sup>2</sup>**Why does the PF needs to satisfy these conditions?**: These assumptions are also known as the *Inada conditions* determine the shape of the production function. These assumptions guarantee the stability of an economic growth path in a neoclassical growth model. While we can loosen the assumption of  $f(0) = 0$  with a loss of generality, it would not make sense to assume  $f'(k) < 0$  because that would mean the more capital we employ in an economy the less output we generate which would be counter-intuitive and crazy to assume. Also, it would be not intuitive to assume or  $f'(k) = 0$  as this would mean capital has no impact on production. The second derivation is more interesting: Assuming  $f''(k) < 0$  means that we do **not** have economies of scale with respect to capital per effective unit of labor. Thus, all economies will converge to a balanced growth path. If we would assume  $f''(k) > 0$  that would mean that  $f'(k)$  would not fall toward zero as  $k$  becomes large and hence the actual investment line,  $sf(k)$ , would not fall below the break-even investment. That would mean that the growth rate would go to infinity which of course makes no sense. ([Romer, 2006](#))

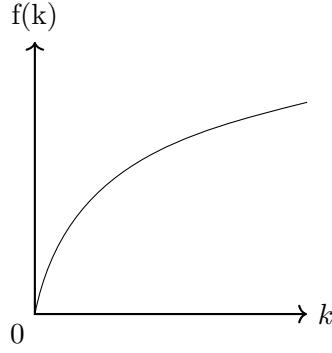


Figure 3.9: An intensive-form PF with positive but diminishing marginal returns

2. satisfies the Inada conditions:<sup>3</sup>

$$f(0) = 0 \quad (3.12)$$

$$f'(k) = \alpha k^{\alpha-1} > 0, \quad (3.13)$$

$$f''(k) = -(1-\alpha)\alpha k^{\alpha-2} < 0, \quad \text{and} \quad (3.14)$$

3. has CRS:

$$f(cK, cAL) = (cK)^{\alpha}(cAL)^{1-\alpha} \quad (3.15)$$

$$= c^{\alpha} c^{1-\alpha} K^{\alpha} (AL)^{1-\alpha} \quad (3.16)$$

$$= c \underbrace{K^{\alpha} (AL)^{1-\alpha}}_{f(K, AL)} \quad (3.17)$$

$$= cY \quad (3.18)$$

### 3.3.2 Evolution of production factors

#### L and A

Assume the initial levels of  $K$  and  $L$  are given and that they continuously change over time.

$$\frac{dL(t)}{dt} = \dot{L}(t) \quad (3.19)$$

$$\frac{dA(t)}{dt} = \dot{A}(t). \quad (3.20)$$

Further assume that labor grows constantly with rate  $n$  and knowledge with  $g$ :

$$\dot{L}(t) = nL(t) \Leftrightarrow n = \frac{\dot{L}(t)}{L(t)} \quad (3.21)$$

$$\dot{A}(t) = gA(t) \Leftrightarrow g = \frac{\dot{A}(t)}{A(t)}. \quad (3.22)$$

As the evolution of labor and knowledge are assumed to be exogenous, we should analyze the evolution of  $K$ .

---

<sup>3</sup>Alternatively, this can be done also without the intensive form: If  $K = 0$  or  $L = 0$ ,  $F(K, L) = 0$ . Check for positive but diminishing returns:

$$\frac{\partial F}{\partial L} = \frac{1}{2} K^{\frac{1}{2}} L^{-\frac{1}{2}} > 0 \quad \text{and} \quad \frac{\partial^2 F}{\partial L^2} = -\frac{1}{4} K^{\frac{1}{2}} L^{-\frac{3}{2}} < 0 \rightarrow \checkmark \text{positive and diminishing}$$

$$\frac{\partial F}{\partial K} = \frac{1}{2} K^{-\frac{1}{2}} L^{\frac{1}{2}} > 0 \quad \text{and} \quad \frac{\partial^2 F}{\partial K^2} = -\frac{1}{4} K^{-\frac{3}{2}} L^{\frac{1}{2}} < 0 \rightarrow \checkmark \text{positive and diminishing}$$

## K

Changes in the capital stock are explained with

$$\dot{K}(t) = sY(t) - \delta K(t), \quad (3.23)$$

where  $sY$  is the fraction of output that is devoted to investment and  $\delta$  is the capital depreciation rate, both are exogenous and constant. All output that is not invested in the capital stock,  $(1-s)Y$ , is consumed as we assume a closed economy here. Both  $s$  and  $\delta$  are exogenous and constant parameters.

### Evolution of $k$

To see the dynamics of  $k$ , that is,  $\dot{k}$ , we need to consider  $\frac{d(\frac{K}{AL})}{dt}$  which is a bit tedious to derive that as you need the two derivation rules

$$\left(\frac{w}{h}\right)' = \frac{w' \cdot h - w \cdot h'}{h^2}$$

and

$$(ab)' = a' \cdot b + a \cdot b'$$

to get with dropping the time argument,  $t$ ,

$$\dot{k} = \frac{d\left(\frac{K}{AL}\right)}{dt} = \frac{\overbrace{\dot{K}}^{w'} \cdot \overbrace{AL}^h - \overbrace{\overbrace{K}^w \cdot (\overbrace{A\dot{L}}^{a' \cdot b} + \overbrace{L\dot{A}}^{a \cdot b'})}^{h'}}{\underbrace{(AL)^2}_{h^2}} \quad (3.24)$$

$$= \frac{\dot{K}}{AL} - \frac{K}{(AL)^2} [A\dot{L} + L\dot{A}] \quad (3.25)$$

$$= \frac{\dot{K}}{AL} - \frac{K\dot{L}}{ALL} - \frac{K\dot{A}}{AAL} \quad (3.26)$$

$$= \frac{\dot{K}}{AL} - \underbrace{\frac{K}{AL}}_k \cdot \underbrace{\frac{\dot{L}}{L}}_n - \underbrace{\frac{K}{AL}}_k \cdot \underbrace{\frac{\dot{A}}{A}}_g \quad (3.27)$$

$$= \frac{\dot{K}}{AL} - kn - kg \quad (3.28)$$

$$= \frac{\dot{K}}{AL} - k(n + g) \quad (3.29)$$

Substituting  $\dot{K} = sY - \delta K$  from [Equation 3.23](#) yields

$$\dot{k} = \frac{sY - \delta K}{AL} - k(n + g) \quad (3.30)$$

$$= s \underbrace{\frac{Y}{AL}}_{y \equiv f(k)} - \delta \underbrace{\frac{K}{AL}}_k - k(n + g) \quad (3.31)$$

$$= sf(k) - \delta k - k(n + g) \quad (3.32)$$

$$\dot{k} = sf(k) - k(\delta + n + g) \quad (3.33)$$

This is the key equation of the Solow model. The change in the capital stock per effective unit of labor, which is the only factor of production that can cause growth in our model, is determined by  $sf(k)$ : the *actual investment per effective unit of labor*, and  $k(\delta + n + g)$ : the *break-even investment*. That is, the investment that must be done to keep  $k$  at its existing level. In other words it describes why  $\frac{K}{AL}$  gets smaller without investments over time:

$\delta k \rightarrow$  capital depreciates (gets less over time)

$nk \rightarrow$  quantity of labor is growing

$gk \rightarrow$  effectiveness of labor is growing

### 3.3.3 Steady-state, $k^*$

The steady-state equilibrium is the point where

$$\dot{k} = 0.$$

At this point, growth is zero as capital per effective labor unit  $k$  remains the same over time. Since output per effective unit of labor  $y$  depends on  $k$  through the production function, it is also unchanging.

The y-axis shows the output per effective unit of labor,  $y$ .

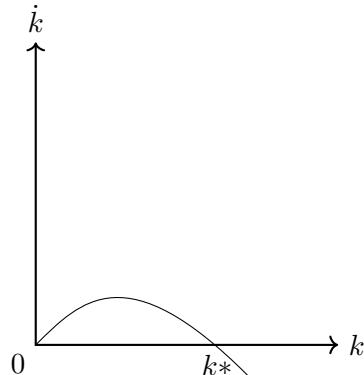
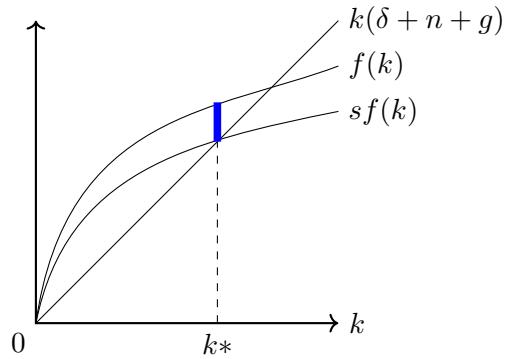


Figure 3.10: Balanced growth in the Solow model

### 3.3.4 Consumption

$sf(k)$  is the proportion a country saves and hence invests.  $k(\delta + n + g)$  refers to how much needs to be invested to keep  $k$  stable. Thus, the thick blue line denotes the fraction of overall production,  $f(k)$ , that goes to consumption,  $C$ , that is

$$C = f(k) - sf(k) \quad (3.34)$$

The dashed line is the proportion that is re-invested. In the steady-state, actual investments equals break-even investment,  $(n + g + \delta)k^*$ . Thus, steady-state consumption is given by

$$c^* = f(k^*) - (n + g + \delta)k^*. \quad (3.35)$$

### 3.3.5 Golden Rule of consumption

Increased investment in the capital stock can only boost growth until the steady state is reached. Thus, the question arises: How much should we invest in the capital stock? Well, the only variable we should consider in the long run when deciding on how much to invest from the output,  $sf(k)$ , is consumption.

Table 3.1: Steady-state growth rates in the Solow model

Variable	Symbol	Steady-state growth rate
labor	$L$	$n$
knowledge	$A$	$g$
Total output	$Y = yAL$	$n + g$
Capital per effective unit of labor	$k = \frac{K}{AL}$	0
Output per effective unit of labor	$y = \frac{Y}{AL} = f(k)$	0
Output per unit of labor	$\frac{Y}{L} = yA$	$g$

The reason is simply that it is consumption not output that defines welfare. Maximal steady-state consumption,  $C^{**}$ , is given by

$$\frac{\partial C^*}{\partial s} = \underbrace{[f'(k^*) - (n + g + \delta)]}_{\text{Golden Rule}} \frac{\partial k^*}{\partial s}. \quad (3.36)$$

The *golden rule* states that consumption is maximized at the point when the slope of the output function,  $f(k)$ , in the upper panel of [Figure 3.10](#) equals  $n + g + \delta$ .

### 3.3.6 Long-run growth rates

In the steady state we have a balanced growth path where all variables grow at a constant rate, see [Table 3.1](#).

Sustained growth requires technological progress as can be seen in the table because output per worker is only driven by  $g$ .

## 3.4 Summary

- The steady-state equilibrium is the point where investment spending is the same as spending on depreciation and the capital-output ratio remains constant; at this point, growth is zero.
- The Solow model provides a means of understanding the transition of economies over time.
- Less developed economies have lower capital-output ratios with accumulating capital they can generate catch up growth.
- Investment is determined by the domestic savings ratio and by the inflow of capital from abroad.
- Investment in capital will increase capital per worker and lead to growth.
- As the stock of capital rises, the extra output produced from an additional unit of capital falls; this property is called diminishing returns.
- In the long run, growth requires technological progress, i.e., output per worker is only driven by  $g$  (ideas).

### Exercise 3.2 — Technological Progress

(Solution → p. [77](#))

In the long run capital per effective unit of labor is constant and hence the only way that the capital per worker and in turn output per worker increases is with technological progress. Show it formally.

### Solution to Exercise 3.2 — Technological Progress

(Exercise → p. 76)

$Y$  grows at  $n + g$  and  $L$  grows at  $n$ , so the quotient grows at the difference:  $g$ . This means that in the steady state, living standards (output per person) grow at the rate of technological progress.

In the long run capital per effective unit of labor is constant and hence the only way that the capital per worker and in turn output per worker increases is with technological progress.

In the steady-state  $\dot{k} = 0$  and hence, we can say that

$$\frac{Y_t}{A_t L_t} = \frac{Y_{t-1}}{A_{t-1} L_{t-1}} \quad (3.37)$$

This simple assumes that in the steady state the output per effective unit of labor is constant. That means, it does not change from period  $t - 1$  to period  $t$ . Please note that while the output per effective unit of labor is constant in the steady state, the output per unit of labor is not.

$$\frac{Y_t}{A_t L_t} = \frac{Y_{t-1}}{A_{t-1} L_{t-1}} \quad (3.38)$$

$$\Leftrightarrow \frac{\frac{Y_t}{L_t}}{\frac{Y_{t-1}}{L_{t-1}}} = \frac{A_t}{A_{t-1}} \quad (3.39)$$

$$\Leftrightarrow \underbrace{\frac{\frac{Y_t}{L_t}}{\frac{Y_{t-1}}{L_{t-1}}} - 1}_{\text{growth rate of } \frac{Y}{L}} = \underbrace{\frac{A_t}{A_{t-1}} - 1}_g \quad (3.40)$$

Thus, in the steady state it is only technological progress, i.e.,  $g$ , that determines per capita growth.<sup>a</sup>

<sup>a</sup>For simplicity, this was shown in discrete times. However, it also holds true in continuous times.

### Exercise 3.3 — Solow Simplified

(Solution → p. ??)

Consider a Solow growth model as introduced in the lecture. Further assume that population (or labor force) does not grow,  $n = 0$ , and that there is no technological change,  $g = 0$ . The parameters of the model are given by  $s = 0.2$  (savings rate) and  $\delta = 0.05$  (depreciation rate).

- Name the main assumptions of the Solow model.
- Which of the following production functions could we use for the Solow model?
  - $Y = K^{0.5} L^{0.5}$
  - $Y = K^{0.4} L^{0.7}$
  - $Y = K^{1/3} L^{2/3}$
- Why it is so important to assume that the production function has constant returns to scale and is concave, that is, the marginal returns for the inputs are positive  $\frac{\partial f(K)}{\partial K} > 0$  but diminishing  $\frac{\partial^2 f(K)}{\partial K^2} < 0$ ?
- Rewrite production function  $Y = K^{1/3} L^{2/3}$  in output per effective unit of labor terms.
- Find the steady-state level of the capital stock. How high is the growth rate of capital per effective unit of labor in the steady-state?
- Calculate the steady-state output per labor.
- Sketch the steady-state level of the capital stock in a two-way plot with output per labor and capital per labor on the axes. Mark in the plot how much of the output goes into capital service and how much is left for consumption.
- Assume that the saving rate increases to  $s = 0.3$  calculate the new steady-state level of the capital stock and the corresponding steady-state output per labor. What would be the output maximizing savings rate?

- i) Discuss if a saving rate of 1 would be a desirable goal. Can you think of a optimal saving rate? What is the *Golden Rule* of Capital Accumulation in the Solow Model?
- j) The golden rule level of the capital stock maximizes consumption per worker in steady-state. Calculate which capital stock would maximizes consumption per worker in steady-state.
- k) What is the associated savings rate that must be imposed by a benevolent social planner to have maximized consumption per worker?
- l) Compare your result in the previous part with the consumption maximizing savings rate. Do citizens need to save more or less? Discuss economic policies that could help the social planner implement real-world situation.

# Chapter 4

## Microeconomic preliminaries

In this section, I cover several microeconomic preliminaries that are crucial for your understanding. These include:

1. Production functions: I discuss different several important features of production.
2. Production Possibility Frontier (PPF): I explain how the PPF curve graphically visualizes the production and growth of firms and countries.
3. Indifference curves: I discuss how indifference curves represent different bundles of goods at which consumers are indifferent.
4. Isoquants: I introduce how isoquants represent different levels of production that can be achieved with different combinations of input factors.
5. Budget constraints: I show you how to graphically sketch budget constraints, which play a significant role in consumer decision-making.

### 4.1 Production functions

A firm or a company is a productive unit. In particular, it is an organization that produces goods and services. In short, it can be called *output*. To do so, it uses inputs called *factors of production*, that is, labor, capital, land, skills, etc. The relationship between the inputs and the output is the production function. The goal of the firm is to achieve whatever goal its owner(s) decide to achieve through the firm. Usually, it is (and in Germany for example it has to be the case by law) to generate profits, i.e., total revenue minus total cost for the level of production.

A production function (PF) is a mathematical representation of the process that transforms inputs into output.

- When factors of production are **perfect substitutes** the PF can be written like this:

$$q = f(K, L) = L + K$$

- When factors of production are **perfect complements** the PF can be written like this:

$$q = f(K, L) = \min(L, K)$$

- A special and often used function is the Cobb-Douglas PF:

$$q = f(K, L) = K^\alpha L^{1-\alpha} \quad \text{with } 0 < \alpha < 1$$

The **returns to scale** describes the increase in output when a firm multiples all of its inputs by some factor. Let  $\lambda > 1$ , then, with two factors  $K$  and  $L$ , we can define that for

$$f(cK, cL) = c^\lambda f(K, L),$$

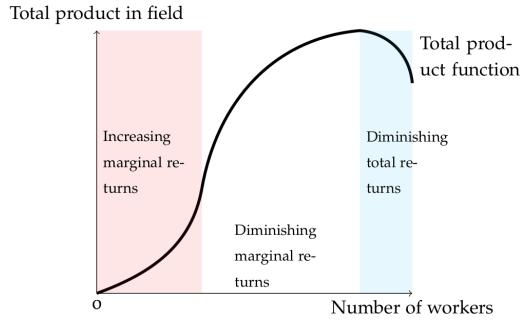


Figure 4.1: Marginal returns

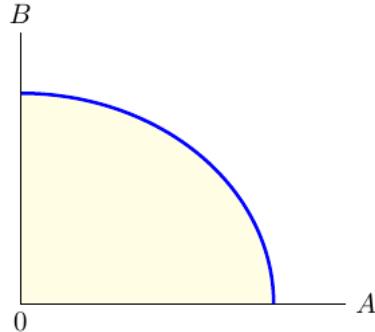


Figure 4.2: The production possibility frontier curve

- $\lambda > 1$  the PF has increasing returns to scale,
- $\lambda = 1$  the PF has constant returns to scale,
- $\lambda < 1$  the PF has decreasing returns to scale.

The **marginal product** is the change in the total output when the input varies by one infinitesimal small unit. Graphically, the marginal product is the slope of the total product function at any point. The slope of the total product function, i.e., the marginal product, is generally not constant. The marginal product to an input is assumed to decrease beyond some level of input. This is called the **Law of diminishing marginal returns**. In particular, we can distinguish (see [Figure 4.1](#))

- **positive marginal returns** when  $f' > 0$  and
- **diminishing marginal returns** when  $f'' < 0$  and
- **increasing marginal returns** when  $f'' > 0$ .

## 4.2 Production possibility frontier curve

The production possibility frontier curve (PPF) as shown in figure 4.2 provides a graphical representation of all possible output options for two products when all available resources and factors of production are fully and efficiently utilized within a given time frame. The PPF serves as the boundary between combinations of goods and services that can be produced and those that cannot.

The PPF is an invaluable tool for illustrating the implications of scarcity, as it offers insights into production efficiency, opportunity costs, and tradeoffs between different choices. Typically, the PPF exhibits concavity since not all factors of production can be used equally productive in all activities.

*Economic growth* refers to the sustained expansion of production possibilities. An economy experiences growth through advancements in technology, enhancements in labor quality, or increases in capital quantity. As an economy's resources increase, its production possibilities expand, causing the PPF to

shift outward. It is worth noting that you can use the PPF to explain production in an “economy” or in a “firm”, respectively.

*Production efficiency* arises when it is impossible to produce more of one good or service without producing less of another. When production occurs directly on the PPF, it signifies efficiency. On the other hand, if production takes place inside the PPF, there is potential to produce more goods without sacrificing any existing ones, indicating inefficiency. When production lies on the PPF, a tradeoff emerges because obtaining more of one good necessitates giving up some quantity of another. This tradeoff incurs a cost, known as an *opportunity cost*.

### Exercise 4.1 — Understanding production

(Solution → p. 81)

- a) Figure 4.3 shows a PPF and five conceivable production points,  $C_i$ , where  $i \in \{1, \dots, 5\}$ . Explain the figure using the following terms: *attainable point*; *available resources*, *unattainable*, *inefficient*, *efficient point*.

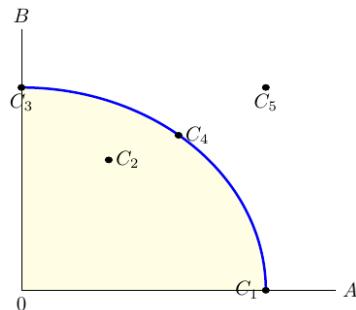


Figure 4.3: Production and different consumption points

- b) What would happen to the PPF if the technology available in a country and needed for the production process became better?
- c) What would happen to the PPF if the resources available in a country and needed in the production process of both goods shrank?
- d) What would happen to the PPF if the resources (technology) available in a country that are needed in the production process...  
 i) ... for both goods increased (improved)?  
 ii) ... for good A shrank (got worse)?  
 iii) ... for good B increased (improved)?
- e) Does the shape of the PPF tell us anything about economies of scale in the production process?
- f) Figure 4.4 shows an extreme PPF. How can such a PPF be explained?

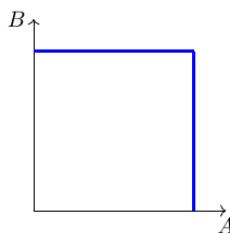


Figure 4.4: Extreme production possibility frontier curve

### Solution to Exercise 4.1 — Understanding production

(Exercise → p. 81)

- a) Any point that lies either on the production possibilities curve or to the left of it is said to be an *attainable point*: it can be produced with currently available resources. Production points that lie in the yellow shaded area are said to be *unattainable* because they cannot be produced using currently available resources. These points represent an *inefficient production*, because existing resources would allow for production of more of at least one good without sacrificing the

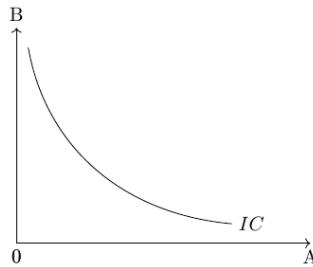


Figure 4.6: Indifference curve

*production of any other good. An efficient point is one that lies on the production possibilities curve. At any such point, more of one good can be produced only by producing less of the other.*

- b) The PPF would shift outwards.
- c) The PPF would shift inwards.
- d) The PPF would shift...
  - i) ... outwards for both goods.
  - ii) ... inwards for good A, see figure 4.5.
  - iii) ... outwards for good B.
- e) With economies of scale, the PPF would curve inward, with the opportunity cost of one good falling as more of it is produced. A straight-line (linear) PPF reflects a situation where resources are not specialized and can be substituted for each other with no added cost. With constant returns to scale, there are two opportunities for a linear PPF: if there was only one factor of production to consider or if the factor intensity ratios in the two sectors were constant at all points on the production-possibilities curve.
- f) Here is one example: Suppose a country that is endowed with two factors of production and that one factor can only be used for producing good A and the other factor can only be used to produce good B.

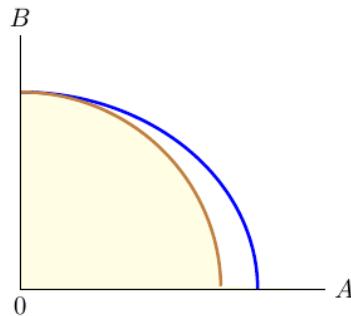


Figure 4.5: Shrinking production possibilities in good A

### 4.3 Indifference curves and isoquants

Combinations of two goods that yield the same level of utility for consumers are represented by indifference curves, see figure 4.6. These curves illustrate the various bundles of goods where consumers are equally satisfied. That means all points on an indifference curve represent the same level of utility. The shape of the indifference curve is determined by the underlying utility function, which captures the preferences of consumers for consuming different combinations of the two goods.

The slope of an indifference curve indicates the rate at which the two goods can be substituted while maintaining the same level of utility for the consumer. Technically, the slope represents the marginal rate of substitution, which is equal to the absolute value of the slope. It measures the maximum

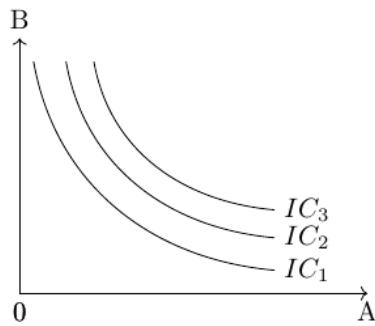


Figure 4.7: Indifference curve

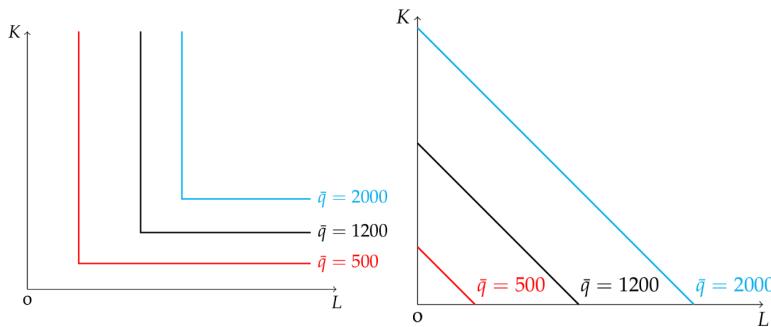


Figure 4.8: Perfect complements or substitutes

quantity of one good that a consumer is willing to give up in order to obtain an additional unit of the other good.

It is assumed that consumers aim to attain the highest possible indifference curve because a higher curve, located further to the right on a coordinate system, represents a higher level of utility. In figure 4.7 for example,  $IC_1$  represents a lower level of utility than  $IC_2$ .

Similar to the concept of indifference curves, an **isoquant** shows the combinations of factors of production that result in the same quantity of output.

#### Exercise 4.2 — Isoquants

(Solution → p. ??)

1. Which of the two plots of figure 4.8 show isoquants when factors of production are **perfect complements** and **perfect substitutes**, respectively?
2. Discuss the features of a Cobb-Douglas PF with respect to returns to scale and marginal product of production for both inputs. Sketch the total output curve in an output- $K$  and an output- $L$  quadrant. Sketch the isoquants for different levels of production.

## 4.4 Budget constraint

In microeconomics, the concept of a budget constraint plays a vital role in understanding consumer decision-making and helps to analyze consumer choices and trade-offs. The budget constraint represents the limitations faced by consumers in allocating their limited income across different goods and services. The budget constraint indicates that the total expenditure on goods and services, calculated by

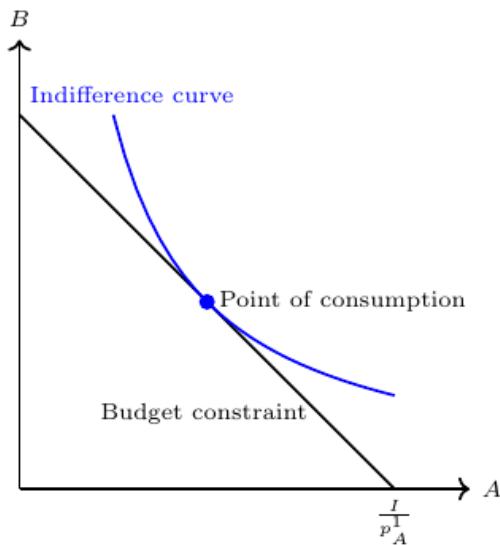


Figure 4.9: Optimal consumption choice

multiplying the prices of each item by its corresponding quantity, must be less than or equal to the consumer's income. Mathematically, the budget constraint can be expressed as:

$$P_1 \cdot Q_1 + P_2 \cdot Q_2 + \dots + P_n \cdot Q_n \leq I$$

where  $P_n$  represent the prices of goods,  $Q_n$  denote the quantities of goods  $n$  consumed.  $I$  denotes the consumer's income or their *budget*.

Consumers strive to maximize their utility by selecting the optimal combination of goods and services within the constraints imposed by their limited income. This involves making decisions about how much of each good to consume while staying within the budgetary limits. The graphical representation of the ideal consumption point is depicted in Figure 4.9.

By studying the budget constraint, economists can gain insights into consumer behavior, price changes, and the impact of income fluctuations on consumption patterns.

#### Exercise 4.3 — Cobb-Douglas PF

(Solution → p. ??)

Discuss the features of a Cobb-Douglas PF with respect to returns to scale and marginal product of production for both inputs. Sketch the total output curve in a output- $K$  and a output- $L$  quadrant. Sketch the isoquants for different levels of production.

# Chapter 5

## Market

### Learning objectives

- Distinguish between quantity demanded and demand, and explain what determines demand.
- Distinguish between quantity supplied and supply, and explain what determines supply.
- Explain how demand and supply determine price and quantity in a market, and explain the effects of changes in demand and supply.

Recommended readings:

- [Shapiro et al. \(2022, ch. 3\)](#)

### 5.1 Introduction: What is a market?

#### 5.1.1 The problem of value: The Water-Diamond Paradox

“Water is clearly important. We literally can’t live without it. Yet you can get water in your apartment in New York without paying for it. On modern Roman streets you can wash your hands or bathe your dog at any old fire hydrant. In the office and in the dorm you can drink water from the fountain down the hall.

Diamonds are different. You can live without diamonds. Yet they are very expensive, valued extremely highly per ounce in the marketplace.

Notice how strange this is - how a good such as a diamond, which is beautiful but inessential, could be so much more expensive per ounce than an essential and not necessarily beautiful good, such as water. The case is called ‘the water/diamond paradox.’ It is the first and the deepest question of value. What, after all, determines the value of things?” — <http://www.theeconomicconversation.com>

#### Exercise 5.1 — From moral to amoral theories of value

(Solution → p. ??)

Discuss the water-diamond paradox. Can you think of similar examples of goods that have a high price but no *real value*. Also discuss, what is the *value of a good* when its not the price?

#### 5.1.2 Elements of a market

- A market is any arrangement that brings buyers and sellers together.
- A **market** might be a physical place or a group of buyers and sellers spread around the world who never meet.

- In this chapter, we study a **competitive market** that has so many buyers and so many sellers that no individual buyer or seller can influence the price.
- **Quantity demanded** is the amount of a good, service, or resource that people are willing and able to buy during a specified period at a specified price. The quantity demanded is an amount per unit of time. For example, the amount per day or per month.
- **Supply and demand** are the forces that make market economies work because they determine prices in a market economy.
- **Prices**, in turn, allocate the economy's scarce resources.
- The model of the market based on supply and demand, like any other model, is based on a series of assumptions.

### Assumptions of the classical model

The classical model of supply and demand in free markets is basically based on the following assumptions (also see: exercise 1.4):

- Many buyers and sellers
- Homogeneous products
- Perfect information
- Free entry and exit
- Perfect mobility of factors of production
- Profit maximization
- No externalities

## 5.2 Demand

### 5.2.1 The law of demand

Other things remaining the same,

- If the price of the good rises, the quantity demanded of that good decreases.
- If the price of the good falls, the quantity demanded of that good increases.

#### Exercise 5.2 — Greed

(Solution → p. ??)

Watch Gordon Gekko's "Greed is good" speech taken from the movie *Wall Street* (1987):



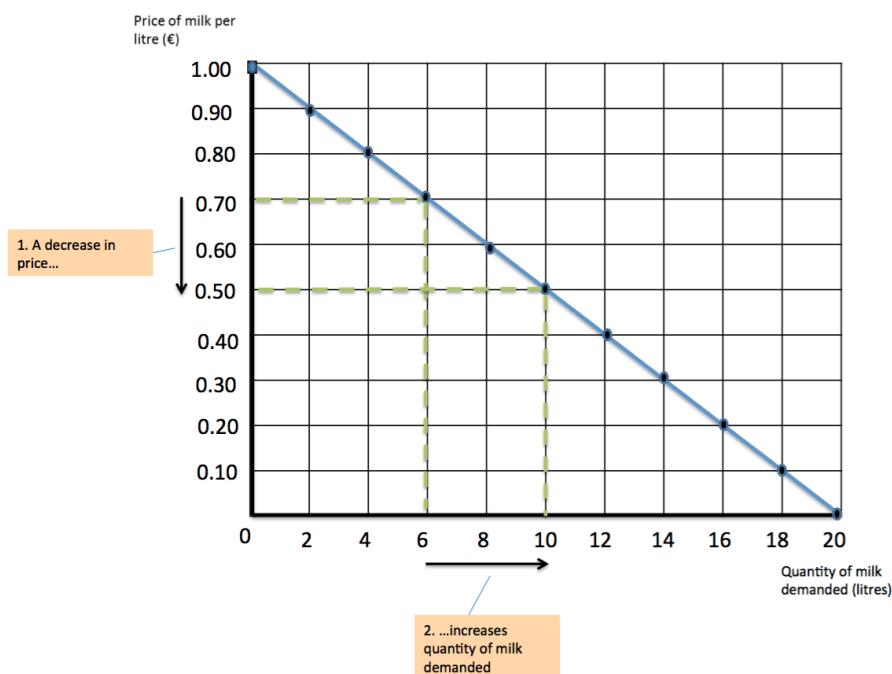
▶ <https://youtu.be/VVxY0QS6ggk> and discuss the relationship of *greed* and the *law of demand*.

### 5.2.2 Demand schedule and demand curve

Demand is the relationship between the quantity demanded and the price of a good when all other influences on buying plans remain the same. Demand is illustrated by a demand schedule and a demand curve. The demand curve shows the relationship between price and quantity demanded

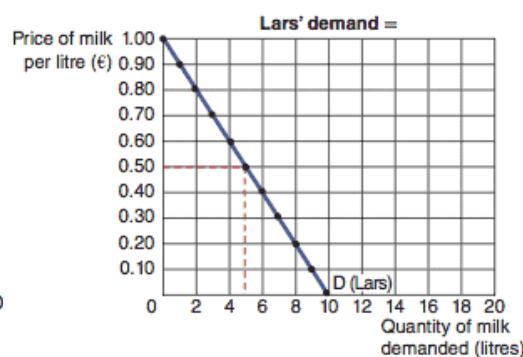
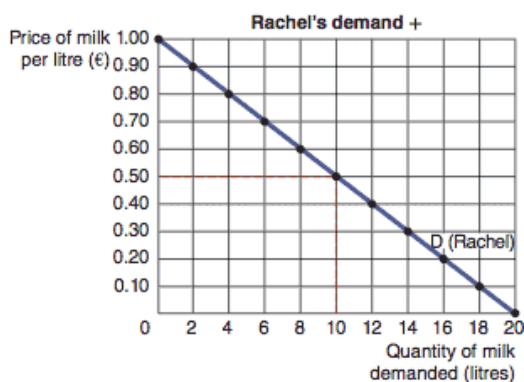
## Rachel's demand schedule

Price of milk per litre (€)	Quantity of milk demanded (litres per month)
.00	20
.1	18
.2	16
.3	14
.4	12
.5	10
.6	8
.7	6
.8	4
.9	2



### 5.2.3 Market demand versus individual demand

- Market demand refers to the sum of all individual demands for a particular good or service.
- Graphically, individual demand curves are summed horizontally to obtain the market demand curve.



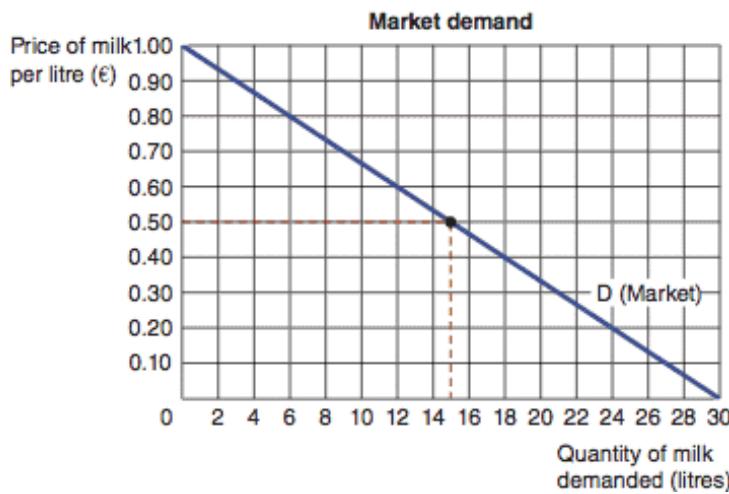
### Exercise 5.3 — Aggregate individual demand

(Solution → p. 88)

Sketch the market demand for milk, i.e., the sum of the demands of all the buyers in a market.

### Solution to Exercise 5.3 — Aggregate individual demand

(Exercise → p. 88)



### Movements along the curve versus shifts

- Movements along the demand curve are caused by a change in the price of the product.
- Ceteris paribus condition – other factors affecting demand are held constant so that we can analyze the effect of a change in price on demand.
- A shift in the demand curve is caused by a factor affecting demand other than a change in price.

### Exercise 5.4 — Sources of demand

(Solution → p. ??)

- Can you think of factors that change demand for a given price? Do the prices of other goods play a role?
- A **substitute** is a good that can be consumed in place of another good. For example, apples and oranges are substitutes.
- A **complement** is a good that goes well with another good. For example, sausages and mustard or fish and chips.
- Fill in the blanks:

The demand for a good \_\_\_\_\_ (increases/decreases) if the price of one of its substitutes rises.

The demand for a good \_\_\_\_\_ (increases/decreases) if the price of one of its substitutes falls.

The demand for a good \_\_\_\_\_ (increases/decreases) if the price of one of its complement rises.

The demand for a good \_\_\_\_\_ (increases/decreases) if the price of one of its complement falls.

A rise in the expected future price of a good \_\_\_\_\_ (increases/decreases) the current demand for that good.

A fall in the expected future price of a good \_\_\_\_\_ (increases/decreases) current demand for that good.

- A **normal good** is a good for which the demand increases if income increases and demand decreases if income decreases.
- An **inferior good** is a good for which the demand decreases if income increases and

- demand increases if income decreases.
- Can you give examples for normal and inferior goods.
  - Fill in the blanks:  
When income is expected to increase in the future, or when credit is easy to get and the cost of borrowing is low, the demand for some goods \_\_\_\_\_ (increases/decreases).  
When income is expected to decrease in the future, or when credit is hard to get and the cost of borrowing is high, the demand for some goods \_\_\_\_\_ (increases/decreases).
  - Is the following statement true or false:  
Changes in expected future income and the availability and cost of credit has the greatest effect on the demand for big ticket items such as homes and cars.

### Movements along the demand curve

Suppose the price of milk falls.

- More milk will be demanded because of income and substitution effects.
- **The income effect.** Assume that incomes remain constant. Then a fall in the price of milk means that consumers can now afford to buy more with their income.
- **The substitution effect.** Milk is lower in price compared to other similar products so some consumers will choose to substitute the more expensive drinks with the now cheaper milk.

### Shifts in the demand curve

A shift in the demand curve—to the left or right—is caused by any change that alters the quantity demanded at every given price.

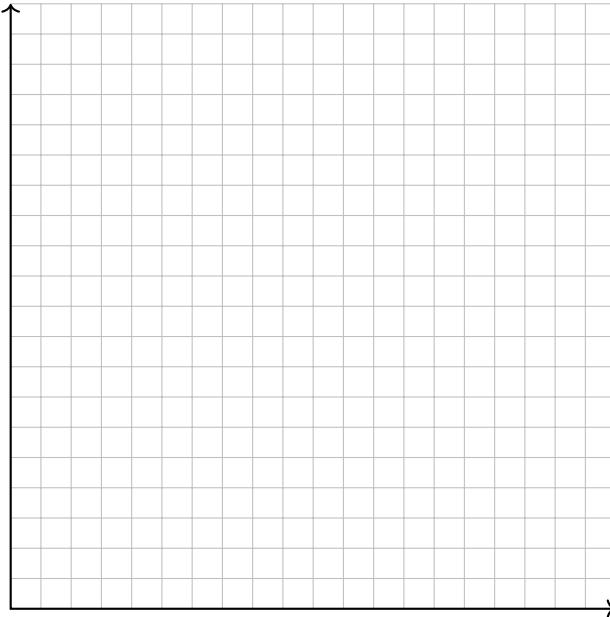
#### Shifting factors:

- Price of related goods: substitutes and complements
- Income: A lower income means consumer can spend less in total, so they spend less on some—and probably most—normal goods but more on inferior goods.
- preferences
- number of buyers (population)
- advertising
- expectation of consumers if demand is influenced by expectations of future income and future prices
- ...

#### Exercise 5.5 — Three demand curves

(Solution → p. ??)

Draw a plot with three demand curves. One curve should represent an economy in an economic booming phase, one in an economic downturn and one in between.



## 5.3 Supply

### 5.3.1 The law of supply

Other things remaining the same, it holds that:

- If the price of a good rises, the quantity supplied of that good increases.
- If the price of a good falls, the quantity supplied of that good decreases.

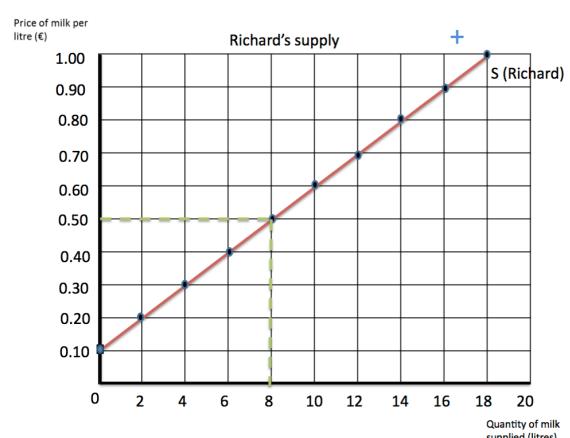
#### Supply: Definitions

- **Quantity supplied** is the amount of a good that sellers are willing and able to sell.
- The **supply schedule** is a table that shows the relationship between the price of the good and the quantity supplied.
- The **supply curve** is the graph of the relationship between the price of a good and the quantity supplied

### 5.3.2 Supply schedule and supply curve

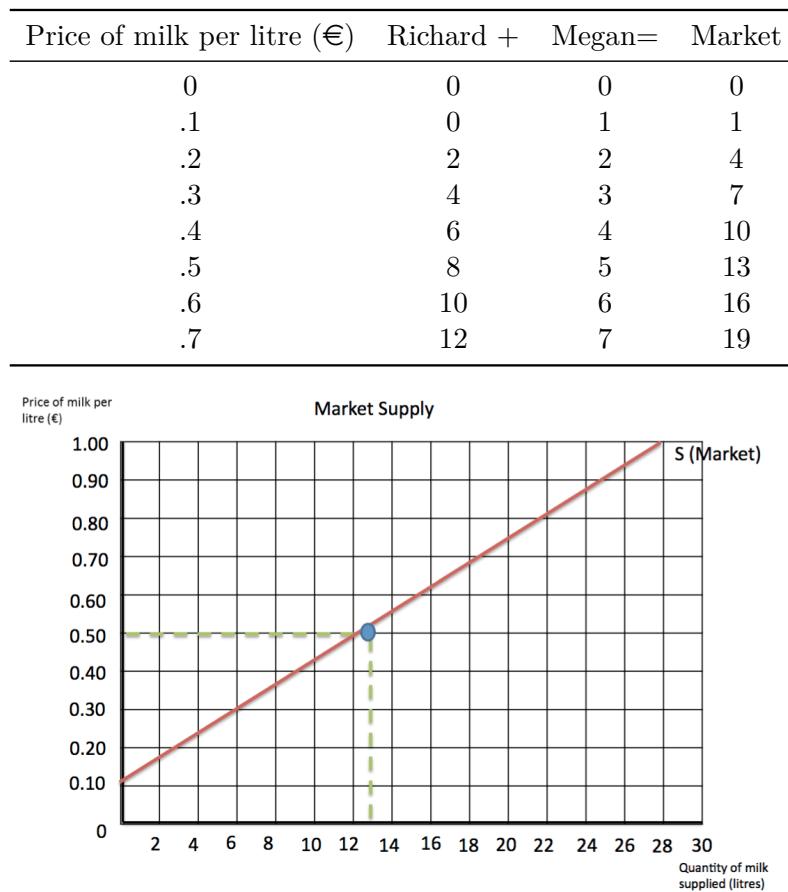
The following supply curve shows the relationship between price and quantity supplied of Richard who is a farmer.

Price of milk per litre (€)	Quantity of milk supplied (litres per month)
.00	0
.1	0
.2	2
.3	4
.4	6
.5	8
.6	10
.7	12
.8	14
.9	16
1	18



### 5.3.3 Market supply versus individual supply

Market supply refers to the sum of all individual supplies for all sellers of a particular good or service.



### Movements along the curve versus shifts

- The supply curve shows how much producers offer for sale at any given price, holding constant all other factors that may influence producers' decisions about how much to sell.
- A change in any of these other factors (other than a change in prices) shifts the supply curve to the left or to the right.

### Shifts in the supply curve

- Profitability of other goods in production and prices of goods in joint supply.
- Technology.
- Number of Sellers
- Natural/Social Factors such as the weather and changing attitudes.
- Input prices – the prices of the factors of production.
- Expectations of producers about the future state of the market.
- A change in the number of sellers in the market.
- Prices of Resources and Other Inputs: Resource and input prices influence the cost of production. And the more it costs to produce a good, the smaller is the quantity supplied of that good.
- Expected Future Prices:** Expectations about future prices influence supply. Expectations of future prices of resources also influence supply.

- Productivity which is output per unit of input. An increase in productivity lowers costs and increases supply.
- ...

### Exercise 5.6 — Prices of Related Goods in Production

(Solution → p. 92)

- A change in the price of one good can bring a change in the supply of another good.
- A **substitute in production** is a good that can be produced in place of another good.
- Give examples for goods that are substitutes in production.
- Fill in the blanks:  
The quantity supplied of a good \_\_\_\_\_ (increases/decreases) if the price of one of its substitutes in production falls.  
The quantity supplied of a good \_\_\_\_\_ (increases/decreases) if the price of one of its substitutes in production rises.  
The quantity supplied of a good \_\_\_\_\_ (increases/decreases) if the price of one of its complements in production rises.  
The quantity supplied of a good \_\_\_\_\_ (increases/decreases) if the price of one of its complements in production falls.

### Solution to Exercise 5.6 — Prices of Related Goods in Production (Exercise → p. 92)

*decreases, increases, decreases, increases*

## 5.4 Market equilibrium

### Equilibrium Price

- The price that balances quantity supplied and quantity demanded.
- Graphically, this is the price at which the supply and demand curves intersect.

### Equilibrium Quantity

- The quantity supplied and the quantity demanded at the equilibrium price.
- Graphically, this is the quantity at which the supply and demand curves intersect.

**What is an equilibrium** In economics, economic equilibrium is a situation in which economic forces such as supply and demand are balanced and in the absence of external influences the (equilibrium) values of economic variables will not change.

**When we look on supply and demand:** Price adjustments lead to an alignment of the quantities of goods supplied and demanded.

### Exercise 5.7 — Demand and Supply

(Solution → p. 93)

Given the demand function

$$x(p) = -\frac{3}{4}p + 300$$

and the supply function

$$x_S(p) = \frac{5}{4}p - 100$$

Determine the equilibrium market price and quantity both graphically and algebraically.

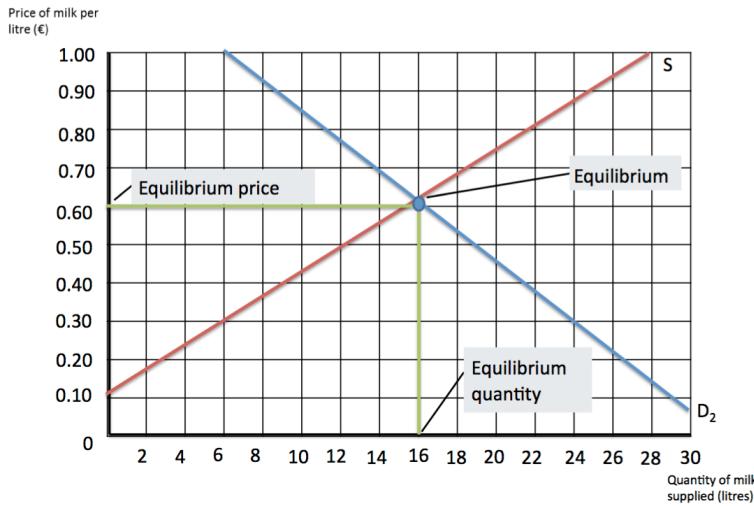


Figure 5.1: Market equilibrium of supply and demand

### Solution to Exercise 5.7 — Demand and Supply

(Exercise → p. 92)

To find the equilibrium, a.k.a. the intersection of the two functions, you need to solve the system of equations by solving both both equations fo either  $x$  or  $p$  and set both equal. To substitute for  $x$  you should calculate

$$-\frac{3}{4}p + 300 = \frac{5}{4}p - 100$$

$$p^* = 200$$

$$\text{and } x^* = 150$$

To substitute for  $p$  you need to solve both equations for  $p$ :

$$x = x(p) = -\frac{3}{4}p + 300 \Leftrightarrow p(x) = -\frac{4}{3}x + 400$$

$$x_S(p) = \frac{5}{4}p - 100 \Leftrightarrow p_S(x) = \frac{4}{5}x + 80$$

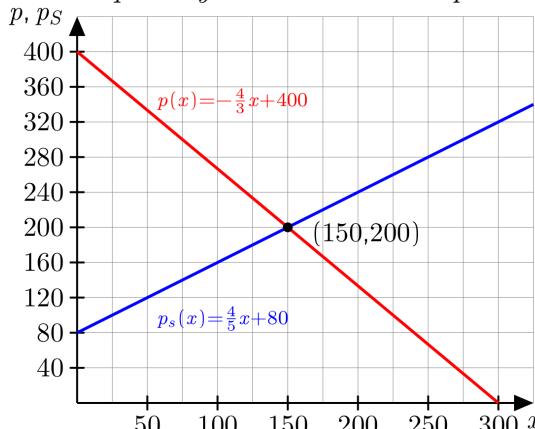
and calculate

$$-\frac{4}{3}x + 400 = \frac{4}{5}x + 80$$

$$x^* = 150$$

$$\text{and } p^* = 200$$

The equilibrium market price and quantity is in  $x = 150$  and  $p = 200$ .



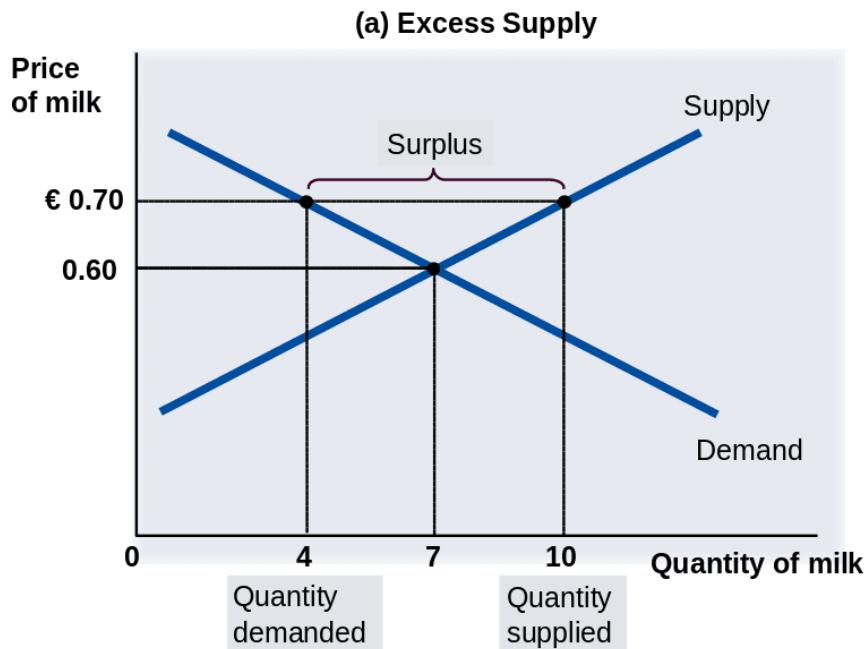


Figure 5.2: Markets not in equilibrium

### Supply > Demand (Surplus / Excess)

- If price > equilibrium price,
- then quantity supplied > quantity demanded.
- There is excess supply or a surplus.
- Suppliers will lower the price to increase sales, thereby moving towards equilibrium.

### Supply < Demand (Shortage)

- If price < equilibrium price, the quantity demanded > the quantity supplied.
- There is excess demand or a shortage.
- Suppliers will raise the price due to too many buyers chasing too few goods, thereby moving toward equilibrium.

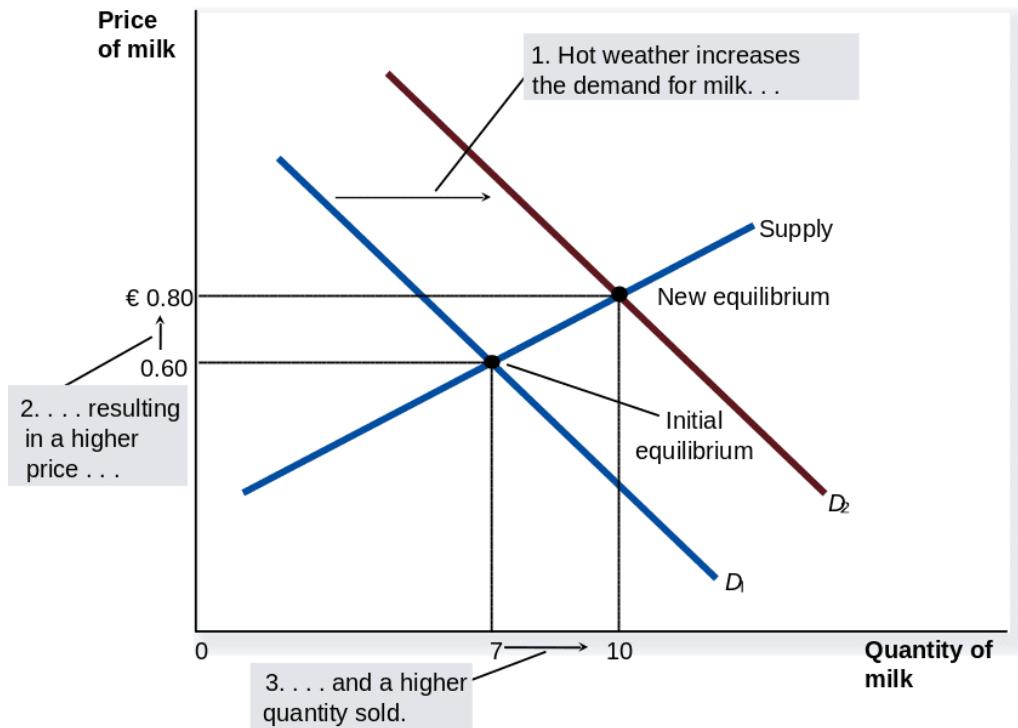
### Prices as signals Law of supply and demand

- The price of any good adjusts in order to bring the quantity supplied and the quantity demanded for that good into balance.
- The main function of a price in a free market is to act as a signal to both buyers and sellers.
- Buyers check whether they are willing to pay the price of an item, i.e., if the benefits (*utility*) exceeds the costs.
- Sellers examine whether the price of a good exceeds the costs of production.

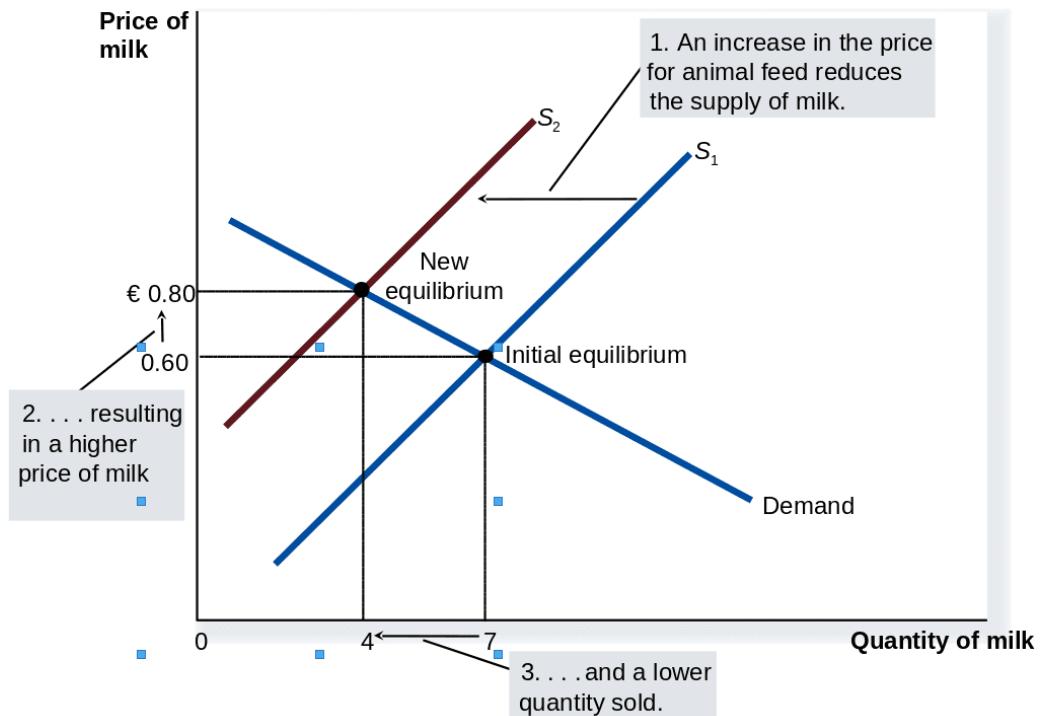
### Three steps to analyzing changes in equilibrium

1. Decide whether the event shifts the supply or demand curve (or both).
2. Decide whether the curve(s) shift(s) to the left or to the right.
3. Use the supply and demand diagram to see how the shift affects equilibrium price and quantity.

## How an increase in demand affects the equilibrium



## How a decrease in supply affects the equilibrium



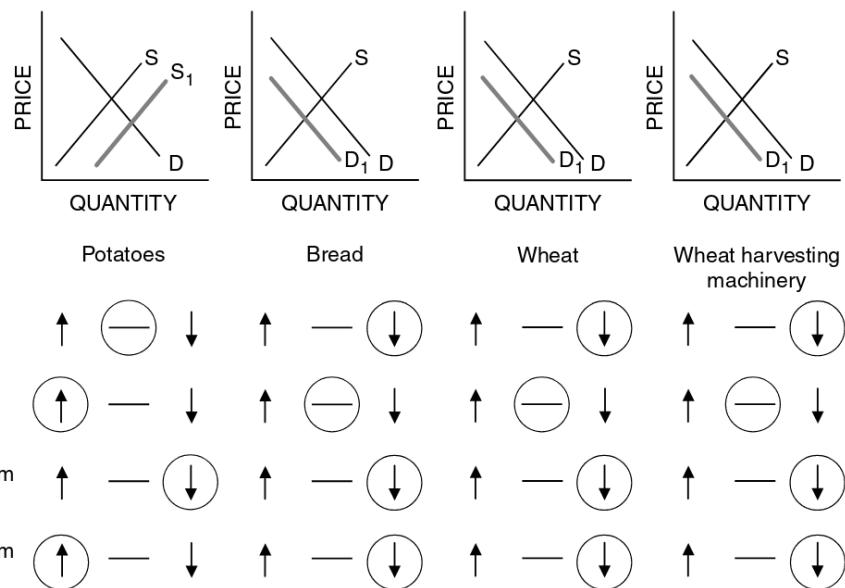
### Exercise 5.8 — Effects of a new fertilizer

(Solution → p. 96)

Assume that a new fertilizer dramatically increases the number of potatoes that can be harvested with no additional labor or machinery. Also assume that this fertilizer does not affect wheat farming and that people are satisfied to eat either potatoes or bread made from wheat flour. Illustrate for both markets, potato and bread, how demand, supply, the equilibrium prices, and quantities change due to the new fertilizer.

### Solution to Exercise 5.8 — Effects of a new fertilizer

(Exercise → p. 95)



Source: Advanced Placement Economics Microeconomics: Teacher Resource Manual Council for Economic Education, New York, N.Y.

### Exercise 5.9 — Effects of a study on coffee

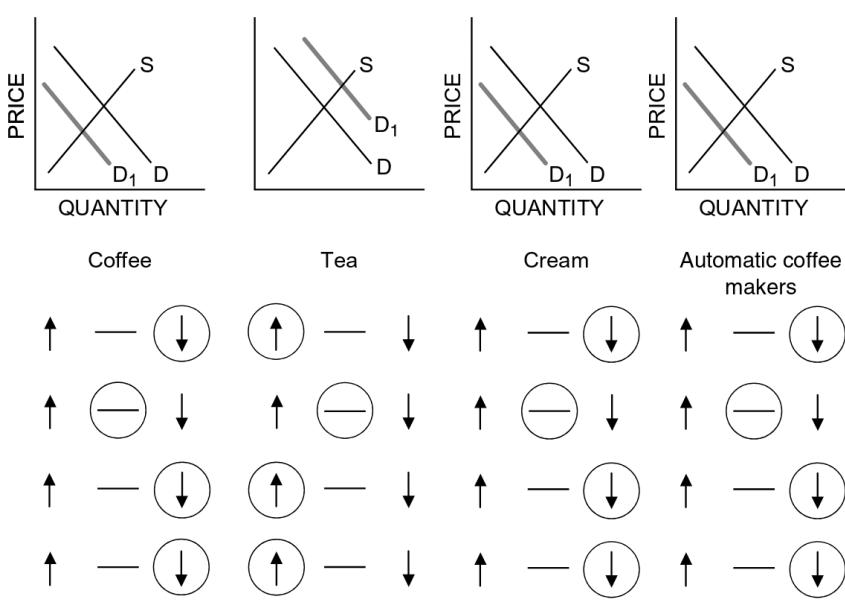
(Solution → p. 96)

Assume new studies show that coffee is worse for people's health than tea and that more people use cream in coffee than in tea.

Illustrate the changes in the markets of coffee, tea, and cream.

### Solution to Exercise 5.9 — Effects of a study on coffee

(Exercise → p. 96)



Source: Advanced Placement Economics Microeconomics: Teacher Resource Manual © Council for Economic Education, New York, N.Y.

### Exercise 5.10 — Housing market

(Solution → p. 97)

- (1) Which of the following factors cause an increase in the demand for houses in Berlin:
- An increase in the annual income of many citizens of Berlin.
  - A reduced rate of immigration into Berlin.
  - Lower interest rates on loans to buy houses.

- (2) The demand for cement in Berlin would (increase / decrease), which would result in (higher / lower) prices for cement in Berlin.  
 (3) Employment of workers who build houses would (increase / decrease) and their wages would (increase / decrease).

### Solution to Exercise 5.10 — Housing market

(Exercise → p. 96)

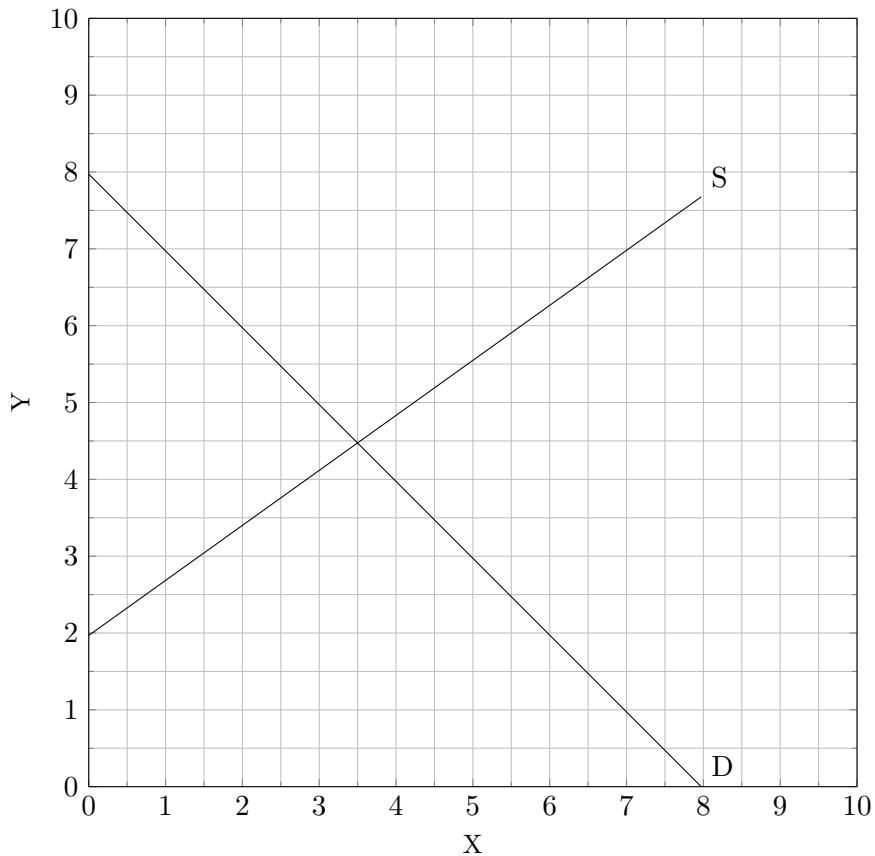
- (1)a, (1)c  
 (2) increase; higher  
 (3) increase; increase

### Exercise 5.11 — Market of supply and demand

(Solution → p. ??)

The following diagram shows the supply and demand schedule for a given good in a closed economy. The supply function is labeled with S and the demand function is labeled with D.

- What will be the equilibrium market price?
- How many items are traded?



## 5.5 How markets allocate resources

### Learning objectives

- Explain what is meant by an efficient allocation of resources in an economy and describe the market conditions that must exist to achieve this goal.
- Define consumer and producer surplus.

Markets use prices as signals to allocate resources to their highest valued uses. Consumers will pay higher prices for goods and services that they value more highly. Producers will devote more resources

to the production of goods and services that have higher prices, other things being equal. And other things being equal, workers will provide more hours of labor to jobs that pay higher salaries.

This allocation principle applies both to product markets for items such as cars, houses, and haircuts and to resource markets for items such as labor, land, and equipment. Households play two important roles in an economy—they demand goods and services and supply resources. Businesses also have dual roles—they supply goods and services and demand resources. The interaction of demand and supply in product and resource markets generates prices that serve to allocate items to their highest valued alternatives. Factors that interfere with the workings of a competitive market result in an inefficient allocation of resources, causing a reduction in society's overall well-being.

### 5.5.1 Efficient allocation of resources

Remember Milton Friedman's words:

*"There was no commissar sending out orders from some central office. It was the magic of the price system: the impersonal operation of prices that brought them together and got them to cooperate, to make this pencil, so you could have it for a trifling sum."*

*"Literally thousands of people cooperated to make this pencil. [...] It was the **magic of the price system** – the impersonal operation of prices that brought them together and got them to cooperate to make this pencil so that you could have it for a trifling sum."*

Also, recall Adam [Smith \(1776\)](#) who wrote in perhaps the most influential book in economics ever written, *An Inquiry into the Nature and Causes of the Wealth of Nations* that the pursuit of self-interest in a marketplace would promote the general interest. He said resources would be guided, as if by an **invisible hand**, to their best uses. That invisible hand was the **marketplace**.

- When the net benefits of all economic activities are maximized, economists say the allocation of resources is **efficient**.
- The concept of an efficient allocation of resources incorporates production, but it includes efficiency in the consumption of goods and services as well.

The 'magic' (usually) only happens if the assumptions of the classical model hold (see: exercise [1.1](#)).

In the upcoming sections, we will discuss some examples where markets are not efficient and welfare is suboptimal. Before that, however, we need to introduce a way to measure welfare.

### 5.5.2 Consumer and producer surplus

In our discussions, we've gained an understanding of market dynamics, exploring how the interplay of supply and demand shapes prices. Now we explore whether the equilibrium achieved in the market is truly optimal for both consumers and suppliers. Consumer surplus and producer surplus are helpful concepts within economics to do welfare analysis. They help us understand the benefits that consumers and producers gain from participating in a market exchange. [Figure 5.3](#) graphically visualizes both surpluses.

Consumer surplus refers to the additional value that consumers receive beyond what they actually pay for a product or service in the market. It is essentially the difference between what consumers are willing to pay for a good or service (their willingness to pay) and the actual price they pay.

On the other side, producer surplus pertains to the benefit that producers receive from market transactions. It's the difference between the price at which producers are willing to supply a good or service and the actual price they receive. This surplus highlights the additional revenue that producers gain beyond what they need to cover their production costs.

Both consumer surplus and producer surplus contribute to the overall economic welfare in a market. Maximizing both surpluses ensures that resources are allocated efficiently, benefiting both sides of the

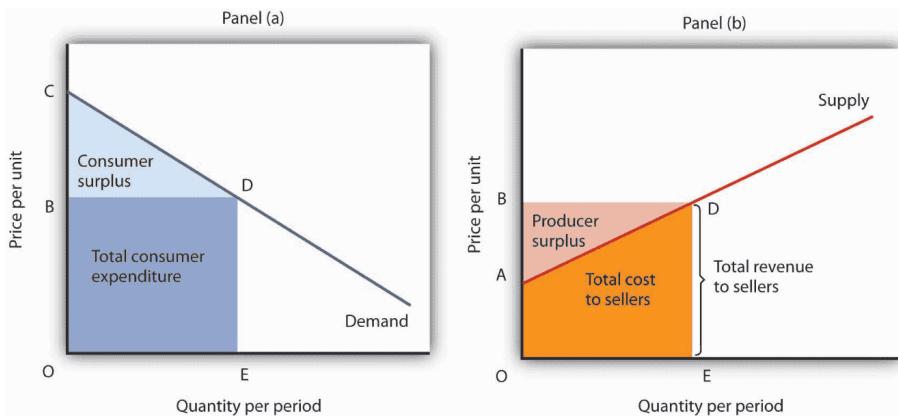


Figure 5.3: Consumer and producer surplus

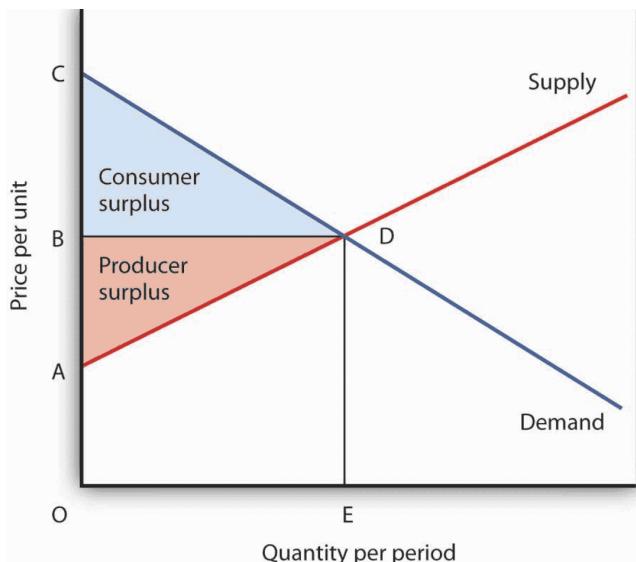


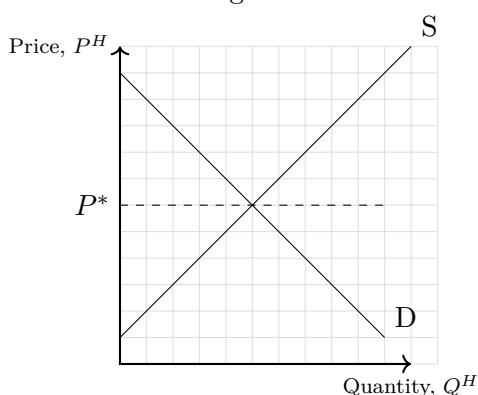
Figure 5.4: Consumer and producer surplus and overall welfare in a free market

exchange and contributing to societal well-being. The equilibrium point where these surpluses are maximized is the point where the demand and supply curves intersect. [Figure 5.4](#) visualizes that.

### Exercise 5.12 — Welfare and taxes

(Solution → p. 100)

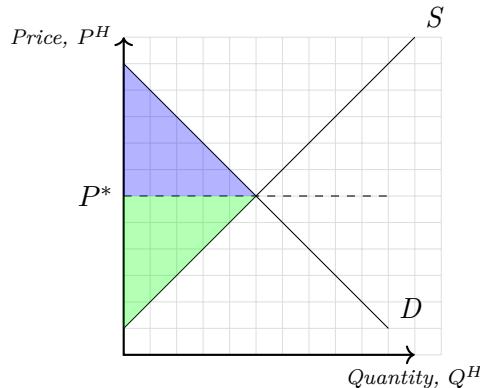
- a) The following diagram shows the supply and demand schedule for a given good in a closed economy, where  $P^* = 6\text{€}$  denotes the equilibrium market price and  $Q^* = 5000$  denotes the equilibrium quantity traded in the market. Calculate producer surplus, consumer surplus, and total welfare and sketch them in the diagram below.



- b) Using the diagram above, discuss the impact of a 16.6 % value-added tax per unit sold (the price consumer now have to pay is 7€) on the quantity traded. Calculate producer surplus, consumer surplus, and total welfare.

### Solution to Exercise 5.12 — Welfare and taxes

(Exercise → p. 99)



- a) The blue triangle represents consumer surplus. The green triangle represents producer surplus. Both surpluses summed up give total welfare.  
 $cs=12500$ ,  $ps=12500$ ,  $tw=25000$
- b)  $cs=8000$ ,  $ps=8000$ ,  $tax=8000$ ,  $tw=24000$

## 5.6 Summary

- Economists use the model of supply and demand to analyze competitive markets.
- In a competitive market, there are many buyers and sellers, each of whom has little or no influence on the market price.
- The demand curve shows how the quantity of a good depends upon the price.
  - According to the law of demand, as the price of a good falls, the quantity demanded rises. Therefore, the demand curve slopes downward.
  - In addition to price, other determinants of how much consumers want to buy include income, the prices of complements and substitutes, tastes, expectations, and the number of buyers.
  - If one of these factors changes, the demand curve shifts.
- The supply curve shows how the quantity of a good supplied depends upon the price.
  - According to the law of supply, as the price of a good rises, the quantity supplied rises. Therefore, the supply curve slopes upward.
  - In addition to price, other determinants of how much producers want to sell include input prices, technology, expectations, and the number of sellers.
  - If one of these factors changes, the supply curve shifts.
- To analyze how any event influences a market, we use the supply and demand diagram to examine how the event affects the equilibrium price and quantity.
- In market economies, prices are the signals that guide economic decisions and thereby allocate resources.
- The equilibrium price is the price at which the quantity demanded equals the quantity supplied. It is determined by the intersection of the demand and supply curves.

- A surplus exists if the quantity of a good or service supplied exceeds the quantity demanded at the current price; it causes downward pressure on price. A shortage exists if the quantity of a good or service demanded exceeds the quantity supplied at the current price; it causes upward pressure on price.
- An increase in demand, all other things unchanged, will cause the equilibrium price to rise; quantity supplied will increase. A decrease in demand will cause the equilibrium price to fall; quantity supplied will decrease.
- An increase in supply, all other things unchanged, will cause the equilibrium price to fall; quantity demanded will increase. A decrease in supply will cause the equilibrium price to rise; quantity demanded will decrease.
- To determine what happens to equilibrium price and equilibrium quantity when both the supply and demand curves shift, you must know in which direction each of the curves shifts and the extent to which each curve shifts.

## 5.7 Glossary

**budget constraint line** shows the possible combinations of two goods that are affordable given a consumer's limited income

**complements** Goods that *go together*; a decrease in the price of results in an increase in demand for the other, and vice versa.

**competitive market** A market in which there are many buyers and many sellers so that each has a negligible impact on the market price.

**consumer equilibrium** when the ratio of the prices of goods is equal to the ratio of the marginal utilities (point at which the consumer can get the most satisfaction).

**deadweight loss** the loss in social surplus that occurs when a market produces an inefficient quantity.

**demand curve** A graph illustrating how much of a given product a household would be willing to buy at different prices.

**demand schedule** A table that shows the relationship between the price of the good and the quantity demanded.

**diminishing marginal utility** the common pattern that each marginal unit of a good consumed provides less of an addition to utility than the previous unit.

**elasticity** A general concept that can be used to quantify the response in one variable when another variable changes.

**equilibrium** The condition that exists when quantity supplied and quantity demanded are equal. At the equilibrium, there is no tendency for price to change.

**excess demand or shortage** The condition that exists when quantity demanded exceeds quantity supplied at the current price.

**excess supply or surplus** The condition that exists when quantity supplied exceeds quantity demanded at the current price.

**giffen good** A good for which, other things equal, an increase in price leads to an increase in demand which is violating the basic law of demand.

**inferior good** A good for which, other things equal, an increase in income leads to a decrease in demand.

**labor supply** It usually refers to the amount of time workers wish to work at a given wage.

**labor demand** It usually refers to the amount of time employers demand work at a given wage.

**law of demand** The claim that, other things equal, the quantity demanded of a good falls when the price of the good rises.

**law of supply** The claim that, other things equal, the quantity supplied of a good rises when the price of the good rises.

**marginal utility** the additional utility provided by one additional unit of consumption.

**marginal utility per dollar** the additional satisfaction gained from purchasing a good given the price of the product; MU/Price.

**market** A group of buyers and sellers of a particular good or service.

**normal good** A good for which, other things equal, an increase in income or a decrease in the price leads to an increase in demand

**perfectly competitive market** Defined by two primary characteristics: (1) the goods being offered for sale are all the same, and (2) the buyers and sellers are so numerous that no single buyer or seller can influence the market price

**perfect substitutes** Identical goods.

**price ceiling** A maximum price that sellers may charge for a good, usually set by the government; a legal maximum price.

**price control** government laws to regulate prices instead of letting market forces determine prices.

**price floor** a legal minimum price.

**producer surplus** the extra benefit producers receive from selling a good or service, measured by the price the producer actually received minus the price the producer would have been willing to accept.

**quantity demanded** the amount of a good that buyers are willing and able to purchase.

**quantity supplied** The amount of a particular good that sellers are willing and able to sale.

**substitutes** Goods that can serve as a replacement for one another; when the price of one increases, demand for the other goes up.

**supply** Supply is the willingness and ability of producers to create goods and services to take them to market.

**supply curve** A graph illustrating how much of a given product a firm will supply at different prices.

**total utility** satisfaction derived from consumer choices.

**demand** Demand refers to the willingness and ability of consumers to purchase a given quantity of a good or service at a given point in time or over a period in time.

## Chapter 6

# Managerial Economics

Please read the lecture note that you find here:

<https://hubchev.github.io/me/>

The PDF of these lecture notes can be downloaded here:

<https://hubchev.github.io/me/Managerial-Economics.pdf>

# Chapter 7

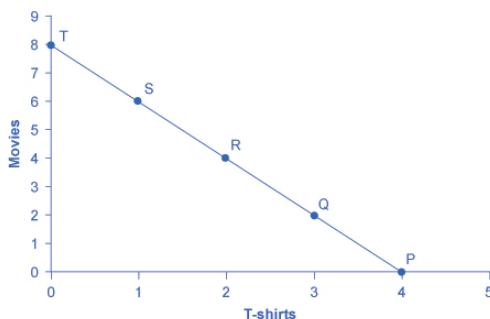
## Consumption and production choices

### 7.1 Decision making at the margin

#### 7.1.1 Total utility and diminishing marginal utility

To understand how a household will make its choices, economists look at what consumers can afford, as shown in a budget constraint line, and the total utility or satisfaction derived from those choices. In a budget constraint line, the quantity of one good is measured on the horizontal axis and the quantity of the other good is measured on the vertical axis. The budget constraint line shows the various combinations of two goods that are affordable given consumer income. Consider the situation of Jose, shown in the following figure. Jose likes to collect T-shirts and watch movies.

A Choice between Consumption Goods. Jose has income of \$56. Movies cost \$7 and T-shirts cost \$14. The points on the budget constraint line show the combinations of movies and T-shirts that are affordable.



Jose wishes to choose the combination that will provide him with the greatest **utility**, which is the term economists use to describe a person's level of satisfaction or happiness with his or her choices.

The table below shows how Jose's utility is connected with his consumption of T-shirts or movies. The most common pattern of total utility, as shown here, is that consuming additional goods leads to greater total utility, but at a decreasing rate. The third column shows marginal utility, which is the additional utility provided by one additional unit of consumption. This equation for marginal utility is:

$$MU = \frac{\text{change in total utility}}{\text{change in quantity}}$$

Notice that marginal utility diminishes as additional units are consumed, which means that each subsequent unit of a good consumed provides less additional utility. This is an example of the law of diminishing marginal utility, which holds that the additional utility decreases with each unit added.

### 7.1.2 Calculating total utility

The question now is how can he maximize his utility? Well, in this case Jose has only five different options because it does not make sense to consume half of a t-shirt. Thus, we simply need to calculate for each of these option his overall utility and go for the highest number which is in point S.

Point	T-Shirts	Movies	Total Utility
P	4	0	$81 + 0 = 81$
Q	3	2	$63 + 31 = 94$
R	2	4	$43 + 58 = 101$
S	1	6	$22 + 81 = 103$
T	0	8	$0 + 100 = 100$

### 7.1.3 Marginal utility per unit of money

Another way to look at this is by focusing on satisfaction per dollar. In other words, the **marginal utility per dollar** is the amount of additional utility Jose receives given the price of the product.

$$\text{marginal utility per dollar} = \frac{\text{marginal utility}}{\text{price}}$$

For Jose's T-shirts and movies, the marginal utility per dollar is shown in [Table 7.1](#).

Table 7.1: Marginal utility and consumers' decision

Quantity of T-Shirts	Total Utility	Marginal Utility	Marginal Utility per Dollar	Quantity of Movies	Total Utility	Marginal Utility	Marginal Utility per Dollar
1	22	22	$22/\$14=1.6$	1	16	16	$16/\$7=2.3$
2	43	21	$21/\$14=1.5$	2	31	15	$15/\$7=2.14$
3	63	20	$20/\$14=1.4$	3	45	14	$14/\$7=2$
4	81	18	$18/\$14=1.3$	4	58	13	$13/\$7=1.9$
5	97	16	$16/\$14=1.1$	5	70	12	$12/\$7=1.7$
6	111	14	$14/\$14=1$	6	81	11	$11/\$7=1.6$
7	123	12	$12/\$14=1.2$	7	91	10	$10/\$7=1.4$

The table stems from [Shapiro et al. \(2022\)](#).

Jose's first purchase will be a movie because it gives him the highest marginal utility per dollar and it is affordable. Jose will keep purchasing movies because they give him a greater *bang or the buck* until the sixth movie is equivalent to a T-shirt purchase. So he will choose to purchase six movies and one T-shirt.

#### Exercise 7.1 — Error in table

(Solution → p. ??)

In [Table 7.1](#) is an error. Can you find it?

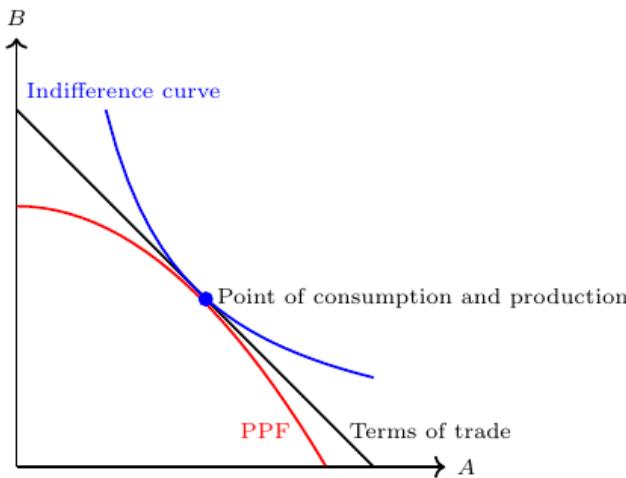


Figure 7.1: Optimal production choice and the terms of trade

**A rule for maximizing utility** This way to come to the optimal choice can be written as a general rule: the utility-maximizing choice between consumption goods occurs where the marginal utility per dollar is the same for both goods:

$$\text{marginal utility per dollar of good 1} = \text{marginal utility per dollar of good 2}$$

$$\begin{aligned}\frac{22}{14} &= \frac{11}{7} \\ 1.6 &= 1.6\end{aligned}$$

## 7.2 Consumption and production choices

In microeconomics, utility maximization (in its simplest form when having just two goods) involves selecting a combination of two goods that satisfies two essential conditions, see figure 7.1:

1. The chosen point of utility maximization must fall within the attainable region defined by the Production Possibility Frontier (PPF) or be affordable within the constraints of a given budget.
2. The selected point of utility maximization must lie on the highest indifference curve that is consistent with the first condition.

These conditions ensure that the consumer selects the optimal bundle of goods that maximizes their utility while taking into account the constraints imposed by production capabilities or budget limitations.

By analyzing production possibilities and individual preferences, economists gain insights into how consumers make choices, allocate resources, and achieve utility maximization. Understanding these concepts helps economists explore the trade-offs and decision-making processes that influence consumer behavior and shape market dynamics.

### 7.2.1 The role of income and budget

If income increases the budget constraint curve shifts outwards (to the right) as shown in figure 7.2.

The utility-maximizing choice on the original budget constraint is M. The dashed horizontal and vertical lines extending through point M allow you to see at a glance whether the quantity consumed of goods on the new budget constraint is higher or lower than on the original budget constraint. On the new budget constraint, a choice like N will be made if both goods are *normal goods*. If good *x* is an *inferior good*, a choice like P will be made. If good *y* is an *inferior good*, a choice like Q will be made.

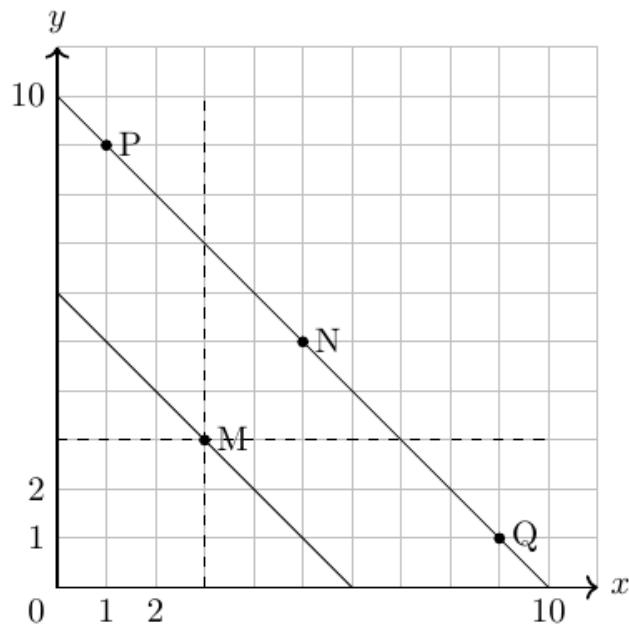


Figure 7.2: Impact of income change on consumption

### 7.2.2 The role of prices

When the price rises, the budget constraint shifts inwards for the good that becomes more expensive. For example, in Figure 7.3 good  $x$  doubles in price and hence the budget line shifts inwards and the old consumption point  $M$  is not attainable anymore. The dashed line make it possible to see at a glance whether the new consumption choice involves less of both goods, or less of one good and more of the other. The new possible choices would be good  $x$ 's and more good  $y$ 's, like point  $H$ , or less of both goods, as at point  $J$ . Choice  $K$  would mean that the higher price of good  $x$  led to exactly the same quantity of good  $x$  being consumed, but fewer of good  $y$ . Choices like  $L$  are theoretically possible (if good  $x$  are giffen goods) but highly unlikely in the real world, because that would mean that a higher price for goods  $x$  means a greater quantity consumed of good  $x$ .

### 7.2.3 Substitution and income effect

When prices increase, individuals typically respond by reducing their consumption of the product with the higher price. This reaction is driven by two factors, both of which can occur simultaneously.

The *substitution effect* occurs when a price change incentivizes consumers to consume less of a good with a relatively higher price and more of a good with a relatively lower price.

The *income effect* stems from the fact that a higher price effectively reduces the purchasing power of income (even if actual income remains the same). This reduction in purchasing power leads to a decrease in the consumption of the good, particularly when the good is considered normal.

Figure 7.4 illustrates the Hicksian decomposition for a price reduction of good  $A$ , which affects the consumption of goods  $A$  and  $B$ , shifting the consumption point from  $C$  to  $D$ . The point  $C'$  represents the hypothetical consumption point resulting from a rotated budget constraint that reflects the new price relationship.

#### Exercise 7.2 — The graphical foundations of demand curves

(Solution → p. ??)

A shift in the budget constraint means that when individuals are seeking their highest utility, the quantity that is demanded of that good will change. In this way, the logical foundations of demand curves—which show a connection between prices and quantity demanded—are based on the underlying idea of individuals seeking utility.

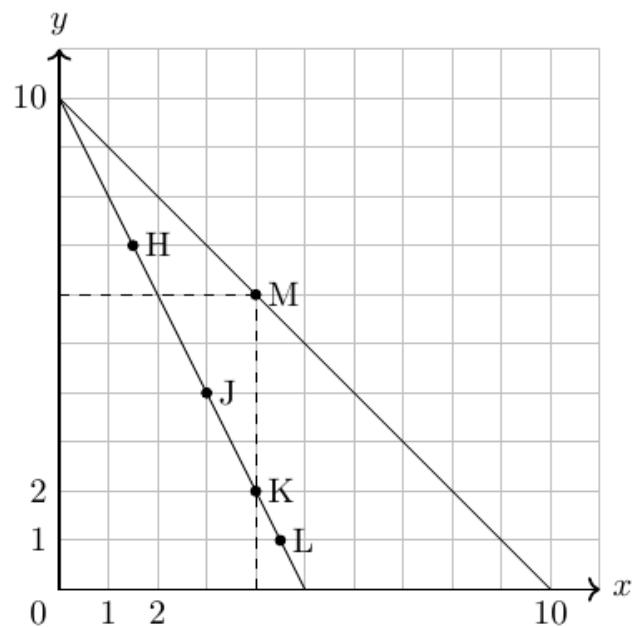


Figure 7.3: Impact of price change on consumption

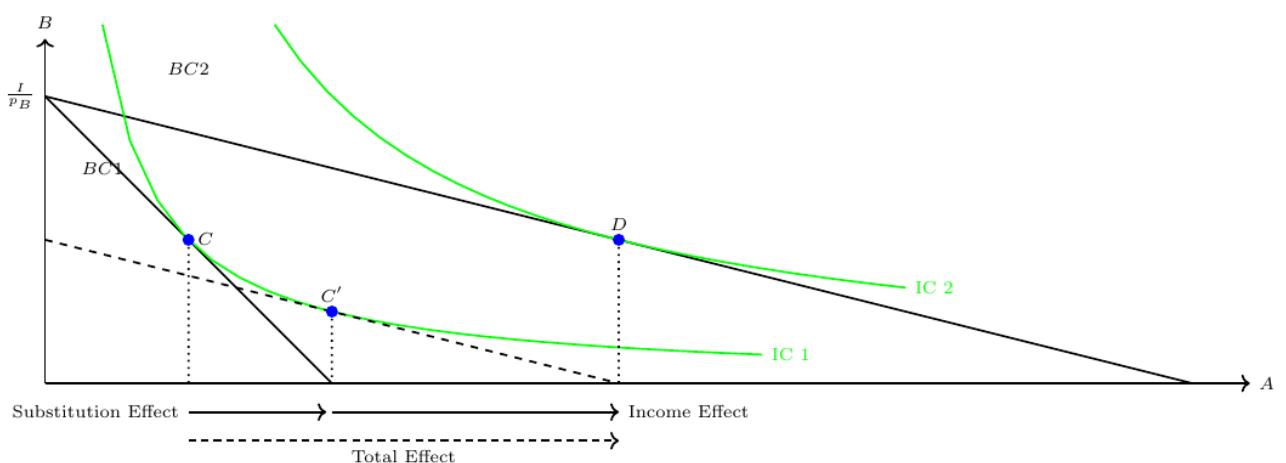


Figure 7.4: Impact of income change on consumption

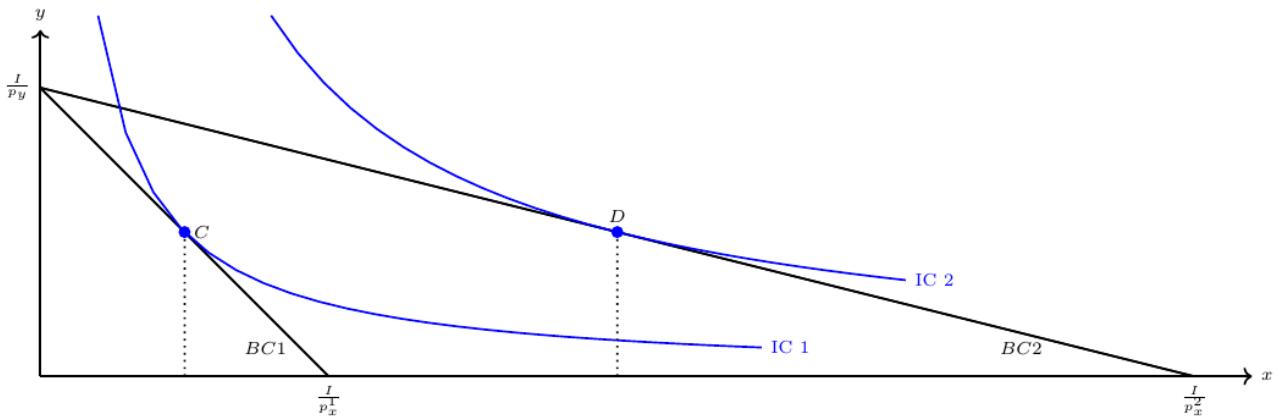


Figure 7.5: Graphical derivation of the demand function

In Figure 7.5, two points of consumption are displayed, illustrating the optimal choices made by customers when faced with prices  $p_x^1 > p_x^2$ . The objective of this exercise is to graphically derive the demand function for good  $x$ . To accomplish this, please provide a second two-dimensional plot below the existing graph, with the price of good  $x$ ,  $p_x$ , represented on the y-axis.

#### 7.2.4 Consumption, production, and terms of trade

Market prices in a closed economy: The price relation of two goods, the so-called terms of trade, is determined by the slope of the Production Possibility Frontier (PPF) at the point where it is tangent to the indifference curve. This relationship highlights the trade-off between the two goods and their relative scarcity within a closed economy.

Utility maximizing production: The production point that maximizes utility is where the PPF is tangent to the price relation, i.e. the *terms of trade*. This principle applies not only in a closed economy (autarky) but also under free trade (open economy). It implies that producers should allocate resources in a way that balances the trade-off between producing more of one good at the expense of another, while considering consumer preferences. Figure 7.1 depicts this.

**Exercise 7.3 — Understanding indifference curves and budget constraints** (Solution → p. 109)

1. Suppose two goods are perfect substitutes<sup>a</sup>. Draw the indifference curves for perfect substitutes.
2. Suppose two goods are perfect complements<sup>b</sup>. Draw the indifference curves for perfect complements.
3. Suppose you have a fixed income  $I = 10$  that you can spend on consuming two goods  $x, y$  at certain prices  $p_x = 1, p_y = 1$ . Draw the budget line consisting of all possible combinations of two goods that a consumer can buy at certain market prices by allocating his income. Using indifference curves, sketch what each consumer should consume to maximize utility.

<sup>a</sup>Two goods are substitutes if they can be used for the same purpose or provide the same utility to the consumer

<sup>b</sup>Two goods are complements if they go well together and the demand for one good is related to the demand for another good. A perfect complement is a good that must be consumed together with another good

**Solution to Exercise 7.3 — Understanding indifference curves and budget constraints** (Exercise → p. 109)

1.  $IC_3$  represents the highest level of utility.  $IC_1$  represents the lowest level of utility.

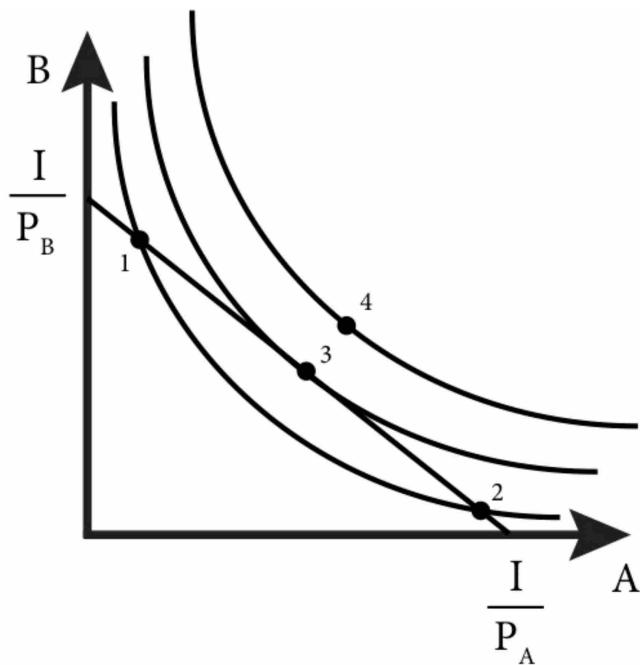


Figure 7.6: Utility maximization  
This graph is taken from Emerson (2019, ch. 4)

2. Task solved in class.
3. Task solved in class.
4. The budget line can be sketched into a  $y$ - $x$  plot by solving  $p_x x + p_y y = I$  for  $y$ :

$$y = \frac{I}{p_y} - \frac{p_x}{p_y} x$$

#### Exercise 7.4 — Utility maximization

(Solution → p. ??)

Figure 7.6 stems from Emerson (2019, ch. 4). Use the following sentences to describe the respective points in the figure.

- Optimal bundle.
- Can do better by trading some B for some A.
- Can do better by trading some A for some B.
- Unaffordable.

Please find solutions to the exercise in Emerson (2019, ch. 4).

#### Exercise 7.5 — Burgers and drinks

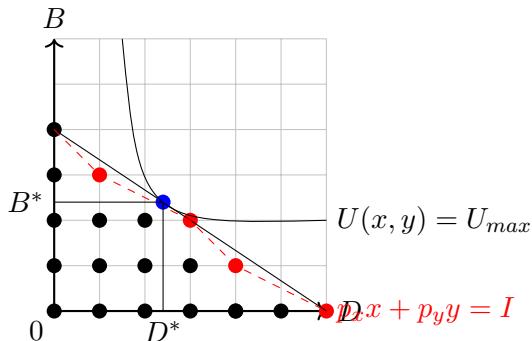
(Solution → p. 111)

Suppose you are in a fast food restaurant and you want to buy burgers and some drinks. You have €12 to spend, a burger costs €3 and a drink costs €2.

- Assume that you want to spend all your money and that you can only buy complete units of each products. What are the possible choices of consumption?
- Given your utility function  $U(x, y) = B^{0.6} D^{0.4}$  calculate for each possible consumption point your overall utility. How will you decide?
- Assume that you want to spend all your money and that both products can be bought on a metric scale where one burger weights 200 grams and a drink is 200 ml. How much of both goods would you consume now? Hint: Use the Lagrangian multiplier method.<sup>a</sup>

<sup>a</sup>Also see: <http://www.sfu.ca/~wainwrig/5701/notes-lagrange.pdf>

- a) In the plot, I marked all 19 possible bundles of burger and drinks of consumption. The budget constraint is shown by the solid line.



- b) We now should calculate the utility of all 19 points but only the red dots denote choices that may yield an optimal utility. The best utility is at when we buy 2 burger and 3 drinks:

$$U = 2^{0.6} 3^{0.4} = 2.35$$

- c) Solve:

$$\mathcal{L} = B^{0.6} D^{0.4} - \lambda(12 - 3B - 2D)$$

FOC:

$$\begin{aligned} 12 - 3B + 2D &= 0 \\ .6B^{-0.4}D^{0.4} + 3\lambda &= 0 \\ .4B^{0.6}D^{-0.6} + 2\lambda &= 0 \end{aligned}$$

Solving the second and third FOC for  $\lambda$ , substituting  $\lambda$  gives:

$$B = D$$

which we can plug in the first FOC to get

$$B^* = 2.4 \quad \text{and} \quad D^* = 2.4$$

## 7.3 Consumption choice using the Lagrangian Multiplier

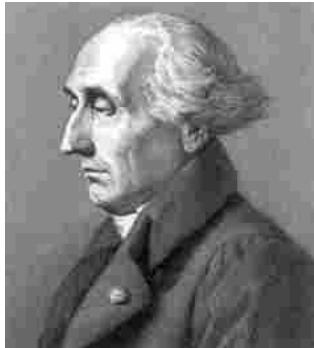
In exercise 7.5 we have seen a method how to make a optimal consumption decision when the numbers of bundles of goods is finite. However, if there is an infinite amount of possibilities a consumer could choose, we need a more advanced method, the Lagrangian Multiplier Method.

### 7.3.1 Lagrangian Multiplier Method

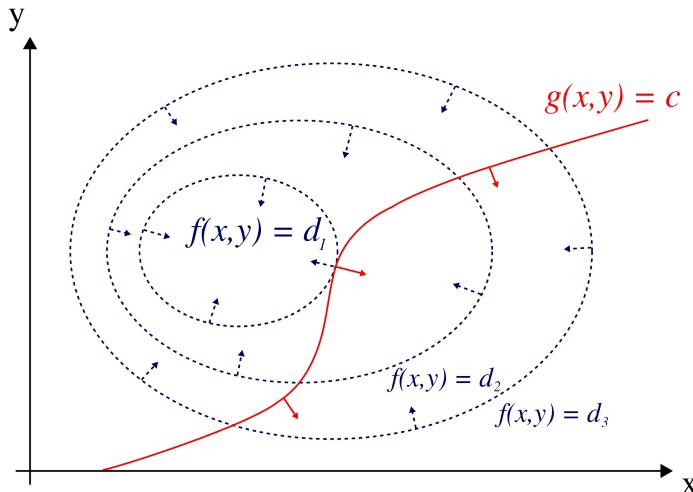
The method is a strategy for finding the local maxima and minima of a function subject to constraints.<sup>1</sup>

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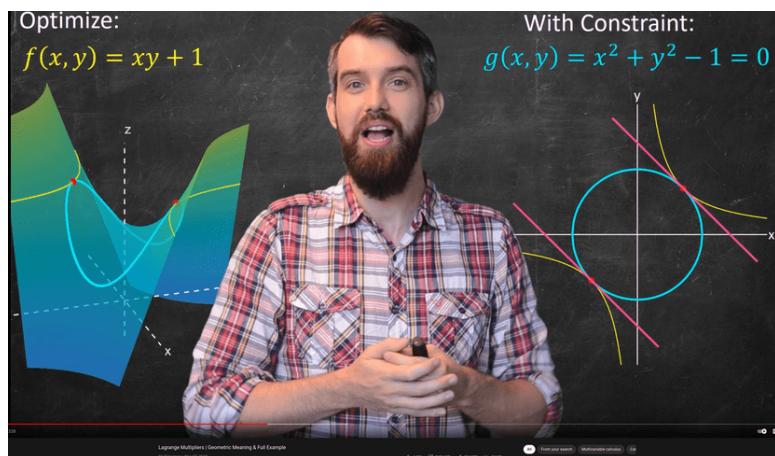
<sup>1</sup>For a detailed mathematical explanation, feel free to watch Aviv Censor's video <https://youtu.be/AxEVJoxv-Z8>.



Joseph-Louis Lagrange  
(1736-1813)



The red curve shows the constraint  $g(x, y) = c$ . The blue curves are contours of  $f(x, y)$ . The point where the red constraint tangentially touches a blue contour is the maximum of  $f(x, y)$  along the constraint, since  $d_1 > d_2$ .



<https://youtu.be/8mjcnxGMwFo>  
Lagrange Multipliers / Geometric Meaning & Full Example

Figure 7.7: Lagrange Multiplier graphically explained

**Step 1: The problem to be solved** The problem that we want to solve can be written in the following way,

$$\begin{aligned} \max_{x,y} \quad & F(x,y) \\ \text{s.t.} \quad & g(x,y) = 0 \end{aligned}$$

where  $F(x,y)$  is the function to be maximized and  $g(x,y) = 0$  is the constraint to be respected. Notice that  $\max_{x,y}$  means that we must solve (maximize) with respect to  $x$  and  $y$ .

**Step 2: Define the Lagrangian Multiplier** Define a new function, the *Lagrangian*  $\mathcal{L}$ , by combining the two functions of the problem and adding the new variable  $\lambda$ . The  $\lambda$  is called the *Lagrange Multiplier*.

$$\mathcal{L}(x,y,\lambda) = F(x,y) - \lambda g(x,y)$$

**Step 3: Find the first order conditions** Differentiate  $\mathcal{L}$  w.r.t.  $x, y$ , and  $\lambda$  and equate the partial derivatives to 0:

$$\begin{aligned} \frac{\partial \mathcal{L}(x,y,\lambda)}{\partial x} = 0 &\Leftrightarrow \frac{\partial F(x,y)}{\partial x} - \lambda \frac{\partial g(x,y)}{\partial x} = 0 \\ \frac{\partial \mathcal{L}(x,y,\lambda)}{\partial y} = 0 &\Leftrightarrow \frac{\partial F(x,y)}{\partial y} - \lambda \frac{\partial g(x,y)}{\partial y} = 0 \\ \frac{\partial \mathcal{L}(x,y,\lambda)}{\partial \lambda} = 0 &\Leftrightarrow g(x,y) = 0 \end{aligned}$$

**Step 4: Solve the system of equations** The solution to the system of three equations above gives the required optimal quantities.

### Exercise 7.6 — Consumption Choice

(Solution → p. 113)

Suppose you want to spend your complete budget of €30,

$$I = 30,$$

on the consumption of two goods,  $A$  and  $B$ . Further assume good  $A$  costs €6,

$$p_A = 6,$$

and good  $B$  costs €4,

$$p_B = 4$$

and that you want to maximize your utility that stems from consuming the two goods. Calculate how much of both goods to buy and consume, respectively, when your utility function is given as

$$U(A,B) = A^{0.8}B^{0.2}$$

### Solution to Exercise 7.6 — Consumption Choice

(Exercise → p. 113)

$$\begin{aligned} \mathcal{L} &= A^{0.8}B^{0.2} - \lambda(30 - 6A - 4B) \\ \text{FOC: } \frac{\partial \mathcal{L}}{\partial \lambda} &= 30 - 6A - 4B = 0 \quad (*) \\ \frac{\partial \mathcal{L}}{\partial A} &= 0.8A^{-0.2}B^{0.2} + 6\lambda = 0 \quad (**) \\ \frac{\partial \mathcal{L}}{\partial B} &= 0.2A^{0.8}B^{-0.8} + 4\lambda = 0 \quad (***) \end{aligned}$$

System of 3 equation with 3 unknowns can be solved in various ways. The easiest way is to solve  $(**)$  and  $(***)$  for  $\lambda$  and substitute it out:

1. solve for  $\lambda$

$$\begin{aligned} -\frac{2}{15}A^{-0.2}B^{0.2} &= \lambda \quad (**') \\ -\frac{1}{20}A^{0.8}B^{-0.8} &= \lambda \quad (***) \end{aligned}$$

2. set both equations equal by substituting  $\lambda$  and solve for  $B$

$$\begin{aligned} \frac{2}{15}A^{-0.2}B^{0.2} &= \frac{1}{20}A^{0.8}B^{-0.8} \\ B &= 0.375A \quad (****) \end{aligned}$$

3. Now, plug in  $(****)$  into  $(*)$  to get a number for  $A$

$$\begin{aligned} 30 &= 6A + 4 \cdot 0.375A \\ \Leftrightarrow 30 &= 7.5A \\ \Leftrightarrow A &= 4 \end{aligned}$$

4. Use  $A = 4$  in  $(*)$  to get a number for  $B$

$$\begin{aligned} 30 &= 6 \cdot 4 + 4B \\ \Leftrightarrow 6 &= 4B \\ B &= \frac{6}{4} = 1.5 \end{aligned}$$

Thus, we'd consume 4 units of good A and 1.5 of good B.

### Exercise 7.7 — Derivation of Demand Function

(Solution → p. 114)

A representative consumer has on average the following utility function:  $U = xy$ , and faces a budget constraint of  $B = P_x x + P_y y$ , where  $B$ ,  $P_x$  and  $P_y$  are the budget and prices, which are given. Solve the following choice problem:

Maximize  $U = xy$  s.t.  $B = P_x x + P_y y$ .

### Exercise 7.8 — Cobb-Douglas and Demand

(Solution → p. 115)

A consumer who has a Cobb-Douglas utility function  $u(x, y) = Ax^\alpha y^\beta$  faces the budget constraint  $px + qy = I$ , where  $A$ ,  $\alpha$ ,  $\beta$ ,  $p$ , and  $q$  are positive constants. Solve the consumer's problem:

$$\max Ax^\alpha y^\beta \quad \text{subject to} \quad px + qy = I$$

### Solution to Exercise 7.7 — Derivation of Demand Function

(Exercise → p. 114)

The Lagrangian for this problem is

$$Z = xy + \lambda(B - P_x x - P_y y)$$

The first order conditions are

$$\begin{aligned} Z_x &= y - \lambda P_x = 0 \\ Z_y &= x - \lambda P_y = 0 \\ Z_\lambda &= B - P_x x - P_y y = 0 \end{aligned}$$

Solving the first order conditions yield the following solutions

$$x^M = \frac{B}{2P_x} \quad y^M = \frac{B}{2P_y} \quad \lambda = \frac{B}{2P_x P_y}$$

where  $x^M$  and  $y^M$  are the consumer's demand functions.

### Solution to Exercise 7.8 — Cobb-Douglas and Demand

(Exercise → p. 114)

The Lagrangian is

$$\mathcal{L}(x, y) = Ax^\alpha y^\beta - \lambda(px + qy - I)$$

Therefore, the first-order conditions are

$$\begin{aligned}\mathcal{L}'_x(x, y) &= A\alpha x^{\alpha-1} y^\beta - \lambda p = 0 & (*) \\ \mathcal{L}'_y(x, y) &= A\alpha x^\alpha \beta y^{\beta-1} - \lambda q = 0 & (**) \\ px + qy - I &= 0 & (***)\end{aligned}$$

Solving (\*) and (\*\*) for  $\lambda$  yields

$$\lambda = \frac{A\alpha x^{\alpha-1} y^{\beta-1} y}{p} = \frac{Ax^{\alpha-1} x \beta y^{\beta-1}}{q}$$

Cancelling the common factor  $Ax^{\alpha-1} y^{\beta-1}$  from the last two fractions gives

$$\frac{\alpha y}{p} = \frac{x \beta}{q}$$

and therefore

$$qy = px \frac{\beta}{\alpha}$$

Inserting this result in (\*\*\* ) yields

$$px + px \frac{\beta}{\alpha} = I$$

Rearranging gives

$$px \left( \frac{\alpha + \beta}{\alpha} \right) = I$$

Solving for  $x$  yields the following demand function

$$x = \frac{\alpha}{\alpha + \beta} \frac{I}{p}$$

Inserting

$$px = qy \frac{\alpha}{\beta}$$

in (\*\*\* ) gives

$$qy \frac{\partial}{\beta} + qy = I$$

and therefore the demand function

$$y = \frac{\beta}{\alpha + \beta} \frac{I}{q}$$

**Solution to Exercise ?? — Derivation of demand function using the Lagrangian multiplier**

(Exercise → p. ??)

The Lagrangian for this problem is

$$Z = xy + \lambda(B - P_x x - P_y y)$$

The first order conditions are

$$\begin{aligned} Z_x &= y - \lambda P_x = 0 \\ Z_y &= x - \lambda P_y = 0 \\ Z_\lambda &= B - P_x x - P_y y = 0 \end{aligned}$$

Solving the first order conditions yield the following solutions

$$x^M = \frac{B}{2P_x} \quad y^M = \frac{B}{2P_y} \quad \lambda = \frac{B}{2P_x P_y}$$

where  $x^M$  and  $y^M$  are the consumer's demand functions.

**Solution to Exercise ?? — Cobb-Douglas and demand**

(Exercise → p. ??)

The Lagrangian is

$$\mathcal{L}(x, y) = Ax^\alpha y^\beta - \lambda(px + qy - I)$$

Therefore, the first-order conditions are

$$\begin{aligned} \mathcal{L}'_x(x, y) &= A\alpha x^{\alpha-1} y^\beta - \lambda p = 0 & (*) \\ \mathcal{L}'_y(x, y) &= A\beta x^\alpha y^{\beta-1} - \lambda q = 0 & (**) \\ px + qy - I &= 0 & (***) \end{aligned}$$

Solving (\*) and (\*\*) for  $\lambda$  yields

$$\lambda = \frac{A\alpha x^{\alpha-1} y^{\beta-1} y}{p} = \frac{A x^{\alpha-1} x \beta y^{\beta-1}}{q}$$

Cancelling the common factor  $Ax^{\alpha-1} y^{\beta-1}$  from the last two fractions gives

$$\frac{\alpha y}{p} = \frac{x \beta}{q}$$

and therefore

$$qy = px \frac{\beta}{\alpha}$$

Inserting this result in (\*\*\* ) yields

$$px + px \frac{\beta}{\alpha} = I$$

Rearranging gives

$$px \left( \frac{\alpha + \beta}{\alpha} \right) = I$$

Solving for  $x$  yields the following demand function

$$x = \frac{\alpha}{\alpha + \beta} \frac{I}{p}$$

Inserting

$$px = qy \frac{\alpha}{\beta}$$

in  $(*)$  gives

$$qy \frac{\partial}{\beta} + qy = I$$

and therefore the demand function

$$y = \frac{\beta}{\alpha + \beta} \frac{I}{q}$$

### Exercise 7.9 — Labor and Machines

(Solution → p. 117)

Suppose you rent a factory for a month to produce as many masks as possible. After you have paid the rent, you need to decide how many machines to buy and how many workers to hire for the given month. What is optimal amount of workers and machines to employ at the given month, if you assume the following:

- $L$  denotes the number of workers
- $K$  denotes the number of machines
- $Q$  denotes the number of masks produced
- $p_L$  denotes the price of a worker for a month
- $p_K$  denotes the price of a machine for a month
- $B$  denotes the money you can invest in the production of masks for the next month
- $B = 216$
- the production of masks can be explained by the following Cobb-Douglas production function:  $Q = K^{0.4}L^{0.6}$
- $p_L = 2$
- $p_K = 8$

### Solution to Exercise 7.9 — Labor and Machines

(Exercise → p. 117)

1. Set up Lagrangian:

$$\mathcal{L} = K^{0.4}L^{0.6} - 216\lambda + 2\lambda L + 8\lambda K$$

2. FOC:

$$0 = .4K^{-0.6}L^0.4 - 8\lambda \quad (*)$$

$$0 = .6K^{-0.4}L^{-0.4} - 2\lambda \quad (**)$$

$$0 = 216 - 2L - 8K \quad (***)$$

3. Solving  $(*)$  and  $(**)$  for  $\lambda$  and substituting  $\lambda$  gives us:

$$\frac{1}{6}L = K \quad (****)$$

4. Plugging  $(****)$  into  $(***)$ , we get

$$0 = 216 - 2L - 8 \cdot \left(\frac{1}{6}L\right) \Rightarrow L = 64\frac{4}{5}$$

5. Using that result in (\*\*\*) *again*, we get

$$216 - 2 \cdot 64 \frac{4}{5} + 8K \Rightarrow K = 10 \frac{4}{5}$$

Thus, the optimal combination of inputs is  $L = 64 \frac{4}{5}$  and  $K = 10 \frac{4}{5}$ .

# Chapter 8

## Elasticity

### Learning Objectives

- Explain the concept of price elasticity of demand and its calculation.
- Explain what it means for demand to be price inelastic, unit price elastic, price elastic, perfectly price inelastic, and perfectly price elastic.
- Explain how and why the value of the price elasticity of demand changes along a linear demand curve.
- Understand the relationship between total revenue and price elasticity of demand.
- Discuss the determinants of price elasticity of demand.

Required Reading:

■ Shapiro et al. (2022, ch. 5)

### 8.1 How to measure an elasticity

- **Elasticity** is the measurement of the percentage change of one economic variable in response to a change in another.
- Here: Elasticity refers to the degree to which individuals, consumers or producers change their demand or the amount supplied in response to price or income changes.
- Elasticity is a **normalized measure**. That means, the units of measurements of the variables (€, Cent, kg, g) do not play a role and that enables us to compare how different goods react to price changes, for example.

**The price elasticity of demand (PED)** The price elasticity of demand is computed as the percentage change in the quantity demanded divided by the percentage change in price:

$$\text{PED} = \frac{\text{Percentage change in quantity demanded}}{\text{Percentage change in price}} = \frac{\frac{q_{t=\text{today}} - q_{t=\text{yesterday}}}{q_{t=\text{yesterday}}}}{\frac{p_{t=\text{today}} - p_{t=\text{yesterday}}}{p_{t=\text{yesterday}}}}$$

#### Exercise 8.1 — How Rachel's demand reacts to changes in price

(Solution → p. 120)

Rachel's demand curve is linear. Her demand decreases from **10 to 6** litres of milk if the price increases from **50 to 70** cent. Suppose you know that Rachel's demand curve for cookies is also linear and that her demand decreases from **3 to 1** cookies if the price increases from **20 to 40** cent.

As the prices changed in both cases by 20 cent, can we say that she reacts more sensitive to prices of milk as compared to cookies because she buys 4 units more of milk and just 2 units less of cookies?

### Solution to Exercise 8.1 — How Rachel's demand reacts to changes in price (Exercise → p. 119)

*No, we cannot without talking about elasticities. We would compare apples with pears, or here: cookies with milk, i.e., the unit of measurement is different.*

*So, let us calculate the elasticities:*

**Example milk:** If the price of a litre milk increases from €0.50 to €0.70 and the amount demanded falls from 10 to 6 litres, then the price elasticity of demand (PED) for milk is calculated as:

$$PED_{milk}^* = \frac{\frac{6-10}{10} \cdot 100}{\frac{(\€.70-\€.50)}{\€.50} \cdot 100} = -1$$

**Example cookie:** If the price of a cookie increases from €0.20 to €0.40 and the amount demanded falls from 3 to 1 cookie, then the price elasticity of demand (PED) for cookies is

$$PED_{cookie}^* = \frac{\frac{1-3}{3} \cdot 100}{\frac{(\€.40-\€.20)}{\€.20} \cdot 100} = -\frac{2}{3}$$

That means, if the price increases by 1%, Rachel will demand 1% less of milk and  $\frac{2}{3}\%$  less cookies. Thus, we can say she is more price sensitive to milk.

### Exercise 8.2 — Check for Units of Measurement and Direction of Change (Solution → p. 120)

- a) Assume a cookie weights 100g and we use \$ as currency with one Dollar is equal to 0.86 Euros. Recalculate the  $PED_{cookie}$  using g as the unit of measurement.
- b) You have heard that problem with the *simple* method of calculation is that the precise magnitude of the elasticity depends on the direction of change. Thus, calculate the elasticities if the prices decrease from €0.70 to €0.50 and from €0.20 to €0.40, respectively. In other words, assume that quantities and prices from the earlier example change in the opposite direction.

### Solution to Exercise 8.2 — Check for Units of Measurement and Direction of Change (Exercise → p. 120)

- a) **Check: Units of Measurement** To exchange 0.20€ to \$, calculate:

$$0.40\text{€} \cdot \frac{1\$}{0.86\text{€}} = .465116279\$$$

and hence  $.20\text{€} = .23255814\$$ . Then,

$$PED_{cookie}^* = \frac{\frac{100g-300g}{300g} \cdot 100}{\frac{(.465116279-\$.23255814)}{\$.23255814} \cdot 100} = -\frac{2}{3}$$

*Check: it remains the same.*

- b) **Check: Direction of Change**

$$PED_{milk}^* = \frac{\frac{10-6}{6} \cdot 100}{\frac{(\€.50-\€.70)}{\€.70} \cdot 100} = \frac{\frac{2}{3}}{\frac{2}{7}} = -\frac{7}{3}$$

$$PED_{cookie}^* = \frac{\frac{3-1}{1} \cdot 100}{\frac{(\epsilon.20 - \epsilon.40)}{\epsilon.40} \cdot 100} = -4$$

The result is much different. Thus, this way of calculation cannot be a good one. **Solution**  
 ⇒ **Midpoint Method**

## 8.2 Midpoint method

The midpoint formula computes percentage changes by dividing the change by the average value (i.e., the midpoint) of the initial and final value. It is independent of the direction of change and hence is preferable to the *simple* method. For example, when a change in price from  $P_1$  to  $P_2$  comes along with a change in demand from  $Q_1$  to  $Q_2$  the formula can be written like this:

$$\text{Price Elasticity of Demand (PED)} = \frac{\frac{Q_2 - Q_1}{\left(\frac{(Q_2 + Q_1)}{2}\right)}}{\frac{(P_2 - P_1)}{\left(\frac{(P_2 + P_1)}{2}\right)}}$$

In short:  $PED = \frac{\Delta Q/\bar{Q}}{\Delta P/\bar{P}}$

Note that omitting ".100" from both the numerator and denominator, using the  $\Delta$  symbol to denote a difference, and denoting the average of the two values by a bar allow the formula to be simplified.

In more general terms, the elasticity of two variables,  $x$  and  $y$ , can be denoted like this:

$$\epsilon_{y,x} = \frac{\Delta y / \bar{y}}{\Delta x / \bar{x}}$$

### Exercise 8.3 — Midpoint Method and the Direction of Change (Solution → p. 121)

Check if applying the midpoint method is really a solution, i.e., the elasticities of milk and cookies are direction of change.

### Solution to Exercise 8.3 — Midpoint Method and the Direction of Change (Exercise → p. 121)

$$PED_{milk} = \frac{\frac{10-6}{(10+6)/2}}{\frac{(.50-.70)}{(.50+.70)/2}} = -\frac{3}{2} = -1.5$$

$$PED_{milk} = \frac{\frac{6-10}{(6+10)/2}}{\frac{(.70-.50)}{(.70+.50)/2}} = -1.5$$

$$PED_{cookie} = \frac{\frac{1-3}{4}}{\frac{(.40-.20)}{(.20-.40)/.30}} = -.375$$

$$PED_{cookie} = \frac{\frac{3-1}{4}}{\frac{(.20-.40)}{(.20-.40)/.30}} = -.375$$

Thus, a 1% increase in price will lead to a drop in quantity demanded of 1.5% for milk and .375% for cookies.

## 8.3 Elasticity and demand

### 8.3.1 Terms: Elastic, inelastic, perfect elastic, and perfect inelastic

- The PED is called **perfectly elastic** if  $|PED| \rightarrow \infty$ , i.e., quantity has an infinite response to even a small price change and
- **perfectly inelastic** if  $PED = 0$ , i.e., quantity does not respond at all to a price change.
- Moreover, we speak of **price inelastic demand**: if  $0 < |PED| < 1$ , i.e., the quantity demanded does not respond strongly to price changes, and of
- **price elastic demand** if  $|PED| > 1$ , i.e., the quantity demanded responds strongly to price changes.

Because the price elasticity of demand measures by how much quantity demanded responds to the price, it is closely related to the slope of the demand curve. However, the slope of the demand curve does not give you the PED, see: [122!](#)

#### Exercise 8.4 — Sketch Demand Curves

(Solution → p. ??)

1. Sketch demand curves for
  - Normal goods with price inelastic demand
  - Normal goods with perfect price inelastic demand
  - Normal goods with price elastic demand
  - Normal goods with perfect price elastic demand
2. Do the same for a *giffen good*.

#### Determinants of the PED

- Availability of close substitutes
- Necessities versus luxuries
- Time horizon

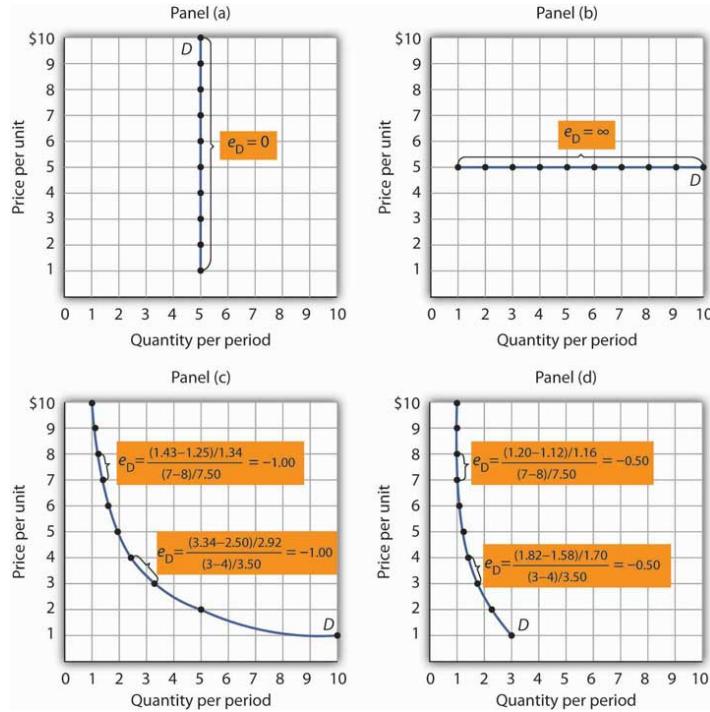
#### Demand tends to be more elastic:

- The larger the number of close substitutes.
- If the good is a luxury.
- The longer the time period (not always).

#### Price elasticity of a linear demand curve

- The slope of a linear demand curve is constant, but the elasticity is not.
  - At points with a low price and a high quantity, demand is inelastic.
  - At points with a high price and a low quantity, demand is elastic.
- Total revenue also varies at each point along the demand curve.
- Demand curves that exhibit a constant price elasticity are called *iso-elastic*.

### 8.3.2 Constant price elasticities



Source: Anon (2020, P. 154)

### 8.3.3 Be careful not to confuse elasticity with slope.

The slope of a line is the change in the value of the variable on the vertical axis divided by the change in the value of the variable on the horizontal axis between two points. Elasticity is the ratio of the percentage changes. The slope of a demand curve, for example, is the ratio of the change in price to the change in quantity between two points on the curve. The price elasticity of demand is the ratio of the percentage change in quantity to the percentage change in price. As we will see, when computing elasticity at different points on a linear demand curve, the slope is constant—that is, it does not change—but the value for elasticity will change.

## 8.4 Responsiveness of demand to other factors

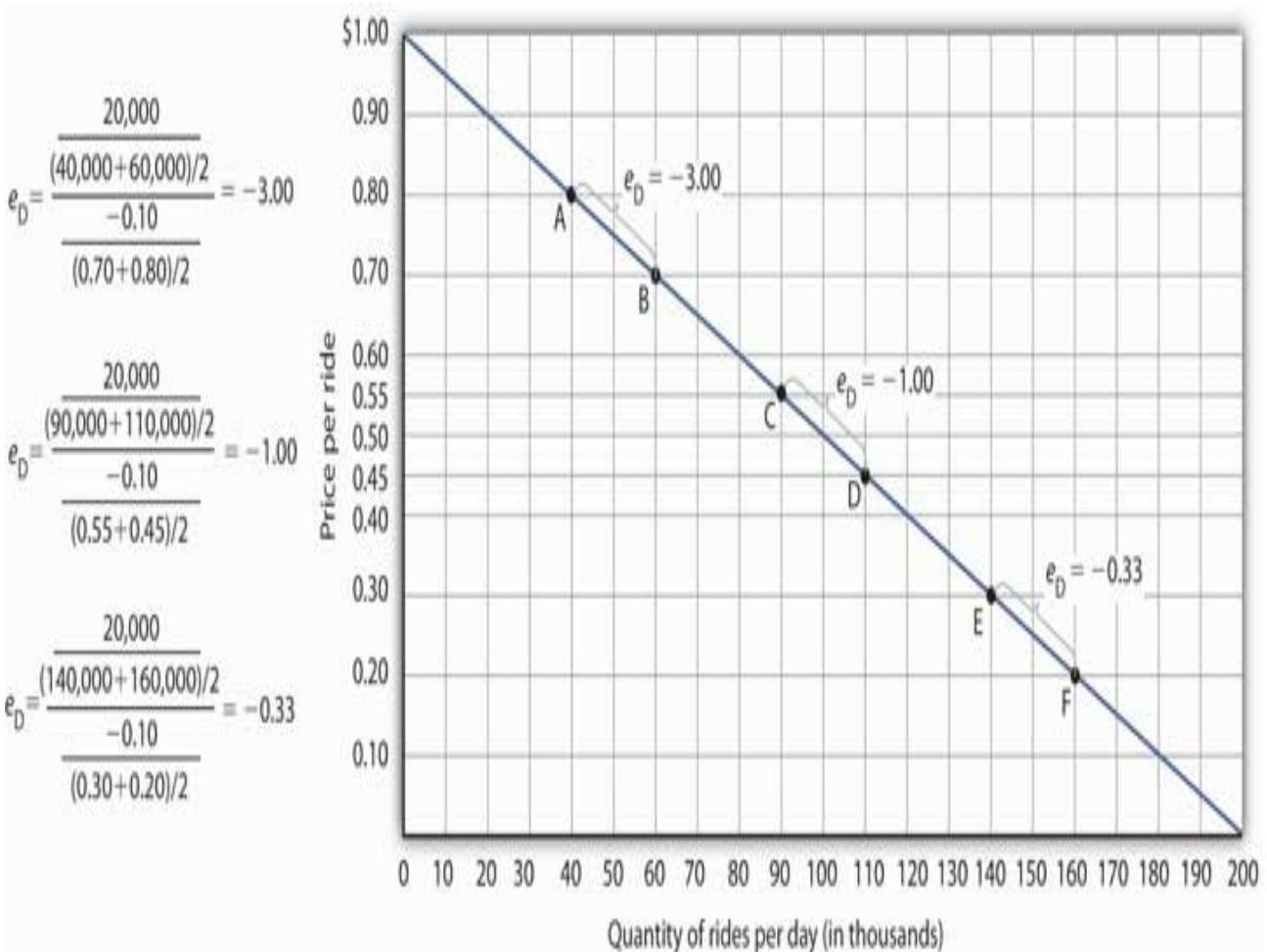
### 8.4.1 Income elasticity of demand

- Income elasticity of demand (IED) measures how much the quantity demanded of a good changes if the income changes.
- It is measured as the ratio of the percentage change in quantity demanded to the percentage change in income:

$$IED = \frac{\Delta Q / \bar{Q}}{\Delta I / \bar{I}}$$

### 8.4.2 Income elasticity of demand: Categorization

- Positive income elasticity: Normal goods ( $IED > 0$ )  
→ For a given price, the quantity demanded increases with increasing income
- Low positive income elasticity: income-inelastic demand ( $0 < IED < 1$ ) → Necessities such as food, heating, clothing
- High positive income elasticity: Income elastic demand ( $1 < IED$ )  
→ Luxury goods. Examples: Sports cars, furs, champagne



Source: Anon (2020, P. 148)

Figure 8.1: Price Elasticities of Demand for a Linear Demand Curve

- Negative income elasticity: Inferior goods ( $IED < 0$ )
  - At a given price, the quantity demanded falls with increasing income. **Examples:** cheap substitutes, supermarket coffee

#### Exercise 8.5 — Income and Normal and Inferior Goods in Demand

(Solution → p. ??)

Fill in the blanks: For **normal goods**:

- An increase in income \_\_\_\_\_ (increases/decreases) demand.
- An decrease in income \_\_\_\_\_ (increases/decreases) demand.

For **inferior goods**:

- An increase in income \_\_\_\_\_ (increases/decreases) demand.
- An decrease in income \_\_\_\_\_ (increases/decreases) demand.

#### 8.4.3 Cross-price elasticity of demand

The cross-price elasticity of demand (CPED) is a measure of how much the quantity demanded of one good responds to a change in the price of another good.

$$CPED = \frac{\% \text{ change in quantity demanded of good 1}}{\% \text{ change in price of good 2}}$$

Substitutes have positive cross-price elasticities, while complements have negative cross-price elasticities.

**Interpretation:** If the cross-price elasticity is for example one ( $CPED=1$ ), then an increase of the price of good 2 increases the demand of good 1. Thus, the two goods are in a competitive relationship,

i.e., they are substitutes.

### Exercise 8.6 — Prices across Goods and Demand

(Solution → p. ??)

Fill in the blanks: For **substitutes** A and B:

- An increase in  $P_B$  \_\_\_\_\_ (increases/decreases) demand for good A.
- An decrease in  $P_B$  \_\_\_\_\_ (increases/decreases) demand for good A.

For **complements** A and B:

- An increase in  $P_B$  \_\_\_\_\_ (increases/decreases) demand for good A.
- An decrease in  $P_B$  \_\_\_\_\_ (increases/decreases) demand for good A.

## 8.5 Demand and revenue

### 8.5.1 The price elasticity of demand and revenue

Total revenue is the amount paid by buyers and received by sellers of a good. It is computed as the price of the good times the quantity sold.

$$\pi = p \cdot q$$

with  $\pi$  denoting the total revenue,  $p$  being the price, and  $q$  the quantity of goods.

The problem in assessing the impact of a price change on total revenue of a good or service is that a **change in price always changes the quantity demanded in the opposite direction**. An increase in price reduces the quantity demanded, and a reduction in price increases the quantity demanded. The question is how much. Because total revenue is found by multiplying the price per unit times the quantity demanded, it is not clear whether a change in price will cause total revenue to rise or fall.

Consider the following three examples of price increases for gasoline, pizza, and diet cola.

**Gasoline—an increase in price can increase total revenue.** Suppose that 1,000 gallons of gasoline per day are demanded at a price of \$4.00 per gallon. Total revenue for gasoline thus equals \$4,000 per day (=1,000 gallons per day times \$4.00 per gallon). If an increase in the price of gasoline to \$4.25 reduces the quantity demanded to 950 gallons per day, total revenue rises to \$4,037.50 per day (=950 gallons per day times \$4.25 per gallon). Even though people consume less gasoline at \$4.25 than at \$4.00, total revenue rises because the higher price more than makes up for the drop in consumption.

**Pizza—price increase left total revenue unchanged** Suppose 1,000 pizzas per week are demanded at a price of \$9 per pizza. Total revenue for pizza equals \$9,000 per week (=1,000 pizzas per week times \$9 per pizza). If an increase in the price of pizza to \$10 per pizza reduces quantity demanded to 900 pizzas per week, total revenue will still be \$9,000 per week (=900 pizzas per week times \$10 per pizza). Again, when price goes up, consumers buy less, but this time there is no change in total revenue.

**Cola—price increase in price can decrease reduced total revenue** Suppose 1,000 cans of diet cola per day are demanded at a price of \$0.50 per can. Total revenue for diet cola equals \$500 per day (=1,000 cans per day times \$0.50 per can). If an increase in the price of diet cola to \$0.55 per can reduces quantity demanded to 880 cans per month, total revenue for diet cola falls to \$484 per day (=880 cans per day times \$0.55 per can). As in the case of gasoline, people will buy less diet cola when the price rises from \$0.50 to \$0.55, but in this example total revenue drops.

Is there a way to predict how a price change will affect total revenue? There is; the **effect depends on the price elasticity of demand**.

### Exercise 8.7 — Elasticity and total revenue

(Solution → p. ??)

 Read in chapter 4 of Parkin (2012) the section *Total Revenue and Elasticity*.

- Sketch the relationship of elasticity and total revenue.
- Explain the *Laffer curve*. See  [https://en.wikipedia.org/wiki/Laffer\\_curve](https://en.wikipedia.org/wiki/Laffer_curve)

### Exercise 8.8 — Prices and revenue

(Solution → p. ??)

Fill in the blanks: When demand is price elastic:

- An increase in price \_\_\_\_\_ (reduces/increases) total revenue.
- An reduction in price \_\_\_\_\_ (reduces/increases) total revenue.
- The following statement is \_\_\_\_ (true/false): Total revenue moves in the direction of the direction of the quantity change.

When demand is price inelastic:

- An increase in price \_\_\_\_\_ (reduces/increases) total revenue.
- An reduction in price \_\_\_\_\_ (reduces/increases) total revenue.
- The following statement is \_\_\_\_ (true/false): Total revenue moves in the direction of the direction of the price change.

When demand is unit price elastic:

- An increase in price \_\_\_\_\_ (has no change in/increases/decreases) total revenue.
- An reduction in price \_\_\_\_\_ (has no change in/increases/decreases) total revenue.
- The following statement is \_\_\_\_ (true/false): Total revenue does not change as prices changes.

### Exercise 8.9 — Prices elasticities and revenues

(Solution → p. 126)

 Suppose the market demand and supply for milk is given as follows (Note: price is measured in € and milk is measured in litre):

$$Q^D = 30 - 30P$$

$$Q^S = 30P - 3.$$

- Draw the market supply and market demand in a two way plot.
- Calculate the equilibrium price in € and quantity sold.
- Calculate the total revenue.
- Assume that a fixed price of €0.60 is set for milk. Calculate the equilibrium quantity sold and total revenue.
-  READ: <https://courses.lumenlearning.com/economics2e-demo/chapter/calculating-price-elasticities-using-the-midpoint-formula/> and answer the “TRY IT” question there.  
 Additionally, answer the following question: Calculate the price elasticity of demand (PED) when the price changes from €0.55 to €0.60. Is the PED (1) inelastic, (2) perfect inelastic, (3) elastic or (4) perfect elastic.

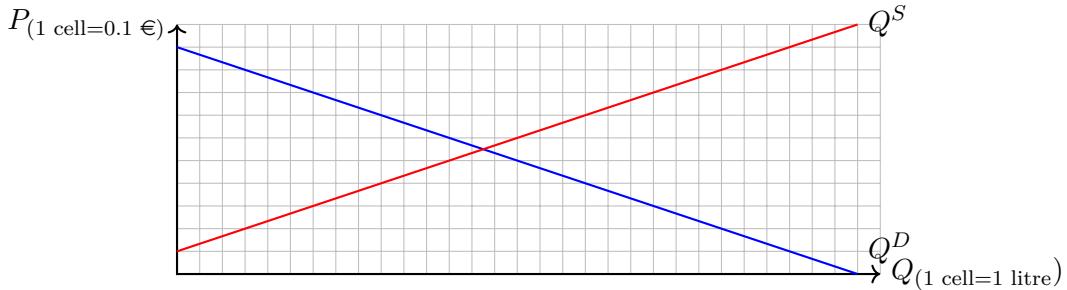
### Solution to Exercise 8.9 — Prices elasticities and revenues

(Exercise → p. 126)

- As we usually draw market supply and demand, respectively, with the price on the y-axis, it is helpful to solve both equations for P. Doing so allows to see the constant term and the

intercept of zero.

$$\begin{aligned}
 Q^D &= 30 - 30P \\
 \Leftrightarrow Q &- 30 = -30P \\
 \Leftrightarrow -Q^D + 30 &= 30P \\
 \Leftrightarrow -\frac{1}{30}Q^D + 1 &= P \\
 \Leftrightarrow P &= 1 - \frac{1}{30}Q^D \\
 Q^S &= 30P - 3 \\
 \Leftrightarrow Q^S + 3 &= 30P \\
 \Leftrightarrow P &= 0.1 + \frac{1}{30}Q^S
 \end{aligned}$$



b) Set  $Q^D = Q^S$  and solve for  $P$ :

$$\begin{aligned}
 30 - 30P &= 30P - 3 \\
 \Leftrightarrow -60P &= -33 \\
 \Leftrightarrow P^* &= \frac{33}{60} = 0.55
 \end{aligned}$$

Then, it is straightforward to calculate the equilibrium quantity. Simply plug in  $P^*$  in the market demand or market supply equations or use the two equations we derived in exercise a).

$$30 - 30 \cdot 0.55 = 30 - 16.5 = 13.5$$

$$30 \cdot 0.55 - 3 = 16.5 - 3 = 13.5$$

Or:

$$\begin{aligned}
 0.1 + \frac{1}{30}Q &= 1 - \frac{1}{30}Q \Leftrightarrow \frac{2}{30}Q = 0.9 \\
 Q &= \frac{30}{2} \cdot 0.9 = 13.5
 \end{aligned}$$

c) The total revenue is €7.425:

$$TR = 13.5 \cdot 0.55 = 7.425$$

d) As the price of €0.60 is higher than the equilibrium price of the free market, supply will exceed demand:

$$\begin{aligned}
 Q^D &= 30 - 30 \cdot 0.6 = 12 \\
 Q^S &= 30 \cdot 0.6 - 3 = 15
 \end{aligned}$$

Only 12 litres of milk will be sold and total revenue is €7.2:

$$TR = 12 \cdot 0.6 = 7.2$$

e)

$$PED = \frac{\frac{13.5-12}{(13.5+12)/2}}{\frac{(.55-.60)}{(.60+.55)/2}} = \frac{\frac{1.5}{12.75}}{\frac{-0.05}{0.575}} = \frac{0.117647059}{-0.086956522} = -1.352941174$$

A PED of -1.35 indicates that milk is a price-elastic good.

## 8.6 Elasticity and supply

- The quantity supplied of a good or service is the quantity sellers are willing to sell at a particular price during a particular period, all other things unchanged.
- The price elasticity of supply (PES) is a measure of how much the quantity supplied of a good responds to a change in the price of that good.
- The measure is analogous to the PED but with the quantity of goods supplied,  $S$ , instead of the quantity of goods demanded,  $D$ .

### Exercise 8.10 — Sketch supply curves

(Solution → p. ??)

Sketch a

- price inelastic supply curve
- perfect price inelastic supply curve
- price elastic supply curve
- perfect price elastic supply curve

### 8.6.1 Determinants of price elasticity of supply

- **Time period:** Supply is more price elastic in the long run
- Productive capacity and the ability of sellers to change the amount of the good they produce
  - Supply of beach-front land is price inelastic
  - Supply of books, cars, or manufactured goods is elastic
- Size of the firm or industry
  - Mobility of the factors of production
  - Ease of storing stock or inventories

### 8.6.2 Examples for different price elasticities

- **Perfectly Elastic Demand:** Luxury goods with close substitutes (sports cars, yachts, ...)
- **Perfectly Inelastic Demand:** Live-Saving Drugs
- **Perfectly Elastic Supply:** Goods where supply can be easily expanded (Cola, Pizza, ...)
- **Perfectly Inelastic Supply:** Single and/or unique items (e.g., in art or architecture)

### Exercise 8.11 — Labor supply and labor demand

(Solution → p. ??)

A **labor supply curve** shows the number of workers who are willing and able to work in an occupation at different wages. A **labor demand curve** shows the number of workers firms are willing and able to hire at different wages.

- Can you analyze the impact of a minimum wage law given when labor supply increases

- with higher wages and labor demand decreases with higher wages.
- Analyze the impact of a minimum wage when labor supply is perfectly inelastic.

## 8.7 Summary

- The price elasticity of demand measures the responsiveness of quantity demanded to changes in price; it is calculated by dividing the percentage change in quantity demanded by the percentage change in price.
- Demand is price inelastic if the absolute value of the price elasticity of demand is less than 1 and it is price elastic if the absolute value is greater than 1.
- Demand is price elastic in the upper half of any linear demand curve and price inelastic in the lower half. It is unit price elastic at the midpoint.
- The income elasticity of demand reflects the responsiveness of demand to changes in income. It is the percentage change in quantity demanded at a specific price divided by the percentage change in income.
- Income elasticity is positive for normal goods and negative for inferior goods.
- The cross-price elasticity of demand measures how much the quantity demanded of one good responds to the price of another good.
- Cross price elasticity is positive for substitutes, negative for complements, and zero for goods or services whose demands are unrelated.
- When demand is price inelastic, total revenue moves in the direction of a price change. When demand is unit price elastic, total revenue does not change in response to a price change. When demand is price elastic, total revenue moves in the direction of a quantity change.
- The absolute value of the price elasticity of demand is greater when substitutes are available, when the good is important in household budgets, and when buyers have more time to adjust to changes in the price of the good.
- The price elasticity of supply measures the responsiveness of quantity supplied to changes in price. It is the percentage change in quantity supplied divided by the percentage change in price. It is usually positive.
- Supply is price inelastic if the price elasticity of supply is less than 1; it is unit price elastic if the price elasticity of supply is equal to 1; and it is price elastic if the price elasticity of supply is greater than 1. A vertical supply curve is said to be perfectly inelastic. A horizontal supply curve is said to be perfectly elastic.
- The price elasticity of supply is greater when the length of time under consideration is longer because over time producers have more options for adjusting to the change in price.
- When applied to labor supply, the price elasticity of supply is usually positive but can be negative. If higher wages induce people to work more, the labor supply curve is upward sloping and the price elasticity of supply is positive. In some very high-paying professions, the labor supply curve may have a negative slope, which leads to a negative price elasticity of supply.

# Chapter 9

## Market failure

### 9.1 The perfect market

The assumptions of perfect markets and perfect competition, respectively, are:

1. **Many buyers and sellers:** In a perfectly competitive market, there are numerous buyers and sellers, none of whom have a significant influence over market price. Each participant is a price taker, meaning they have no control over the price at which goods or services are exchanged.
2. **Homogeneous products:** The products offered by all firms in a perfectly competitive market are identical or homogeneous. Consumers perceive no differences between the goods or services provided by different sellers. As a result, buyers base their purchase decisions solely on price.
3. **Perfect information:** All buyers and sellers in a perfectly competitive market have complete and accurate information about prices, quality, availability, and other relevant factors. This assumption ensures that market participants can make rational decisions and respond efficiently to changes in market conditions.
4. **Free entry and exit:** Firms can freely enter or exit the market in response to profits or losses. There are no barriers to entry or exit, such as legal restrictions or substantial costs, that prevent new firms from entering the market or existing firms from leaving it.
5. **Perfect mobility of factors of production:** The resources used in production, such as labor and capital, can move freely between different firms and industries. There are no constraints on the mobility of factors of production, allowing firms to allocate resources efficiently.
6. **Profit maximization:** All firms in a perfectly competitive market are profit maximizers. They aim to maximize their profits by adjusting their output levels based on prevailing market conditions. If firms can increase their profits, they will expand production, and if they incur losses, they will reduce output or exit the market.
7. **No externalities and no transaction costs:** There are assumed to be no externalities and transaction costs. That means, there exist no external costs or benefits to third parties not involved in the transaction and that market participants meet at no costs.

These assumptions collectively define perfect competition and form the foundation of its analysis. If all conditions are fulfilled, there is no need for government regulation. Welfare is maximized and no pareto-improvement can be achieved.

## 9.2 Markets are not perfect

### 9.2.1 Should we care?

In previous chapters we have already discussed the power of free markets to allocate resources efficiently. However, the *magic of the price system* actually requires markets to be *perfect*. Unfortunately, perfect competition is never found in the real world. However, it is a useful theoretical model that serves as a reference point for analyzing real-world markets. It provides valuable insights into market functioning and informs policymakers on how to address instances of market failure, where at least one assumption of perfect markets is not met. Usually, in real markets the conditions of perfect markets are not given. However, that does not mean that such imperfect markets perform worse than non-market based solutions of centrally planned economies, for example.

Theory would predict that if firms in an industry would make some profits, new firms will enter the market or existing firms would produce more which both yields an increase in supply. That, in turn, will drive down market prices until all firms earn zero profits and no more firms would have an incentive to enter the market. In the equilibrium, total revenue equals total cost. Thus, firms do not make profits. Firms can only make profits if they have some sort of competitive advantage and hence are not price takers which would be against assumption 1. The most extreme form of competitive advantage is a monopoly. It describes that one firm is the only provider of a certain good or service. This firm can set prices and the supply of the good and service completely. We will discuss that extreme case in the next section.

### 9.2.2 Two fundamental theorems of welfare economics

There are two fundamental theorems of welfare economics. The first states that a market in equilibrium under perfect competition will be Pareto optimal in the sense that no further exchange would make one person better off without making another worse off. The requirements for perfect competition are these:

1. There are no externalities and no transaction costs, and each actor has perfect information.
2. Any efficient allocation of resources can be achieved through competitive markets, given the right redistribution of resources.

#### Metaphor: Runners

In a scenario where the first theorem applies, the competitive market equilibrium is fair and when thinking of a race where runners compete, all runners give their best effort, and the fastest runner wins. This outcome is efficient because each runner is motivated to perform their best to achieve their individual goal, which collectively leads to an optimal overall result. Each runner receives a fair price.

If the race starts with an uneven advantage, the market (or race) isn't efficient initially. However, the second theorem suggests that by redistributing starting positions or providing compensation to less advantaged runners, an efficient outcome can still be achieved. In the economic context, this means that with appropriate policies (taxes, subsidies, etc.), markets can be used to attain efficient outcomes even when the initial distribution is unequal.

In summary, the example of runners in track and field helps illustrate how the two fundamental theorems of welfare economics emphasize the efficiency achieved by competitive markets and the possibility of achieving efficient outcomes through redistribution. Just as runners compete to achieve their best, competitive markets can lead to optimal resource allocation, and policies can ensure fairness and efficiency in the allocation process.

### 9.2.3 Types of imperfect market structures

To develop principles and make predictions about markets and how producers will behave in them, economists have developed a lot of models of market structure including the following.

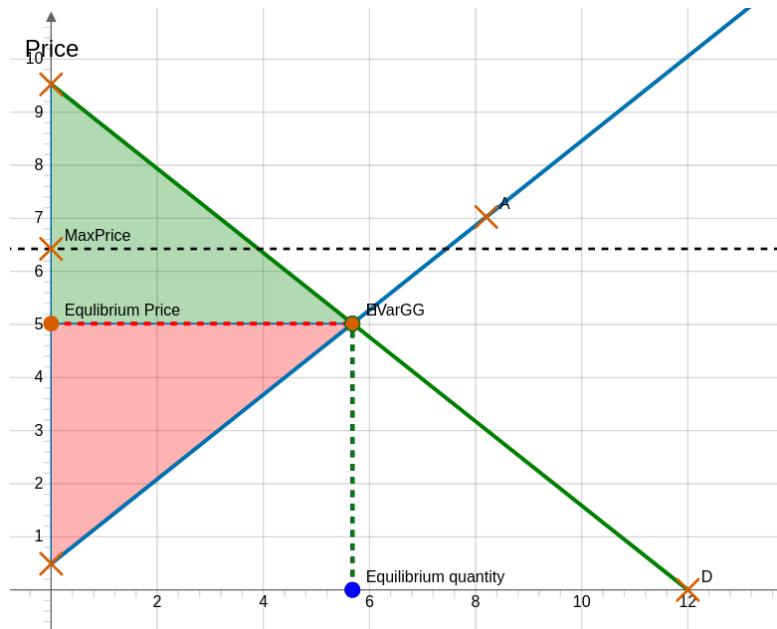


Figure 9.1: Non binding maximum price

- **Monopolistic competition**, also called competitive market, where there is a large number of firms, each having a small proportion of the market share and slightly differentiated products.
- **Oligopoly**, in which a market is by a small number of firms that together control the majority of the market share.
- **Duopoly**, a special case of an oligopoly with two firms.
- **Monopsony**, when there is only one buyer in a market.
- **Monopoly**, in which there is only one provider of a product or service.
- **Natural monopoly**, a monopoly in which economies of scale cause efficiency to increase continuously with the size of the firm. A firm is a natural monopoly if it is able to serve the entire market demand at a lower cost than any combination of two or more smaller, more specialized firms.
- **Perfect competition**, a theoretical market structure that features no barriers to entry, an unlimited number of producers and consumers, and a perfectly elastic demand curve.

As one of the assumptions of the perfect free market is that there is competition, it is obvious that if there is just one or a few competitors, this assumption is not fulfilled. In the following, we discuss what happens to markets that don't have perfect competition.

## 9.3 When market are not free: Price controls

### 9.3.1 Maximum price

A legal maximum price, set to protect consumers, establishes an upper limit for the sale of a good. One example is the price fixing in rental apartments. It is ineffective if set above the equilibrium price, as depicted in [Figure 9.1](#); it becomes binding when placed below the equilibrium price, as shown in [Figure 9.2](#). This can lead to a deadweight loss due to missed mutually beneficial transactions.

### 9.3.2 Minimum price

A legal minimum price is a rule that sets the lowest price for a product, protecting sellers. For example, minimum wage protect the seller of labor time. Only when this minimum price is higher than the

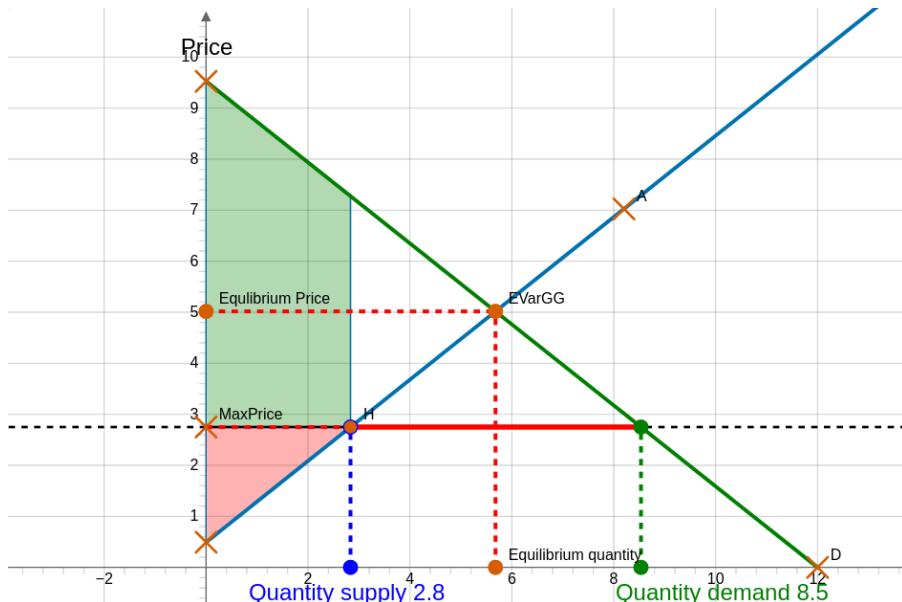


Figure 9.2: Binding maximum price

normal price, it is binding and affects the market.

### Exercise 9.1 — Welfare and price controls

(Solution → p. ??)

Analyze the two scenarios above. Can you sketch in both plots consumer and producer surplus. Who is better off? Who is worse off? And, does overall welfare increase or decrease?

### 9.3.3 Taxes

Taxes change how things are bought and sold. When there's a tax, people who buy things pay more, and people who sell things get less money, no matter who the tax is on. Tax incidence shows how the burden of the tax is divided between buyers and sellers, see [Figure 9.3](#) and [Figure 9.5](#).

The tax has several effects:

- Quantity of goods sold decreases.
- Sales decrease after the tax is applied.
- The tax burden is shared between buyers and sellers, no matter who the tax is imposed on.
- There is a loss of welfare (deadweight loss).

### Exercise 9.2 — Tax Consumer

(Solution → p. ??)

The figure here illustrates the consequences of an fixed excise tax and its implied dead-weight loss when the producers have to pay the tax. (An excise tax is a tax imposed by the government that applies when a producer makes a sale. A fixed excise tax is an amount that the seller must return to the government for each unit sold to a customer.)

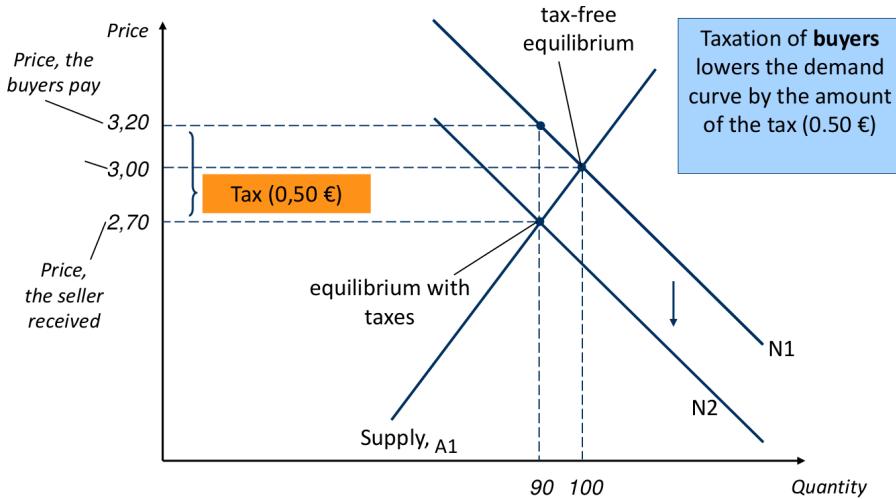


Figure 9.3: Taxes of buyers

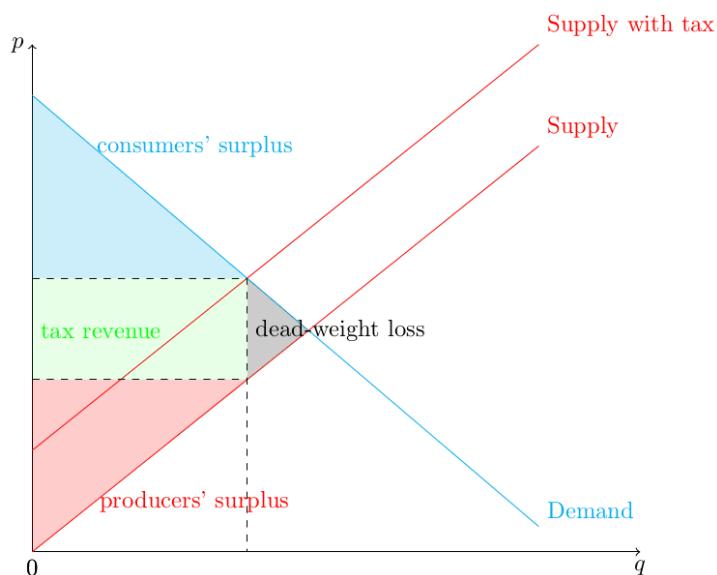


Figure 9.4: Welfare implications of a tax

Sketch a similar figure...

- ...when the consumer have to pay the tax.
- ...when there is a price ceiling. (A price ceiling describes a market where exchanges are not permitted above a certain price.)
- ...when there is a price floor. (A price floor describes a market where exchanges are not permitted under a certain price.)

### Exercise 9.3 — Laffer curve

(Solution → p. ??)

The Laffer Curve is an economic concept that illustrates the relationship between tax rates and tax revenue. It is named after economist Arthur Laffer who sketched that curve in 1974 on a napkin (see Figure 9.6) talking to Dick Cheney and Donald Rumsfeld, two former important US politicians. The curve suggests that there exists a tax rate that maximizes government revenue. At very low and very high tax rates, the government revenue generated may be relatively low, as taxpayers either have little incentive to work (at very high rates) or can evade taxes (at very low rates).

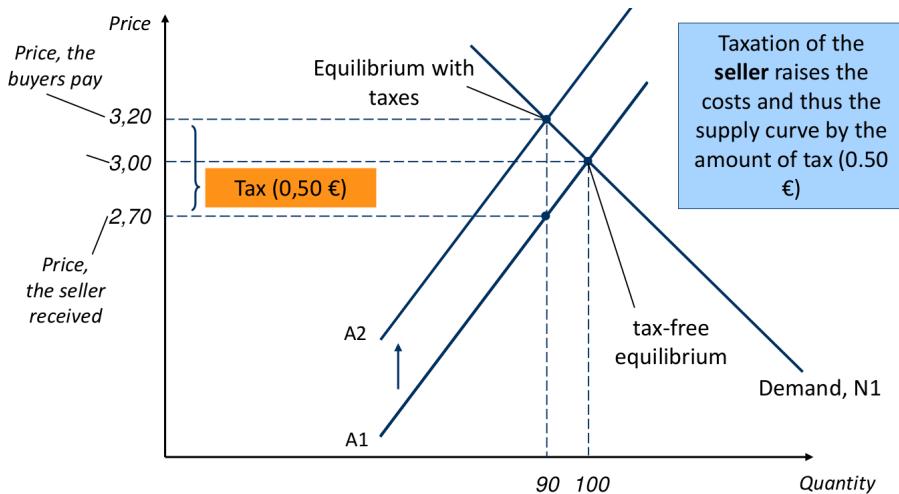


Figure 9.5: Taxes of sellers

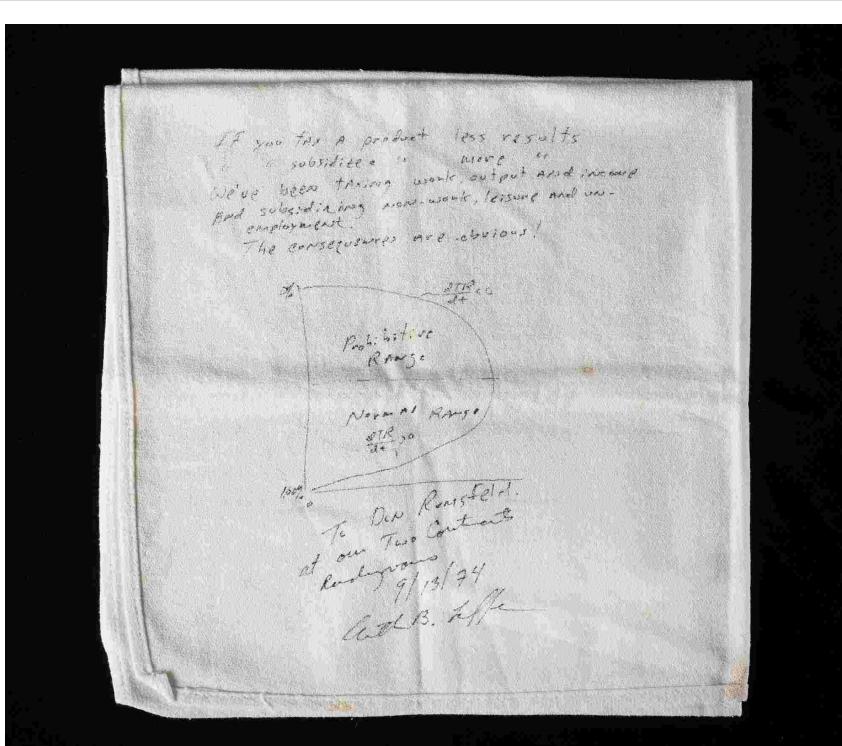


Figure 9.6: Laffer's napkin

Source: National Museum of American History, see:

[https://americanhistory.si.edu/collections/search/object/nmah\\_1439217](https://americanhistory.si.edu/collections/search/object/nmah_1439217).

Now, visit <https://www.online-wvl.de/english/micro/dynvwlengsu3.html> and consider the interactive graph. You can change the tax rate and draw the Laffer curve. What is the impact of the supply and demand elasticity? Can you always spot consumer surplus, producer surplus, tax revenue, and deadweight loss.

### 9.3.4 Subsidies

Subsidies are like negative taxes, producing the opposite impacts of taxes, that are:

- More quantity being bought and sold, respectively.
- A boost in total sales due to the subsidy.
- The benefit are shared between buyers and sellers, regardless of who receives the subsidy.

**Exercise 9.4 — Exercise: Minimum Wage**

(Solution → p. ??)

Analyze welfare effects of a minimum wage that is above the market clearing equilibrium wage.

**Exercise 9.5 — Social Surplus**

(Solution → p. 136)

 The demand and supply functions in a competitive market are given by

$$p = 20 - \frac{1}{2}q$$

and

$$p = 5 + q$$

- a) What is the equilibrium quantity in this market?
- b) What is the equilibrium price in this market?
- c) If the price was 10% higher than the market equilibrium, what would be the excess supply?
- d) If the price was 20% lower than the market equilibrium, what would be the amount of shortage?
- e) What is the consumers' surplus in this market?
- f) What is the social surplus in this market?

**Solution to Exercise 9.5 — Social Surplus**

(Exercise → p. 136)

- a) 10
- b) 15
- c) 4.5
- d) 9
- e) 25
- f) 75

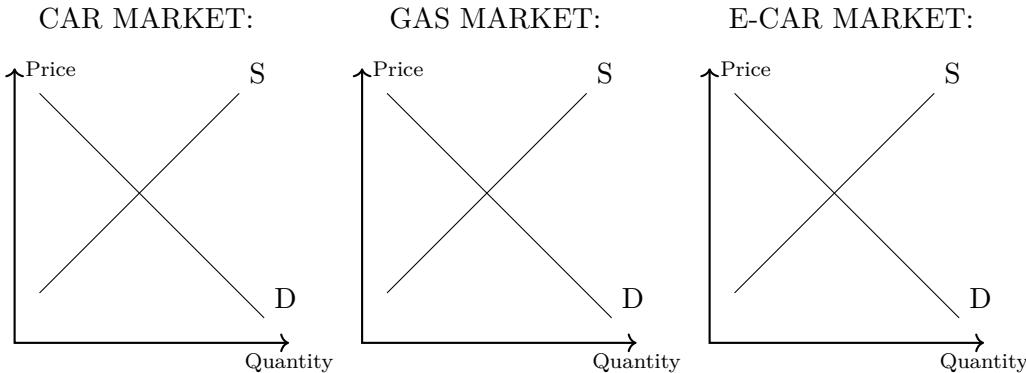
**Exercise 9.6 — Markets Are Connected**

(Solution → p. ??)

 Read section 11.1 of Emerson (2019) which is freely available, see: <https://open.oregonstate.edu/education/intermediatemicroeconomics/chapter/module-11/> and answer the following problem.

 Consider the following goods: gasoline powered cars (*cars*), electricity powered cars (*e-cars*), and gasoline (*gas*).

- a) Are the goods *cars* and *gas* more likely to be substitutes or complements? Explain your decision.
- b) Indicate whether the following pairs of goods are more likely to be substitutes or complements:  
(1) *cars* and *e-cars* (2) *e-cars* and *gas*.
- c) Suppose a new, easy accessible, and huge oil field is found. As a consequence, you expect that the price for gasoline will fall. In the following, you should analyze the impact of this exogenous shock on the three markets in further detail. Assume thereby that the price of gasoline does not alter production of *cars* and *e-cars*, respectively. The three plots below represent the three markets where the supply function, *S*, and demand functions, *D*, refer to the market circumstances before the exogenous shock has happened.  
Sketch in the three plots—for each market—shifts of the supply function and/or the demand function that may happen due to the exogenous shock. Discuss the new the equilibrium prices and quantities on the respective markets.



## 9.4 Monopoly

A monopolist is a firm that is the only provider of a good or service. There is no substitute to it. The ability of a monopolist to raise its price above the competitive level by reducing output is known as *market power*. This implies a loss of total welfare. In contrast with a perfectly competitive firm which faces a perfectly elastic demand (taking price as given), a monopolist faces the market demand. As a consequence, a monopolist has the power to set the market price. While we can consider a competitive firm as a *price taker*, a monopolist is price decision-maker or *price setter*. Firms that have to face fierce competition are more like price takers as they cannot set the price above the market price. If firms in perfect competition would set the price higher, all consumers would simply stop buying from that particular firm. That is not the case for a firm with market power, that is, a firm that has a product with unique features no other competitor has to offer.

### 9.4.1 Revenue function

There are two types of constraints that restrict the behavior of a monopolist (and any other firm):

- Technological constraints summarized in the cost function  $C(x)$ .
- Demand constraints:  $x(p)$ .

Thus, we can write the revenue (or profit) function of the monopolist in two alternative ways:

1. Either by using the demand function:

$$\pi(p) = px(p) - C(x(p))$$

2. Or by using the inverse demand function:

$$\pi(x) = p(x)x - C(x)$$

The demand,  $x(p)$ , and the inverse demand,  $p(x)$ , represent the same relationship between price and demanded quantity from different points of view. The demand function is a complete description of the demanded quantity at each price, whereas the inverse demand gives us the maximum price at which a given output  $x$  may be sold in the market.

### 9.4.2 Revenue and price relationship

Thus, an increase in production by a monopolist has two opposing effects on revenue:

- **A quantity effect:** one more unit is sold, increasing total revenue by the price at which the unit is sold.
- **A price effect:** in order to sell the last unit, the monopolist must cut the market price on all units sold. This decreases total revenue.

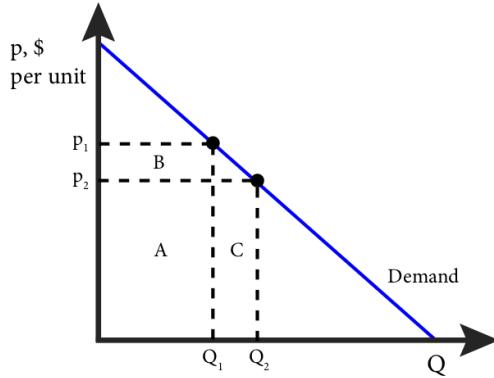


Figure 9.7: Price effects and revenue  
Graph is taken from [Emerson \(2019\)](#).

The two effects are shown in figure 9.7: At price  $p_1$ , the total revenue is  $p_1 \cdot Q_1$ , which is represented by the areas A+B. At price  $p_2$ , the total revenue is  $p_2 \cdot Q_2$ , which is represented by the areas A+C. Area A is the same for both, so the marginal revenue is the difference between B and C or C-B. Note that area C is the price,  $p_2$ , times the change in quantity,  $Q_2 - Q_1$ , or  $p\Delta Q$ ; and area B is the quantity,  $Q_1$ , times the change in price,  $p_2 - p_1$ , or  $\Delta p \cdot Q$ . Since  $p_2 - p_1$  is negative, the change in total revenue is C-B or:  $\Delta TR = p\Delta Q + \Delta p \cdot Q$ . Dividing both sides by  $\Delta Q$  gives us an expression for marginal revenue:

$$MR = \frac{\Delta TR}{\Delta Q} = \underbrace{p}_{\text{quantity effect}} + \underbrace{Q \frac{\Delta p}{\Delta Q}}_{\text{price effect}}$$

When considering a infinitesimal small  $\Delta$ , we can write:

$$\frac{\partial TR}{\partial Q} = p + Q \frac{\partial p}{\partial Q}$$

### 9.4.3 Profit-maximizing level of output

To find the profit-maximizing price and quantity, respectively, we should look at the first-order conditions:

$$\begin{aligned} \max_p \pi(p) &\equiv \overbrace{px(p)}^{\text{total revenue}} - \overbrace{C(x(p))}^{\text{total costs}} \\ \frac{\partial \pi(p)}{\partial p} &= \pi'(p) = x(p) + px'(p) - C'(x(p))x'(p) \stackrel{!}{=} 0 \end{aligned}$$

or

$$\begin{aligned} \max_x \pi(x) &\equiv p(x)x - C(x) \\ \frac{\partial \pi(x)}{\partial x} &= \pi'(p) = \underbrace{p(x)}_{\text{quantity effect}} + \underbrace{xp'(x)}_{\text{price effect}} - C'(x) \stackrel{!}{=} 0 \\ \Rightarrow \underbrace{p(x) + xp'(x)}_{\text{marginal revenue}} &= \underbrace{C'(x)}_{\text{marginal costs}} \\ \Rightarrow MR &= MC \end{aligned}$$

At the profit-maximizing level of output, **marginal revenue equals marginal cost**, that is, an infinitesimal change in the level of output changes revenue and cost equally. In other words, an

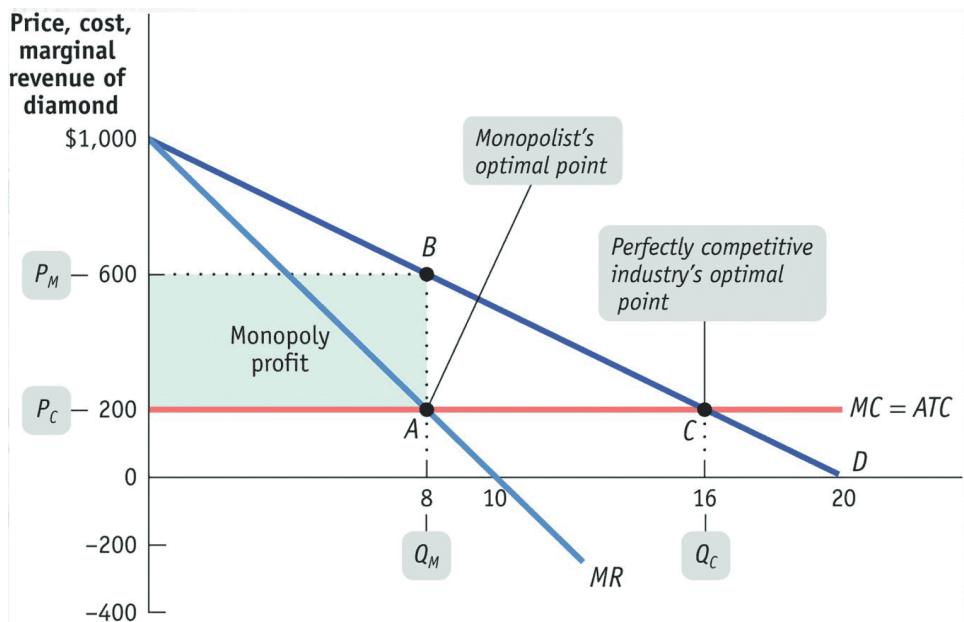


Figure 9.8: Price setting of a monopolist.  
Graph stems from Krugman and Wells (2009).

infinitesimal increase in the level of output increases revenue and cost by the same amount, and an infinitesimal decrease in the level of output reduces revenue and cost by the same amount.

Thus, we can determine a monopoly firm's profit-maximizing price and output by following three steps:

1. Determine the demand, marginal revenue, and marginal cost curves.
2. Select the output level at which the marginal revenue and marginal cost curves intersect.
3. Determine from the demand curve the price at which that output can be sold.

#### 9.4.4 Price effect of a monopoly

Due to the price effect of an increase in output, the marginal revenue curve of a firm with market power always lies below its demand curve. So, a profit-maximizing monopolist chooses the output level at which marginal cost is equal to marginal revenue—not equal to price. As a result, the monopolist **produces less and sells its output at a higher price than a perfectly competitive industry would**. It earns a profit in the short run and the long run.

#### 9.4.5 Welfare

Overall, the price-setting behavior of a monopolist is not good for overall welfare as figure 9.8 shows: The area of the *monopoly profit* and the *consumer surplus*, that is, the triangle above (600-B-1000), stands for total welfare. The triangle A-B-C is deadweight loss, that is, the welfare forgone because the monopolist supplies less goods at a higher price ( $MC=ATC$ ) as compared to the scenario where many firms compete ( $MC=ATC$ ).

##### Exercise 9.7 — Marginal revenue and total revenue

(Solution → p. 140)

Show the relationship between a linear demand curve and the marginal revenue curve in one panel and the relationship of the quantity sold and the total revenue in another panel. What characterizes the price of a profit maximizing monopolist?

### Solution to Exercise 9.7 — Marginal revenue and total revenue (Exercise → p. 139)

See: chapter 15.2 Profit Maximization for Monopolists of [Emerson \(2019\)](#), see: <https://open.oregonstate.edu/intermediatemicroeconomics>.

### Exercise 9.8 — How to maximize profits

(Solution → p. 140)

A company sold a quantity of 750 goods ( $Q_{t=1} = 750$ ) in January ( $t = 1$ ), at a price of 45 € ( $P_{t=1} = 45$ ). In February ( $t = 2$ ), they reduced the price to 40 Euro ( $P_{t=2} = 40$ ) and sold 800 goods ( $Q_{t=2} = 800$ ). Now answer the following questions knowing that the total costs had been 26,500 € in January and 28,000 € in February.

- a) Calculate the price elasticity of demand at the current prices.
- b) Derive the demand function.
- c) Derive the cost function.
- d) Derive the revenue function.
- e) Derive the marginal revenue function.
- f) Derive the marginal cost function.
- g) Calculate the profit-maximizing price and output.
- h) Calculate the amount of profit in January, February, and what the company can expect by setting the prices profit-maximizing.

### Solution to Exercise 9.8 — How to maximize profits

(Exercise → p. 140)

a)  $PED = -\frac{17}{31} \approx -0.5483$

b) As the slope of the demand function is

$$m = \frac{40 - 45}{800 - 750} = -\frac{1}{10},$$

we can apply the point-slope formula<sup>a</sup> and one sales point to get the demand function:

$$\begin{aligned} P - 40 &= -\frac{1}{10}(Q - 800) \\ \Leftrightarrow P &= -\frac{1}{10}Q + 80 + 40 \\ \Leftrightarrow P &= 120 - \frac{1}{10}Q \\ \Leftrightarrow Q &= 1200 - 10P \end{aligned}$$

c) Total costs ( $TC$ ) are given by

$$TC = FC + VC = FC + MC \cdot Q$$

where  $VC$  denote variable costs and  $MC$  marginal costs. We know

$$26500 = FC + 750 \cdot MC$$

$$28000 = FC + 800 \cdot MC$$

Solving that system of equation, we get  $MC = 30$  and  $FC = 4000$ . Thus the cost function is given by

$$TC = 4000 + 30 \cdot Q$$

d) Total revenue is given by  $TR = P \cdot Q(P)$ . Plugging the demand function in gives the revenue function:

$$TR(P) = P \cdot 1200 - 10P = 1200P - 10P^2$$

$$TR(Q) = 120Q - \frac{1}{10}Q^2$$

e) Marginal revenue is given by

$$MR = \frac{\partial TR(Q)}{\partial Q} = 120 - \frac{2}{10}Q$$

f)  $MC = 30$  (see above)

g) Setting  $MC = MR$ , we get the optimal quantity:

$$30 = 120 - \frac{2}{10}Q$$

$$Q^* = 450.$$

Plugging  $Q^*$  into the demand function, we get the optimal price:

$$P^* = 120 - \frac{1}{10} \cdot 450 = 75$$

h) Profit ( $\pi$ ) is given by  $\pi = TR - TC$ :

$$\pi_{t=1} = \underbrace{1200 \cdot 45 - 10 \cdot 45^2}_{TR} - \underbrace{4000 + 30 \cdot 750}_{TC} = 33750 - 26500 = 7250$$

$$\pi_{t=2} = 1200 \cdot 40 - 10 \cdot 40^2 - 4000 + 30 \cdot 800 = 32000 - 28000 = 4000$$

$$\pi_{t=3} = 1200 \cdot 75 - 10 \cdot 75^2 - 4000 + 30 \cdot 450 = 33750 - 17500 = 16250$$

---


$$^a y_2 - y_1 = m(x_2 - x_1)$$

### Exercise 9.9 — Monopolist optimal price

(Solution → p. 141)

A company which is a monopolist in his market has estimated its demand and total cost functions as follows:

$$Q = 40 - 4P.$$

$$C = 1 + 2Q + Q^2.$$

Where  $P$  denotes the price in €,  $Q$  in thousands of units, and  $C$  is measured in thousands of €.

- a) Calculate the total revenue function.
- b) Calculate the profit-maximizing price and output.
- c) Calculate the profits made at the profit-maximizing price.

### Solution to Exercise 9.9 — Monopolist optimal price

(Exercise → p. 141)

- a)  $TR = 40P - 4P^2$  or you solve the demand function  $Q(P)$  for  $P$ :  $P(Q) = 10 - \frac{1}{4}Q$  to get  $TR = 10Q - \frac{1}{4}Q^2$
- b)  $MR = MC$ ,  $MR = TR'(Q) = 10 - 0.5Q$ ,  $MC = C'(Q) = 2 + 2Q$ , set  $MR = MC$ : to get  $Q = 3.2$  which we can use in the demand function to get  $P = 9.2$ .
- c)  $TP = TR - C = 9.2 \cdot 3.2 - (1 + 2 \cdot 3.2 + 3.2^2) = 29.44 - 17.64 = 11.8$ .

## 9.4.6 Monopoly and price discrimination

Discrimination is the practice of treating people differently based on some (irrelevant) characteristic, such as race or gender. It is important to actively fight discrimination whenever it is observed. However, the concept of discrimination takes a different form when it comes to *price discrimination*, which is a business practice involving the sale of the same goods at different prices to different buyers. This practice can be commonly seen in special offers tailored for students or retired individuals.

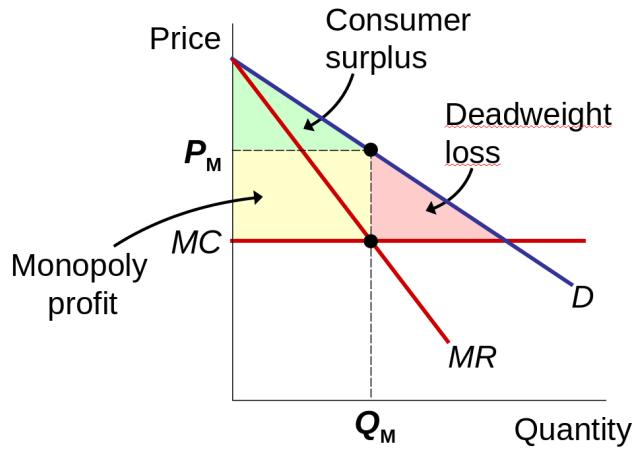


Figure 9.9: Monopoly without price discrimination and welfare

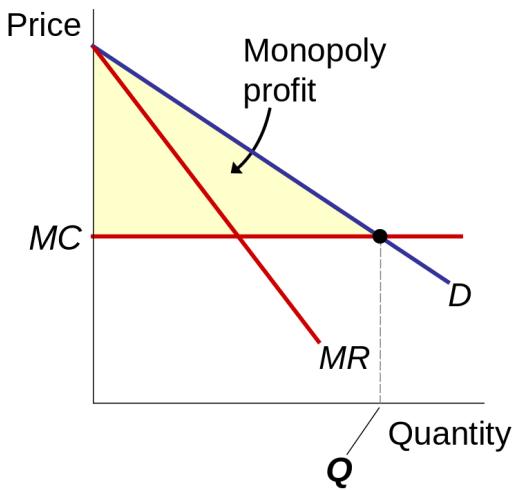


Figure 9.10: Monopoly with price discrimination and welfare

One of the key factors utilized in price discrimination is the willingness to pay (WTP) of individuals. By charging a higher price to buyers with a higher WTP, a firm can maximize its profit. Moreover, and that is kind of surprising, it also comes with a increase in social welfare as is shown in figure 9.10 and figure 9.10. In 9.10, the monopolist charges the same price ( $P_M$ ) to all buyers. A deadweight loss results. In 9.10, however, the monopolist produces the competitive quantity but charges each buyer his or her WTP. This is called perfect price discrimination. The monopolist captures all consumer surplus as profit. But there is no deadweight loss.

In the real world, price discrimination is a common phenomenon, but achieving perfect price discrimination is highly challenging. This is primarily because no firm possesses complete knowledge of every buyer's willingness to pay (WTP), and buyers typically do not disclose this information to sellers. Consequently, firms often divide customers into groups based on observables that are likely correlated with their WTP.

### Examples:

- *Movie tickets:* Discounts for seniors, students, and people who can attend during weekday afternoons. They are all more likely to have lower WTP than people who pay full price on Friday night.
- *Airline prices:* Discounts for Saturday-night stayovers help distinguish business travelers, who usually have higher WTP, from more price-sensitive leisure travelers.
- *Discount coupons:* People who have time to clip and organize coupons are more likely to have

lower income and lower WTP than others.

- *Need-based financial aid:* Low income families have lower WTP for their children's college education. Schools price-discriminate by offering need-based aid to low income families.
- *Quantity discounts:* A buyer's WTP often declines with additional units, so firms charge less per unit for large quantities than small ones. Example: A movie theater charges \$4 for a small popcorn and \$5 for a large one that's twice as big.

## 9.5 External effects

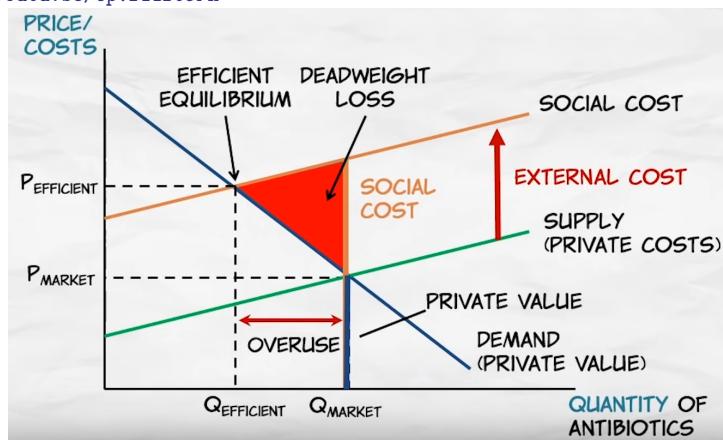
### 9.5.1 Introduction

An externality is an uncompensated impact of one economically active unit's (person or firm) actions on the well-being of a bystander. It arises when a person engages in an activity that affects the well-being of a bystander and yet neither pays nor receives any compensation for that effect. When the impact on the bystander is adverse, the externality is called a **negative externality**. When the impact on the bystander is beneficial, the externality is called a **positive externality**. Externalities cause markets to be inefficient and so fail to maximize total surplus. Buyers/consumers and sellers/producers neglect the external effects of their actions. (Otherwise the effects wouldn't be considered to be *external*.)

#### Exercise 9.10 — Positive and negative externalities

(Solution → p. ??)

Watch <https://youtu.be/CpVf11f09Pk>



Can you give some examples for positive and negative externalities, respectively? Can you distinguish whether the externalities stem from consumption or production?

#### Example: Aluminum industry

**Background:** Aluminum factories emit pollution (a negative externality). For each unit of aluminum produced, a certain amount of smoke enters the atmosphere. The smoke poses a health risk for innocent bystanders who breath the air.

How does a negative externality affect the efficiency of the market outcome?

- The cost to society producing aluminum is larger than the cost to the aluminum producers.
- The social cost includes the private costs of the aluminum producers plus the costs of the bystanders impacted by the pollution.
- The social-cost curve is above the supply curve (because it adds the external costs of aluminum production).
- The socially optimal equilibrium (intersection of social-cost curve and demand curve) is different from the actual equilibrium (where externalities are not considered).

**One solution:** policymakers can tax aluminum producers for each ton of aluminum sold. The tax shifts the supply curve upward by the size of the tax. Tax should reflect the external cost of pollutants released into the atmosphere (in order to match the social-cost curve). New market equilibrium would result in socially optimal quantity of aluminum.

**Another solution:** Internalizing the externality: Altering incentives so that people and firms account for the external effects of their actions.

**Alternatives:** If property rights would be clearly defined, we have a (theoretical) chance of a market solution. However, the transaction costs are probably simply too high, i.e., as all people are harmed all people more or less would need to bargain with the polluting firms.

### 9.5.2 Production externalities

Production externalities refer to a side effect from an industrial operation, such as a paper mill producing waste that is dumped into a river. They are usually unintended, and their impacts are typically unrelated to and unsolicited by anyone. They can have economic, social, or environmental side effects. Production externalities can be measured in terms of the difference between the actual cost of production of the good and the real cost of this production to society at large. The impact of production externalities can be positive or negative or a combination of both.

**Examples of production externalities:**

- (+) The construction and operation of an airport will benefit local businesses because of the increased accessibility.
- (+) An industrial company providing first aid classes for employees to increase workplace safety. This may also save lives outside the factory.
- (+) A foreign firm that demonstrates up-to-date technologies to local firms and improves their productivity.
- (+) Many sectors participate of technological innovation that happens in one sector (technological spillovers).
- (-) Noise pollution produced by a productive unit.
- (-) Increased usage of antibiotics propagates increased antibiotic-resistant infections.
- (-) The development of ill-health, notably early-onset Type II diabetes, and metabolic syndrome, as a result of companies over-processing foods including the addition of (too) much sugar.

**Formally** production externalities happen because the output of one productive unit (unit 1) is a function of...

...the amount of output of another productive unit (unit 2).

$$y_1 = f_1(L_1, K_1, y_2)$$

$$y_2 = f_1(L_2, K_2).$$

If  $\frac{\partial y_1}{\partial y_2} < 0$  it is a negative external effect, if  $\frac{\partial y_1}{\partial y_2} > 0$  it is a positive external effect. In case of positive(/negative) external effects, the welfare optimum would require more (/less) of production of productive unit 2.

### 9.5.3 Consumption externalities

**Examples of Consumption Externalities:**

- (+) Going to university. Your education gives benefit to rest of society (You can teach others)

- (+) Taking medicine or a vaccine which prevents spread of infectious disease.
- (-) Consuming fireworks causes damage to the environment and to the health of other people.
- (-) Driving a car pollutes the environment and injure people.
- (-) Smoking and eating unhealthy may cause costs for other people.

**Formally** consumption externalities happen because the utility of one individual is determined by consumption of good  $z_1$  but also by the amount another individual is consuming from good  $z_2$ :

$$u_1 = f_1(z_1, z_2)$$

$$u_2 = f_1(z_2).$$

If  $\frac{\partial u_1}{z_2} < 0$  it is a negative external effect, if  $\frac{\partial u_1}{z_2} > 0$  it is a positive external effect. Or, the utility of an individual is determined by the utility level of another individual:

$$u_1 = f_1(z_1, u_2)$$

$$u_2 = f_1(z_2).$$

If  $\frac{\partial u_1}{u_2} < 0$  it is a negative external effect, if  $\frac{\partial u_1}{u_2} > 0$  it is a positive external effect.

In case of positive(/negative) external effects, the welfare optimum would require more (/less) of production of productive unit 2.

#### 9.5.4 Government interventions

Governments can manage externalities in two ways:

1. **Comand-and-control policies** which regulate behavior directly. Regulations that require or forbid certain behaviors or subsidies good behavior. Example: Making it a crime to dump hazardous chemicals into the water supply.
2. **Market-based policies** which provide incentives so that firms can determine the best way to solve a problem.

**Corrective tax** A tax designed to induce private decisions makers to take into account the social costs that arise from a negative externality.

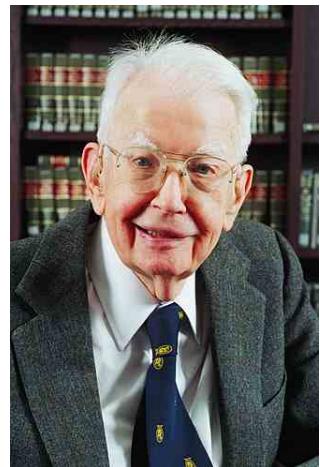
**Tradable Permits** (aka “Cap and Trade”) For example, voluntary transfer of the right to pollute from one firm to another. The government, in effect, creates a scarce resource (“pollution permits”). The result is creation of a market governed by supply and demand. Permits end up in the hands of firms that value them most highly. *Tradable green certificates* of the EU are financial assets issued to producers of certified green electricity and can be regarded as a market-based environmental subsidy.

#### 9.5.5 Private solutions to externalities

In some cases, government intervention is not necessarily needed to address externalities and to coordinate the behavior of market participants. For example, if your neighbor plays loud music you can talk with him and bargain for a good solution at which both are better off in the end. Some types of private solutions:

- Moral codes and social sanctions.
- Charitable and private organizations that aim to help and bring people together.

**The Coase Theorem** states that if property rights exist and transaction costs are low, private transactions are efficient. In other words, with property rights and low transaction costs, there are no externalities. All costs and benefits are taken into account by the transacting parties. So it doesn't really matter how the property rights are assigned as long as property are assigned. The proposition that if private parties can bargain without cost over the allocation of resources, they can solve the problem of externalities on their own. The Coase Theorem only works when the relevant parties come to an agreement and are able to enforce the agreement. This is often not the case. Transaction costs in this respect means the costs that parties incur during the process of agreeing to and following through on a bargain. Efficient bargaining becomes increasingly difficult when the number of interested parties is large. This is because coordinating more people is costly and the more people are involved the less likely is it that private transaction yield success, i.e., an efficient market outcome.



Ronald H. Coase (1910-2013)  
Nobel Prize Winner of 1991

## 9.6 Public goods

There are many goods that have no market price. These goods include things like nature (e.g. rivers, mountains, beaches, lakes, etc.) or government amenities and events (playgrounds, parks, parades). These goods face a different set of economic problems since the normal market forces that provide efficient allocation are absent. Economic goods can be grouped according to the following characteristics:

- Is the good excludable? **Excludability:** The property of a good whereby a person can be prevented from using it.
- Is the good rival in consumption? **Rivalry in consumption:** The property of a good whereby one person's use diminishes other people's use.

Using the above characteristics, it is possible to group goods into four categories. Examples can be found in [Figure 9.11](#).

**Private goods:** Goods that are both excludable and rival in consumption. Example: An ice cream cone. It is excludable because you can prevent someone from eating one. It is rival in consumption because if someone eat an ice-cream cone, another person cannot eat the same cone.

**Public goods:** Goods that are neither excludable nor rival in consumption. Example: A tornado siren in a small town. It is not excludable because it is impossible to prevent any single person from hearing it when the siren sounds. It is not rival in consumption because when one person benefits from the warning it does not reduce the benefit to others.

**Common resources:** Goods that are rival in consumption but not excludable. Example: fish in the ocean. It is rival in consumption because when one person catches a fish there are fewer fish for the next person to catch. It is not excludable because it is difficult to stop fishermen from catching fish from a large ocean.

**Club goods:** Goods that are excludable but not rival in consumption. Example: fire protection in a small town. It is excludable because the fire department can decide not to save a building from a fire. It is not rival in consumption because once paid for the additional cost of protecting one more house is small.

### Important public goods:

- National defense.
- Basic research.
- Fighting poverty.

	Excludable	Non-excludable
Rivalrous	<b>Private goods</b> food, clothing, cars, parking spaces	<b>Common-pool resources</b> fish stocks, timber, coal
Non-rivalrous	<b>Club goods</b> cinemas, private parks, satellite television	<b>Public goods</b> free-to-air television, air, national defense

Figure 9.11: Matrix of Economic Goods With Examples

### Common resources

- Common resources are not excludable (like public goods). Unlike public goods, common resources are rival in consumption: one person's use degrades the resource for others.
- Tragedy of the Commons: A parable that illustrates why common resources are used more than is desirable from the standpoint of society as a whole.
  - Social and private incentives differ.
  - Government can solve the problem through regulation or taxes to reduce consumption.
  - Government can also solve the problem by turning the common resource into a private good.
- Some important common resources:
  - Clean air and water.
  - Congested roads.
  - Fish, whales and other wildlife.

### Some goods switch between public goods and private goods (depending on circumstances)

- Example: A fireworks display performed in a town can be a public good. A fireworks display at a private amusement park (e.g. Disneyland) is a private good.
- Example: A lighthouse operated by the government is a public good. A privately owned lighthouse that charges adjacent ports for operation is a private good.

### The boundaries between goods is not always clear

- **Example:** fish in an ocean may not be excludable because of practical challenges of managing ocean stocks. However, government restrictions and a large coast guard can make fish partially excludable.
- Public goods and common resources are closely related to externalities: both these goods and externalities are the result of something of value having no associated price.
- **Example:** If an individual builds and operates a tornado siren in a town, the neighbors will benefit from the siren without paying for it (positive externality).
- **Example:** If an individual uses a common resource such as fish in the ocean, others are worse off because there are fewer fish to catch (negative externality).
- Private decisions about consumption and production can lead to an inefficient allocation of resources, and government intervention can potentially raise economic well-being.

## The free-rider problem

- Example: A fireworks display. This good is not excludable (you cannot prevent someone from seeing fireworks) and it is not rival in consumption (because one person's enjoyment does not reduce another's enjoyment).
- Free rider: A person who receives the benefit of a good but avoids paying for it.
- The free-rider problem prevents the private market from supplying public goods.
- Government is one solution to this problem. If the total benefit exceeds costs, a government can finance a public good with tax revenue.

## The importance of property rights

- There are some goods that the market does not adequately address or provide for (clean air, for example).
- Governments are relied on to provide necessary common goods.
- Markets cannot allocate resources efficiently without property rights.
- Goods that do not have well established 'owners' lack similar incentives for firms and individual actors.
- Policies that are well planned and necessary can make the allocation of resources more efficient and raise economic well-being.

## 9.7 Imperfect information

In previous sections, we assumed that households and firms have perfect information on products and inputs. For example, to make good choices among goods and services available on the market, consumers must have full information on product quality, availability, and price. To make sound judgments about what inputs to use, producers must have full information on input availability, quality, and price. If that is not given, consumers and producers are likely to make mistakes.

### 9.7.1 Moral hazard

An information problem that arises in insurance markets is *moral hazard*. Often people enter into contracts in which the result of the contract depends on one of the parties' future behavior. A *moral hazard* problem arises when one party to a contract passes the cost of his or her behavior on to the other party to the contract. In other words, *moral hazard* is a situation in which one party engages in risky behavior or fails to act in good faith because it knows the other party bears the economic consequences of their behavior.

### 9.7.2 Information asymmetry

When participants in an economic transaction have different information about the transaction, information is spread asymmetric. This causes often inefficient markets. For example, on the health care market we see a lot of information asymmetries as doctors and suppliers of medical products and services have much more knowledge on the topic and hence may use that information advantage to offer overpriced and not necessarily needed products and treatments.

### 9.7.3 Adverse selection

This sort of imperfect information occurs when a buyer or seller enters into an exchange with another party who has more information. For example, suppose there are two types of workers: lazy workers and hard workers. Each worker knows which he is, but employers cannot tell. If there is only one wage rate, lazy workers will be overpaid and hard workers will be underpaid relatively to their productivity. Another example is the secondhand car market. Suppose buyers cannot distinguish between a high-quality car (a cherry) and a low-quality car (a lemon) but sellers know the quality of their cars. Buyers would be willing to pay €6000 for a good car and €2000 for a bad car. If half the cars for sale are good cars and half are bad cars, the market price of a car would be €4000. Moreover, the asymmetric information this yields a so-called *adverse selection* problem. That is, used car sellers know they are getting far more than their cars are worth by selling at €4000, while owners of good cars know that they are getting far less than their cars are really worth. Thus, more lemon owners are attracted into selling their cars than are cherry owners. This sort of market is known as a *market for lemons* named after the article *The Market for Lemons: Quality Uncertainty and the Market Mechanism* of George Akerlof (1970).



George A. Akerlof  
Nobel Prize winner of 2001

#### Exercise 9.11 — Market failure review

(Solution → p. 149)

- What is an external effect? Explain in detail and define the terms *external benefit* and *external cost*.
- What means *to internalize an external effect*?
- What is a public good? Define briefly.
- What is the free-rider problem and how does government help to overcome it?
- Why is it so important to have monopoly control commission?
- What do property rights have to do with externalities? What are the conditions that must hold so that private market transaction can eliminate external effects.
- What are good reasons for government to tax people and restrict civil rights and liberties?

#### Solution to Exercise 9.11 — Market failure review

(Exercise → p. 149)

- An **externality** is a cost or benefit of a production or consumption activity that spills over to affect people other than those who decide the scale of the activity.  
An **external cost** is the cost of producing a good or service that is not borne by its consumers or producers but by other people.  
An **external benefit** is the benefit of consuming or consuming a good or service that does not accrue to its consumers or producers but to other people.
- In order to eliminate market failures caused by externalities, it is necessary intervene in the market in a way to encourage consumers and producers to change their rational choices so that they produce or purchase quantities that are closer to the social optimum and correct efficiency deviations of externalities. This correction process is called *internalization of externalities*. In other words, when a person considers the consequences of his market transactions on persons that are not part of the market transaction itself we speak of he internalized the external effects of his actions.
- A **public good** is a good or service that can be consumed simultaneously by everyone and from which no one can be excluded. Public goods are non-rival in consumption because one person's consumption of the good does not affect the quantity available for anyone else. Public goods are non-excludable if it is impossible to prevent someone from benefiting from a good

*who has not paid for it.*

- d) *Public goods create a **free-rider problem**. A free-rider is a person who consumes a good without paying for it. Markets fail to supply a public good because no one has an incentive to pay for it. Government can provide the public good and finance the costs with taxes and other duties. The challenge here is to find the optimal level of provision for public goods.*
- e) *The rent seeking behavior of a monopolist prevents the allocation of resources being efficient. Markets fail when monopoly power exists, because a monopolist increase profit by restricting output and increasing price. A major activity of government is to regulate monopoly and to enforce laws that prevent cartels and other restrictions on competition.*
- f) *If property rights are assigned, externalities can be eliminated by private parties bargaining for a jointly optimal solution. This holds only if there are no transaction costs or other market imperfections like imperfect information and if enforcement is possible.*
- g) *Any sort of market failure can act as a legitimate for government to intervene in the market. Economists, however, have different points of view, as to whether or not (and how) government should intervene. An often mentioned criteria is the Pareto criteria: If an intervention yields a Pareto-improvement, that is, a change that harms no one and helps at least one person, most economist would support the policy intervention. However, it is hard to think of any real world market intervention that actually does not harm anybody. Thus, it is very often –to some extend– a normative judgment to support a market intervention or not. The main argument of economist for market interventions in case of market failure is that the intervention can improve overall welfare and hence it is just a matter of redistributing endowments and output, respectively. In other words, when the overall output gets larger due to government action, those who were harmed by the intervention can be compensated so that nobody is worse off due to the government action but at least some are better off. While this may be theoretically clear and true, it may be practically hard to implement because it is hard to identify losers and to calculate their loss. Thus, any market intervention and government activity should be discussed transparent (especially with respect to normative views), with an open mind and by protecting minorities that may be the losers of a government action.*

### Exercise 9.12 — Externalities examples

(Solution → p. 150)

For each of the examples below, please answer the following:

- a) Does an externality exist? If so, classify the externality as positive/negative (or both).
- b) If an externality exists, determine whether the Coase theorem applies (i.e., is it possible or reasonably feasible to assign property rights and solve the problem?)
- c) If an externality exists and the Coase Theorem does not apply, argue which of the government's tools are best suited to address the issue: quantity regulation, taxes/subsidies, tradeable permits, or something else.

Consider the following examples:

1. British Petroleum drills for oil in the gulf coast
2. Carbon emissions from vehicles
3. Your upstairs neighbors throwing an awesome, but loud party
4. Buying a car with added safety features that prevent the drivers/passengers' deaths in the event of an accident
5. Bringing crying babies on a plane

### Solution to Exercise 9.12 — Externalities examples

(Exercise → p. 150)

1. a) Yes. You can either think of there being a negative externality (accidents on oil rigs cause spills, which negatively affect other inhabitants of the gulf states) or a positive externality (identifying where oil is allows other companies to drill for oil more effectively because they know where it is).

- b) If oil spills only damage property, and these property owners can costlessly recoup costs in the legal system, then the drillers will internalize the impact of their drilling on the social cost of the oil spill. But, if it is hard to determine the true costs from an oil spill (e.g. may be hard to figure out whether someone lost their job b/c of an oil spill or b/c of some other reason), then the Coase Theorem may not apply. In the positive externality case: may be difficult to assign property rights to an oil field after it is identified, so Coase Theorem may not apply.
- c) Quantity regulation on the amount of safety/advanced drilling technology investment seems feasible. One could also argue for subsidies for safer drilling technologies (or taxes on less safe technologies). Tradable permits seems difficult to do here.
2. a) Yes. I drive my car which emits gases that harm others, whose harm I do not pay for.  
 b) Coase Theorem is difficult to apply since it would require assigning property rights to those who are harmed. Since many of the harmed are very dispersed (e.g. driving in Charlotte theoretically harms everyone in the world a small amount) and in some cases involves the "unborn" (future generations facing global warming), the feasibility of negotiated private contracts is highly questionable.  
 c) If we believe that the social marginal benefit curve is flat (horizontal), we would want to price the carbon using a tax. Quantity regulation would require different quantities for each producer of carbon but each individual has different marginal costs, so this would be hard to do. Perhaps can also do quantity regulation with tradable permits to solve the issue of not knowing the costs.
3. a) Yes, an externality exists but it may be positive/negative depending on your tastes and preferences.  
 b) Coase Theorem would require the neighbors to own the rights to holding the party. Then the neighbor would pay the other neighbor to have (or not have) the party. This could work (so an answer of "yes" is fine). But, in reality, there are likely many different people who are affected by the throwing of the party (e.g. multiple neighbors hate the noise). Bargaining with all parties may allow one party to hold-up the others, rendering the Coase Theorem inapplicable.
4. a) Depends; If people drive more recklessly as a result of having a safer car, then buying the safety feature imposes a negative externality on other drivers. If having a safety feature does not change the likelihood of an accident or the impact on the other cars, then there is no externality.  
 b) The Coase Theorem does not apply: It would be incredibly difficult to write a contract with those with whom you may eventually be engaged in a car accident.  
 c) Quantity regulation (e.g. regulating the safety feature, or preventing it), or taxation would correct the externality. It seems strange but yes, theoretically we would want to tax the safety feature if it causes people to drive more recklessly.
5. a) Yes, obviously negative.  
 b) Coase Theorem does not apply.  
 c) One solution: tax parents that brings babies on the plane and redistribute the tax to those who are exposed to the crying around the baby in the plane. Airlines potentially could also intervene and lower the ticket price for everyone who has to listen to baby crying (or serve free drinks/snacks when a baby starts crying).

### Exercise 9.13 — Tax a market failure

(Solution → p. 152)

The private marginal benefit (PMB) associated with a product's consumption is

$$PMB = 360 - 4Q$$

and the private marginal cost (PMC) associated with its production is

$$PMC = 6Q$$

Furthermore, the marginal (external) damage (MD) associated with this good's production is

$$MD = 2Q$$

- a) Calculate how much private production and hence consumption is in a free market.
- b) Calculate the social optimal quantity consumed.
- c) As there is an external effect, government decides to intervene and to correct the externality by imposing a tax of  $T$  per unit consumed. What tax should it set to achieve the social optimum?
- d) Can you think of other ways for the government to intervene?

### Solution to Exercise 9.13 — Tax a market failure

(Exercise → p. 151)

a)

$$\begin{aligned} PMB &= PMC \\ 360 - 4Q &= 6Q \\ \Leftrightarrow Q_F^* &= 36 \end{aligned}$$

A: In a free market, 36 units are produced and consumed, respectively.

b)

$$\begin{aligned} MD + PMC &= PMB \\ 6Q + 2Q &= 360 - 4Q \\ \Leftrightarrow Q_S^* &= 30 \end{aligned}$$

A: The social optimum quantity of consumption would be 30 units.

c)

$$\begin{aligned} PMB &= PMC + Tax \\ 360 - 4Q &= 6Q + T \end{aligned}$$

set  $T$  so that  $Q=30$ :

$$\begin{aligned} 360 - 4 \cdot 30 &= 6 \cdot 30 + T \\ T &= 60 \end{aligned}$$

A: A tax of 60 per unit of consumption would make it possible that the social optimum quantity of 30 is consumed.

- d) Other regulations would be thinkable. For example, a government can restrict or tax the production.

# Chapter 10

## Business cycles and unemployment

### In this chapter, we learn...

- ...that the gap between actual GDP and potential GDP is a key measure of the economy's performance in the short run.
- ...the causes of unemployment.
- ...what the reverse multiplier effect is.
- ...the role of wage-setting for the aggregate economy.

Required readings:

 [Shapiro et al. \(2022, ch. 14\)](#)

### 10.1 Unemployment

#### 10.1.1 Introduction

- Unemployment is a serious personal and social economic problem as it means that person loses income and the nation loses production. Persistent unemployment damages a person's future job prospects by destroying their human capital.
- **Individual Costs of Unemployment:**
  - Loss of earnings.
  - Increased risk of slipping into poverty.
  - Deterioration of health.
  - Drugs, alcohol abuse, crime.
  - De-skilling.
  - Workers lose touch with changes in work practices and technology.
- **Economic and Social Costs of Unemployment:**
  - Opportunity cost ⇒ Lost output
  - Tax and benefits effect ⇒ Lower tax revenues, higher welfare payments
  - Social costs (Deteriorating Health, Costs of Crime, Social Unrest, Political Repercussion)
- Each adult can either be...
  - employed,

- unemployed or
- not participate in the labor force.
- **Defining unemployment:** Someone who does not have a job and is willing and available for work is defined as unemployed.
- The official definition of unemployment varies across countries and federal statistical agencies, respectively.
- **How to fight unemployment?** Government programs can affect the time it takes unemployed workers to find new jobs. These programs encompass the following:
  - Government-run employment agencies
  - Training and education schemes
  - Wage subsidies
  - Public employment schemes
  - Unemployment insurance (Passive Labor Market Policy)

### 10.1.2 Reasons for unemployment

In a perfect labor market...

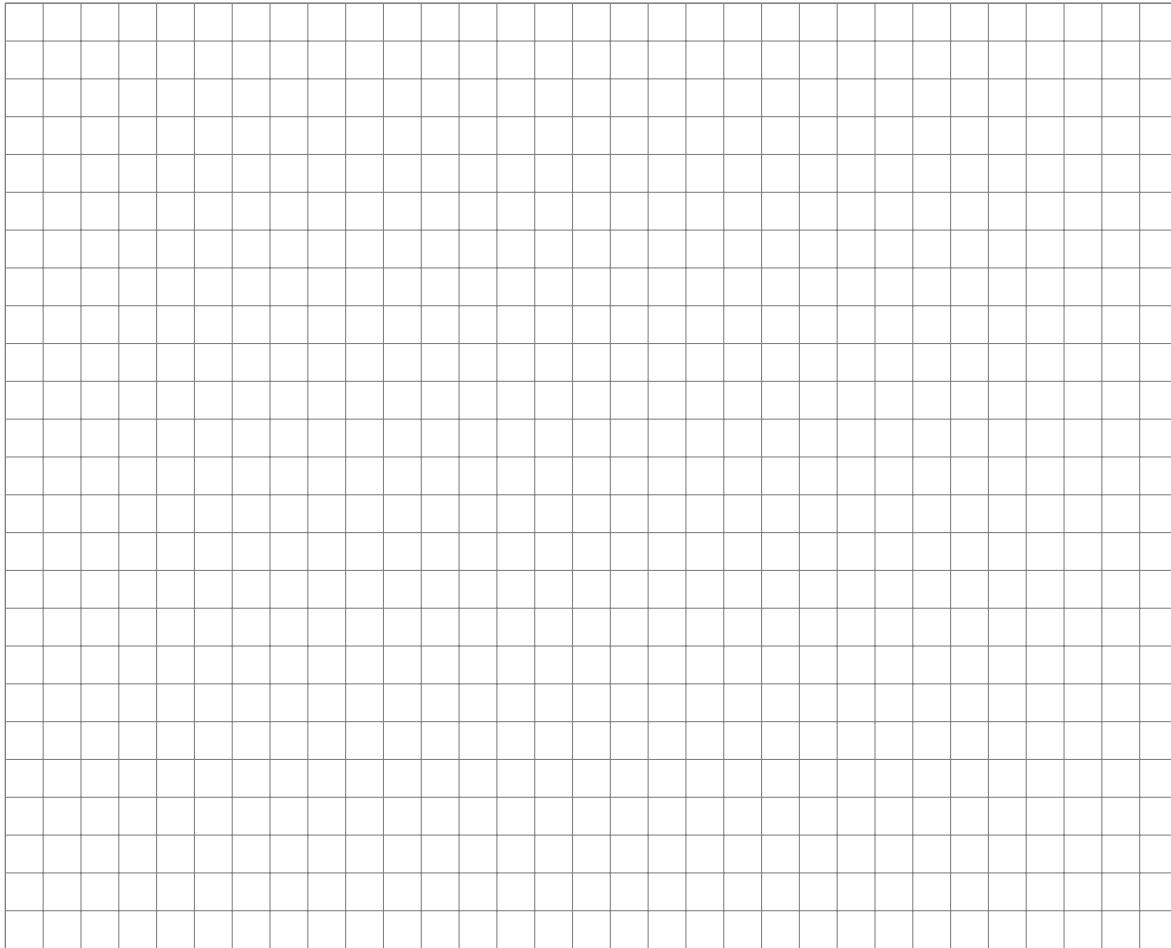
- ...wages would adjust so that the quantity of labor supplied and the quantity of labor demanded would be equal.
- At equilibrium, therefore, there is no unemployment.
- Adjustments of the wage rate would ensure that all workers are always fully employed.

Then why are people unemployed? Answer: because labor markets do not clear instantaneously.

#### **Exercise 10.1 — Perfect labor market**

(Solution → p. ??)

Draw a two-way plot with labor supply and demand which economists often use to paraphrase a market (equilibrium) of full-employment and unemployment, respectively.



Job losses within particular industries may result from<sup>1</sup>

- **Technological change:** Workers whose knowledge, skills and experience are now redundant now have to seek new employment.
- **Structural change in the economy:** Over time structural changes affect the make-up of economies. Structural change can be caused by competition from abroad or by changes in technology and changes in societal norms and trends.
- Workers who lose their jobs in one industry may find that jobs are available but these
  - require skills and experience they do not possess → *occupational immobility*.
  - or are not in the immediate region where they live → *geographic immobility*.
- Alternatively, wages may be too high for labor demand to absorb all labor supply.
  - Three possible reasons for an above equilibrium wage are **minimum wage laws, unions, and efficiency wages** (more on that later)
  - When the wage is above the equilibrium level...
    - \* ...the quantity of labor supplied exceeds the quantity of labor demanded.
    - \* ...workers are unemployed because they are waiting for jobs to open up.

---

<sup>1</sup>If you are interested in imperfect labor markets, read [Boeri and van Ours \(2013\)](#).

### 10.1.3 Why is the wage not at a market-clearing level?

#### Minimum wage

- When the minimum wage is set above the level that balances supply and demand, it creates unemployment.
- Minimum wages are binding most often for the least skilled and least experienced members of the labor force, such as teenagers.

#### Unions



<sup>2</sup>

- A union is a worker association that bargains with employers over wages and working conditions.
- In the early 1980s over half of the UK labor force was unionized but this figure fell rapidly over a few years to a union coverage of 25.4% in 2013.
- The process by which unions and firms agree on the terms of employment is called collective bargaining.
  - Economists have found that union workers typically earn significantly more than similar workers who do not belong to unions.
- A strike may be organized if the union and the firm cannot reach an agreement. A strike refers to when the union organizes a withdrawal of labor from the firm.

**Are unions good or bad for the economy?** Critics argue that unions cause the allocation of labor to be inefficient and inequitable. Wages above the competitive level reduce the quantity of labor demanded and cause unemployment. Some workers benefit at the expense of others.

Advocates of unions contend that unions are a necessary antidote to the market power of firms that hire workers. This is particularly the case in the presence of local monopsonies (there is only one firm hiring workers). In addition, they claim that unions are important for helping firms respond efficiently to workers' concerns.

#### Exercise 10.2 — Unions as the source of market failure

(Solution → p. 157)

Unions aim to protect the workers, right? But what about the unemployed persons? Do unions care about them? They are usually not members of unions. If they do not care about unemployed persons, how can that cause the labor market to fail. In other words, explain the insider-outsider theory of labor economics?

<sup>2</sup>Source: <https://laborunionreport.com/2019/08/16/daily-labor-union-report-for-friday-august-16-2019/>

## Solution to Exercise 10.2 — Unions as the source of market failure (Exercise → p. 156)

The insider-outsider theory of labor economics explains how firm behavior, national welfare, and wage negotiations are affected by a group in a more privileged position. The insiders, those employed by a firm, and the employers are the bargainers over wages. Because the insiders are already employed, they are in a position of power and are ultimately uninterested in expanding the number of jobs available for those who are not already employed. In other words, they are interested in maximizing their own wages rather than expanding jobs by holding wages down and allowing outsiders to become employed. Firms have a strong incentive to bargain with the insiders because of the high cost of replacing those workers. This cost, called labor turnover cost, includes severance pay, hiring process expenditures, and firm-specific training. Because the rate of unemployment has no weight to the monopoly of the union and employers on wage-setting, the natural rate of unemployment rises as the actual rate does. The outsiders (unemployed) become increasingly less relevant in the bargain. Because insiders commonly use their position of power to dissuade outsiders from underbidding their current wage. The result is a labor market that does not see any wage underbidding despite the willingness of many unemployed workers to work at a lower wage. This results in a market failure, meaning that the wage is not being set according to the labor market's needs or preferences.

### Efficiency wages

- Efficiency wages are above-equilibrium wages paid by firms in order to increase worker productivity.
- The theory of efficiency wages states that firms operate more efficiently if wages are above the equilibrium level.<sup>3</sup>
- A firm may prefer higher than equilibrium wages for the following reasons:
  - Worker Health: Better paid workers eat a better diet and thus are more productive.
  - Worker Turnover: A higher paid worker is less likely to look for another job.
  - Worker Effort: Higher wages motivate workers to put forward their best effort.
  - Worker Quality: Higher wages attract a better pool of workers to apply for jobs.

### Exercise 10.3 — Wage increases can cut costs

(Solution → p. ??)

On January 5, 1914, Henry Ford (1863-1947) stunned the world when he announced that the Ford Motor Company would double its workers' wages to five dollars a day. He later said this was the best cost-cutting decision he could have made. What sounds like a paradox is easy to explain. Do it and discuss the role of efficiency wages.

<sup>3</sup>Joseph E. Stiglitz (\*1943) won the Nobel Prize of Economics in 2001 also because of his work on asymmetric information and efficiency wages, see [Shapiro and Stiglitz \(1984\)](#).

## Marx and the reserve army

Karl Heinrich Marx (1818-1883) believed that unemployment was a necessary condition for capitalism to survive because it keeps wages low and at the same time intimidates workers so they do not revolt against the market power of industrialists. Marx referred to the unemployed as the *reserve industrial army of labor*.

- This reserve army consisted of different groups of people including the long-term unemployed and those who move in and out of the labor market at different times for different reasons.
- They are only employed if there is a considerable shortage in the labor market.
- It provides a ready-made pool of potential workers that can be dipped into when output needs to be increased quickly to meet demand.



The Karl Marx University of Trier has never existed. However, there have been several attempts to rename the university. So far, they have all failed. Can you imagine why?

### 10.1.4 Types of unemployment

#### Frictional unemployment

is the unemployment that arises from normal labor turnover. These workers are searching for jobs. The unemployment related to this search process is a permanent phenomenon in a dynamic, growing economy. Frictional unemployment increases when more people enter the labor market or when unemployment compensation payments increase.

- It takes time for workers to search for the jobs that are best suited to their tastes and skills.
- Search unemployment is inevitable because the economy is always changing.
- Workers in declining industries will find themselves looking for new jobs, and firms in growing industries will be seeking new workers.
- If job search takes time, this means that there must always be some unemployment.

#### Structural unemployment

is the unemployment that arises when changes in technology or international competition change the skills needed to perform jobs or change the locations of jobs. Sometimes there is a mismatch between skills demanded by firms and skills provided by workers, especially when there are great technological changes in an industry. Structural unemployment generally lasts longer than frictional unemployment. Minimum wages and efficiency wages create structural unemployment.

#### Voluntary and involuntary unemployment

Voluntary unemployment occurs if people choose to remain unemployed rather than taking jobs that are available. Involuntary unemployment occurs if people want to work at going market wage rates but cannot find employment.

#### Cyclical unemployment

is the fluctuating unemployment over the business cycle. Cyclical unemployment increases during a recession and decreases during an expansion.

## Natural unemployment

is the unemployment that arises from frictions and structural change when there is no cyclical unemployment—when all the unemployment is frictional and structural. Natural unemployment as a percentage of the labor force is called the natural unemployment rate.

## Full employment

is defined as a situation in which the unemployment rate equals the natural unemployment rate.

### Exercise 10.4 — Can unemployment be good?

(Solution → p. 159)

Getting laid off is usually bad for the individual, but may be good long term for society.

Discuss that statement working through each type of unemployment asking whether it is good or bad for society.

### Solution to Exercise 10.4 — Can unemployment be good?

(Exercise → p. 159)

**Frictional?** Good because a healthy, dynamic, economy needs new entrants to the labor force , such as college graduates, and freedom for people to quit a job they don't like.

**Structural?** Good because a healthy, growing economy has technological change that makes some jobs obsolete.

**Cyclical?** Bad because it is unfortunate to have unemployment strictly because of the cyclical nature of the economy. If it were possible to maintain the same level of economic growth with less fluctuation, we would have less cyclical unemployment with a higher level of welfare. Can and should the cycle be managed? This is a big question in Macroeconomics that we will continue to tackle!

**Natural?** From the perspective of an unemployed individual who has yet to find the job he or she wants, unemployment is bad and not natural. However, there is some level of unemployment that is good for society because it will help create more productive matches between firms and workers and allow for technological changes that lead to economic growth.

### Exercise 10.5 — Unemployment in Niger and Qatar

(Solution → p. ??)

Watch  2021 Unemployment Rate Comparison by Country <https://youtu.be/6QgD4GfyFmU>

Discuss why such different countries like Niger and Qatar have such similar and low unemployment rates.

## 10.2 Fluctuations in GDP

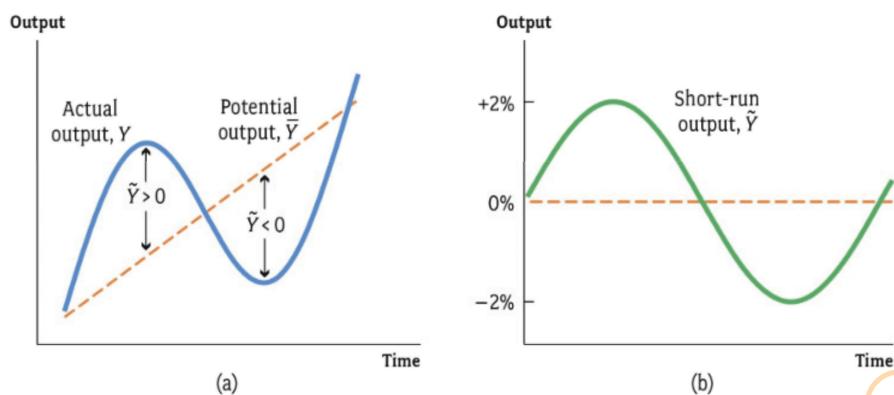


Figure 10.1: Economic fluctuations and short-run output<sup>4</sup>

Actual output in an economy can be viewed as the sum of the long-run trend and short-run fluctuations:

$$\underbrace{\text{actual output}}_{Y_t} = \underbrace{\text{long-run trend}}_{\bar{Y}_t} + \underbrace{\text{short-run fluctuation}}_{\tilde{Y}_t}$$

where  $\bar{Y}_t$  denotes the potential output accounting for the general trend in overall GDP. The short run component  $\tilde{Y}_t$  captures the fluctuations in GDP.

- When the economy is at full employment, the unemployment rate equals the natural unemployment rate and real GDP equals potential GDP.
- When the unemployment rate is greater than the natural unemployment rate, real GDP is less than potential GDP.
- And when the unemployment rate is less than the natural unemployment rate, real GDP is greater than potential GDP.
- The gap between real GDP and potential GDP is called the output gap.

### 10.3 Fluctuations in GDP and unemployment

**Okun's Law** is an empirically observed relationship between unemployment and short-run fluctuations in countries' production. It is named after Arthur Melvin Okun (1928-1980), who first proposed the relationship in 1962. See [Figure 10.2](#).

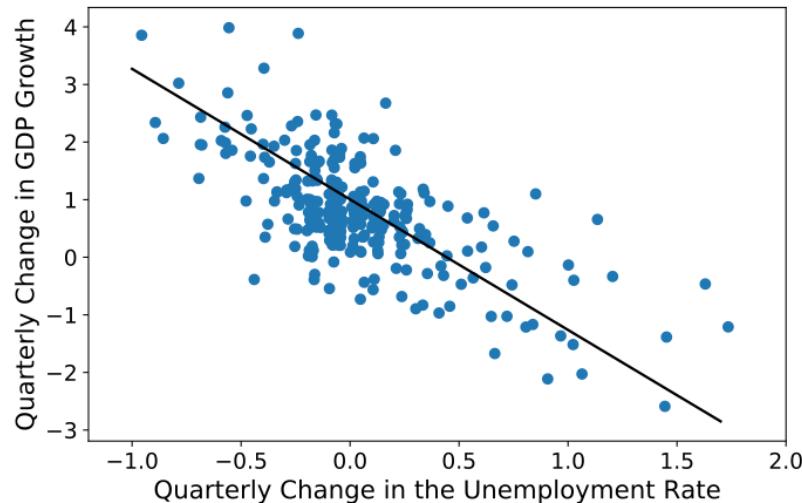


Figure 10.2: Okun's Law<sup>5</sup>

### 10.4 The reverse multiplier effect

When people experience unemployment, they...

- ...cut back their spending on luxuries
  - Goods with a relatively high income elasticity of demand are likely to be affected more significantly.
  - These businesses cut back orders and lay off workers
  - This way, an increase in unemployment can impact on economic activity as a whole and thereby create further unemployment.

- Negative effects often differ locally.
- ... switch their spending to substitute goods which may be seen as inferior goods. So some firms might see an increase in demand, e.g., budget supermarkets.

### Exercise 10.6 — The great depression vs. COVID crisis

(Solution → p. ??)

John Maynard Keynes (1883-1946):

In the long run we are all dead

Watch:  <https://youtu.be/qtAeINU3FKM>



Read:  [https://en.wikipedia.org/wiki/Great\\_Depression\\_in\\_the\\_United\\_States](https://en.wikipedia.org/wiki/Great_Depression_in_the_United_States)

Read:  <https://crsreports.congress.gov/product/pdf/R/R46554/21>

With respect to unemployment: Compare the great depression with the recent COVID crisis.

# Chapter 11

## Economies in the short run: The goods market

In this chapter, we learn...

- ...that demand determines production in the short run.
- ...that an increases in consumer confidence, investment demand, government spending, or a decreases in taxes increase equilibrium output in the short run.
- ...how to derive the building blocks of our short-run model: the IS curve.

Required readings:

■ [Blanchard and Johnson \(2013, Chapter 3\)](#).

### 11.1 Stylized facts

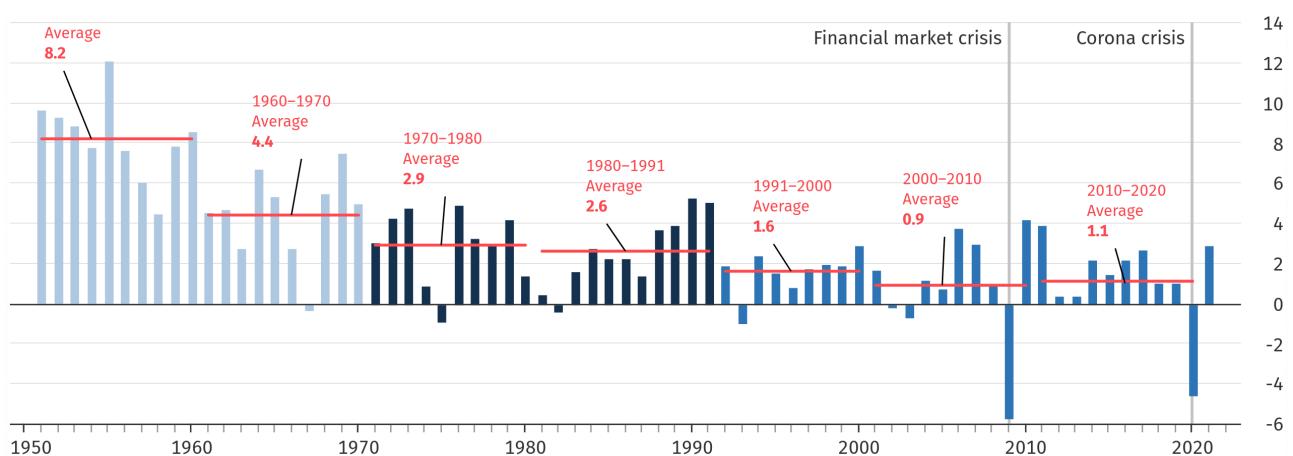


Figure 11.1: Germany's GDP from 1950 to 2022, price adjusted, percentage change on a year earlier  
Source: Statistisches Bundesamt (Destatis), 2022

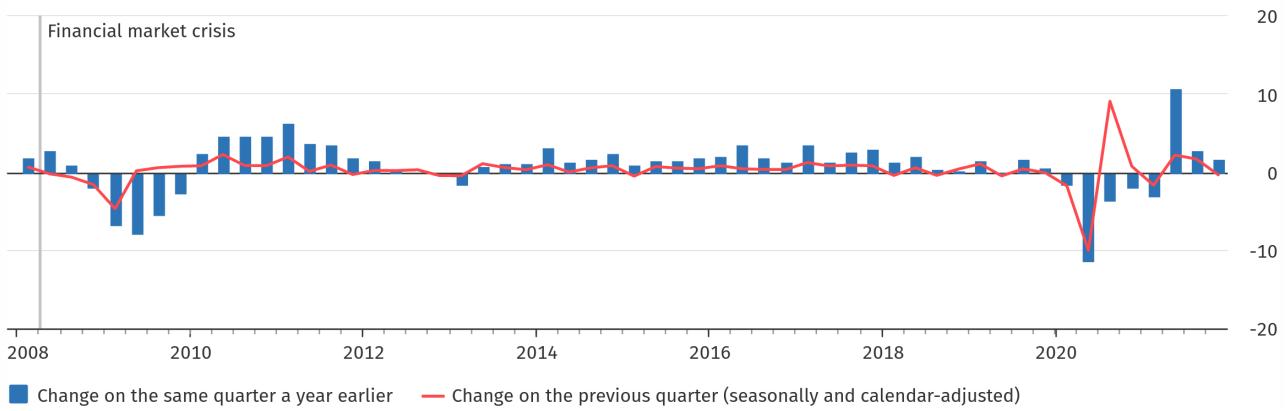


Figure 11.2: GDP, price adjusted, percentage change on a year earlier  
Source: Statistisches Bundesamt (Destatis), 2022

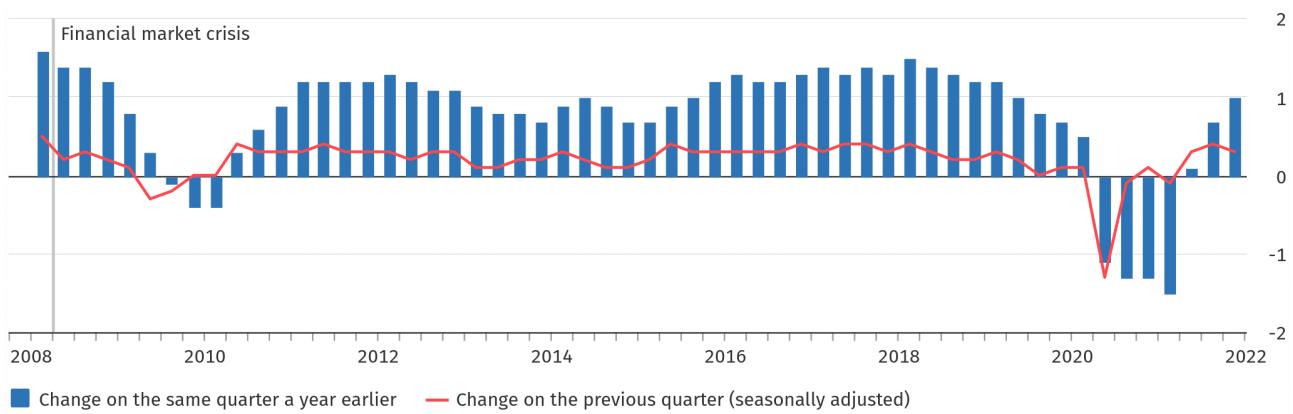


Figure 11.3: Persons in employment in Germany from 1950 to 2022  
Source: Statistisches Bundesamt (Destatis), 2022

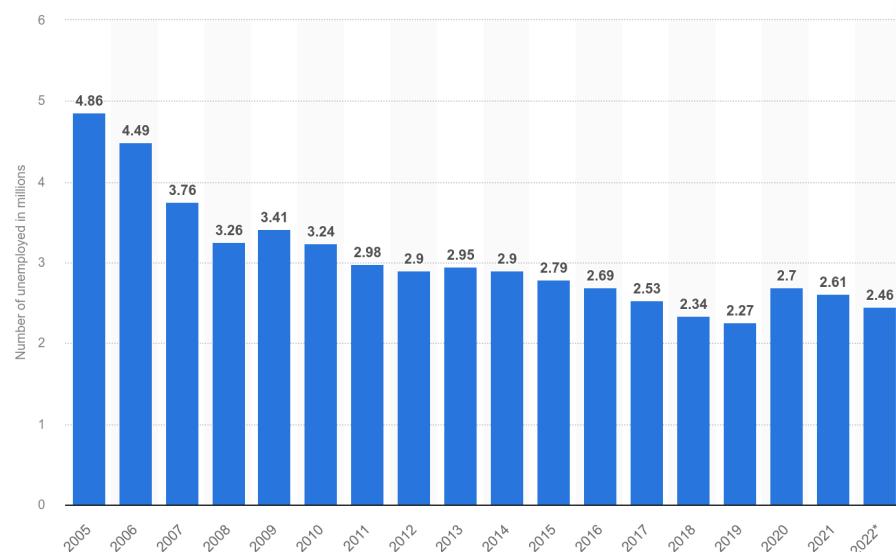
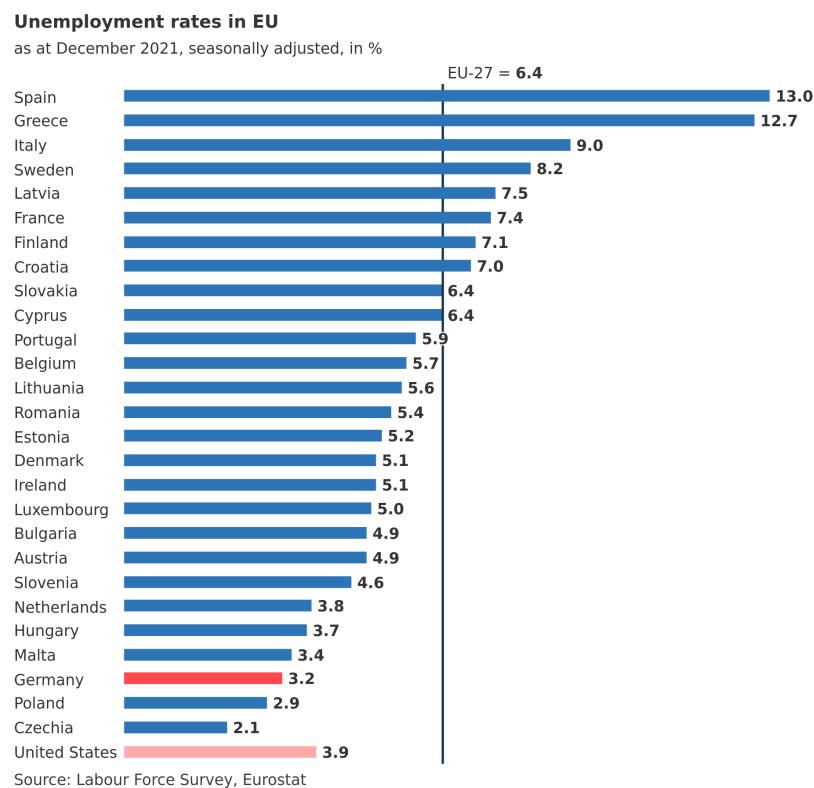


Figure 11.4: Annual average unemployment figures for Germany from 2005 to 2022  
Source: Statista 2022 <https://www.statista.com/statistics/226994/annual-average-unemployment-figures-for-germany/>



© Statistisches Bundesamt (Destatis), 2022

**Figure 11.5: Unemployment rates, EU**  
Source: Statistisches Bundesamt (Destatis), 2022

[https://www.destatis.de/EN/Themes/Labour/Labour-Market/\\_Graphic/\\_Interactive/unemployment-rates-eu-27.html](https://www.destatis.de/EN/Themes/Labour/Labour-Market/_Graphic/_Interactive/unemployment-rates-eu-27.html)

## 11.2 Corona and how to fight an economic crisis

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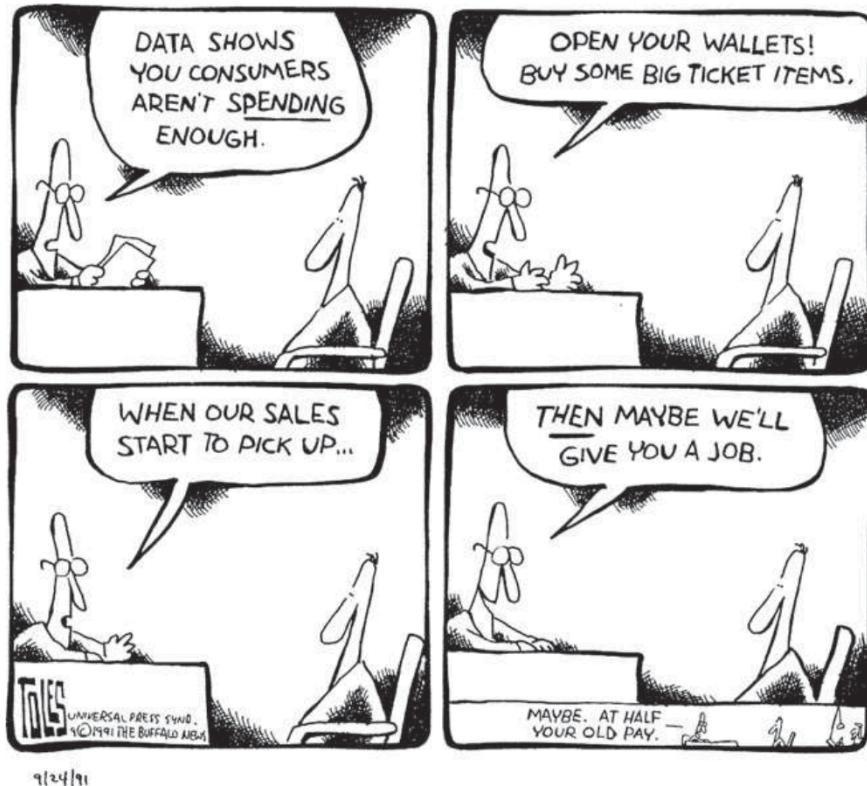


Figure 11.6: Open your wallets!

Source: Taken from *Blanchard and Johnson* (2013, p. 43)

In times of economic crisis...

- ... people cut back their consumption and
- ... businesses cut back orders and lay off workers which in turn makes people consume less...

⇒ How to escape from this self-fulfilling prophecy and vicious circle?

The coronavirus pandemic is slowing global commerce to a crawl, but many of the world's largest economies are taking extraordinary actions to propel them through the crisis. How have national governments acted to reduce the negative economic impact of the Corona pandemic?

To support EU citizens, businesses and countries in the recovery from the economic downturn caused by the COVID-19 pandemic, EU leaders agreed to work on recovery plan for Europe. On 23 April 2020, they committed to establishing an EU recovery fund aimed at mitigating the effects of the crisis. On **21 July 2020**, EU leaders agreed on an overall budget of €1.824 trillion for 2021-2027. Combining the multiannual financial framework (MFF) and an extraordinary recovery effort, Next Generation EU (NGEU), the package will help the EU to rebuild after the COVID-19 pandemic, and will support investment in the green and digital transitions. These elements are in addition to the three safety nets of €540 billion already put in place by the EU to support workers, businesses and countries. On **25 September 2020**, the Council approved €87.4 billion in financial support to 16 member states under the EU's temporary support to mitigate unemployment risks in an emergency (SURE).<sup>1</sup>

**Germany's response** To combat the COVID-19 crisis and subsequently support the recovery, the federal government adopted two supplementary budgets:

<sup>1</sup>The **IMF Policy tracker**: summarizes the key economic responses governments are taking to limit the human and economic impact of the COVID-19 pandemic. The tracker includes 196 economies. See: [www.imf.org/en/Topics/imf-and-covid19/Policy-Responses-to-COVID-19](http://www.imf.org/en/Topics/imf-and-covid19/Policy-Responses-to-COVID-19)

- €156 billion (4.9 percent of GDP) in March and €130 billion (4 percent of GDP) in June.
- The authorities plan to issue €218.5 billion in debt this year to finance the packages.

Early measures include:

1. spending on healthcare equipment, hospital capacity and R&D (vaccine),
2. expanded access to short-term work (*Kurzarbeit*) subsidy to preserve jobs and workers' incomes, expanded childcare benefits for low-income parents and easier access to basic income support for the self-employed,
3. €50 billion in grants to small business owners and self-employed persons severely affected by the Covid-19 outbreak in addition to interest-free tax deferrals until year-end and €2bn of venture capital funding for start-ups,
4. temporarily expanded duration of unemployment insurance and parental leave benefits.

The stimulus package in June comprises a temporary value added tax reduction, income support for families, grants for hart-hit SME's, financial support for local governments, expanded credit guarantees for exporters and export-financing banks, and subsidies/investment in green energy and digitalization. In August, the government extended the maximum duration of short-term work benefits from 12 to 24 months.

At the same time, through the newly created economic stabilization fund WSF (Wirtschaftsstabilisierungsfonds) and the public development bank KfW (Kreditanstalt für Wiederaufbau), the government is expanding the volume of available guarantees and access to public guarantees for firms of different sizes, credit insurers, and non-profit institutions, some eligible for up to 100 percent guarantees, increasing the total volume by at least €757 billion (24 percent of GDP). The WSF and KfW also include facilities for public equity injection into firms with strategic importance.

In addition to the federal government's fiscal package, many local governments (Länder and municipalities) have announced own measures to support their economies, amounting to €141 billion in direct support and €63bn in state-level loan guarantees.

## 11.3 Aggregate demand

When economists think about year-to-year movements in economic activity, they focus on the interactions among **production, income, and demand**:

- Changes in the demand for goods lead to changes in production.
- Changes in production lead to changes in income.
- Changes in income lead to changes in the demand for goods.

### 11.3.1 The composition of GDP

#### **Consumption, $C$**

It refers to the goods and services purchased by consumers such as food, airline tickets, new cars, vacation, ...

#### **Investment, $I$**

It is the purchase of capital goods. It is the sum of nonresidential investment (e.g., purchases by firms of new plants and machines) and residential investment (e.g., purchases by people of new houses).

		Billions of Dollars	Percent of GDP
	<b>GDP (<math>Y</math>)</b>	<b>14,660</b>	<b>100</b>
<b>1</b>	<b>Consumption (<math>C</math>)</b>	<b>10,348</b>	<b>70.5</b>
<b>2</b>	<b>Investment (<math>I</math>)</b>	<b>1,756</b>	<b>12.0</b>
	Nonresidential	1,415	9.7
	Residential	341	2.3
<b>3</b>	<b>Government spending (<math>G</math>)</b>	<b>3,001</b>	<b>20.4</b>
<b>4</b>	<b>Net exports</b>	<b>-516</b>	<b>-3.5</b>
	Exports ( $X$ )	1,838	12.5
	Imports ( $IM$ )	-2,354	-16.0
<b>5</b>	<b>Inventory investment</b>	<b>71</b>	<b>0.5</b>

Source: Survey of Current Business, May 2010, Table 1-1-5

Figure 11.7: The composition of U.S. GDP, 2010

**Warning!** To most people, *investment* refers to the purchase of assets like gold or shares of BMW. Economists use *investment* to refer to the purchase of new capital goods, such as (new) machines, (new) buildings, or (new) houses. When economists refer to the purchase of gold, or shares of BMW, or other financial assets, they (usually) use the term *financial investment*.

### Government Spending, $G$

It refers to the purchases of goods and services by the federal, state, and local governments. It does not include government transfers (e.g., medicare, social security), nor interest payments on the government debt. Although these are clearly government expenditures, they are not purchases of goods and services.

### Imports, $IM$

Imports are the purchases of foreign goods and services by consumers, business firms, and the domestic government.

### Exports, $X$

Exports are the purchases of domestic goods and services by foreign countries.

**Inventory investment is not part of demand and GDP!** In any given year, production and sales need not be equal. Some of the goods produced in a given year are not sold in that year, but in later years. And some of the goods sold in a given year may have been produced in an earlier year. The difference between goods produced and goods sold in a given year is called **inventory investment**.

$$\begin{aligned} \text{production} - \text{sales} &= \text{inventory investment} \\ \Leftrightarrow \text{production} &= \text{sales} + \text{inventory investment}^a \end{aligned}$$

<sup>a</sup>The terms *output* and *production* are synonymous. There is no rule for using one or the other.

If production exceeds sales and firms accumulate inventories as a result, then inventory investment is said to be positive. If production is less than sales and firms' inventories fall, then inventory investment is said to be negative. Inventory investment is typically small.

### 11.3.2 Demand for Goods

Denote the total demand for goods by  $Z$ . Using the decomposition of GDP, we can write  $Z$  as

$$Z \equiv C + I + G + X - IM$$

This equation is an identity (which is why it is written using the symbol  $\equiv$  rather than an equals sign). To think about the determinants of  $Z$  fruitfully, let's make some simplifications to focus on the issue at hand:

- Assume that all firms produce the same good, which can then be used by consumers for consumption, by firms for investment, or by the government.
- A *good* is an item that stands for both physical goods and services.
- Assume that firms are willing to supply any amount of the good at a given price level  $P$ . This assumption allows us to focus on the role demand plays in the determination of output.
- Assume that the economy is closed, i.e., it does not trade with the rest of the world. Thus, both exports and imports are zero. Of course, this is untrue. However, for the moment, this assumption simplifies our discussion because we won't have to think about what determines exports and imports.
- Under the assumption that the economy is closed (a.k.a. in autarky), the demand for goods is simply the sum of (1) consumption, (2) investment, and (3) government spending:

$$Z \equiv C + I + G$$

#### (1) Consumption

$$C = C(\underbrace{Y_D}_{(+)})$$

- The function  $C = C(Y_D)$  is called the consumption function. It is a behavioral equation, i.e., it captures the behavior of consumers.
- The plus below the function,  $(+)$ , denotes that  $\frac{\partial C}{\partial Y_D} > 0$ . In other words, consumption increases with disposable income (but less than one for one).
- Disposable income,  $Y_D$ , is the income that remains once consumers have paid taxes ( $T$ ) and received transfers from the government.

$$Y_D \equiv Y - T \tag{11.1}$$

- A more specific form of the consumption function is the linear relation of [Figure 11.8](#):

$$C = c_0 + c_1 Y_D \tag{11.2}$$

- This function has two parameters,  $c_0$  and  $c_1$ :
  - $c_1$  is called the (marginal) propensity to consume, or the effect of an additional dollar of disposable income on consumption ( $0 \leq c_1 < 1$ ).
  - $c_0$  is the intercept of the consumption function.

#### (2) Investment

Variables that depend on other variables within the model are called **endogenous**. Variables that are not explained within the model are called **exogenous**. For now (we'll relax that assumption later), we assume that investment is taken as given. Thus it is an exogenous variable and we write:

$$I = \bar{I} \tag{11.3}$$

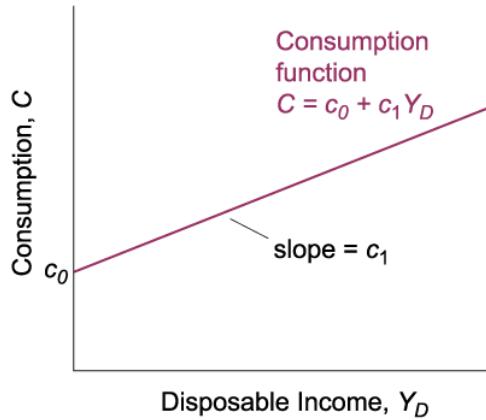


Figure 11.8: Consumption and disposable income  
Source: Taken from [Blanchard and Johnson \(2013, p. 47\)](#)

### (3) Government spending

- Government spending,  $G$ , together with taxes,  $T$ , describes fiscal policy—the choice of taxes and spending by the government.
- We assume that  $G$  and  $T$  are exogenous as these variables are typically chosen by the government and hence, we will not try to explain them in the model.
- As we do not change that assumption later on, we do not use a bar to denote the fact that we treat  $G$  and  $T$  as given. That makes the notation a bit lighter.
- Please note, taxes  $T$  denote taxes minus government transfers.

#### 11.3.3 Equilibrium at the goods market

Equilibrium output is determined by the condition that supply (output/production) be equal to demand.

##### The Determination of equilibrium output

Equilibrium<sup>2</sup> in the goods market requires that production,  $Y$ , be equal to the demand for goods,  $Z$ :

$$Y = Z$$

Then, using our assumptions of (1) to (3):

$$\begin{aligned} Y &= \underbrace{C + I + G}_Z \\ Y &= \underbrace{c_0 + c_1 Y_D}_C + \underbrace{\bar{I}}_I + G \\ Y &= c_0 + c_1 \underbrace{(Y - T)}_{Y_D} + \bar{I} + G \end{aligned}$$

The equilibrium condition is that, production,  $Y$ , be equal to demand,  $Z$ . Demand,  $Z$ , in turn depends on income,  $Y$ , which itself is equal to production and outcome, respectively.<sup>3</sup>

<sup>2</sup>If you struggle with the term *equilibrium* help yourself: [https://en.wikipedia.org/wiki/Economic\\_equilibrium](https://en.wikipedia.org/wiki/Economic_equilibrium)

<sup>3</sup>We use  $Y$  to denote both production and income. This is no accident. Remember: we can look at GDP either from the production side or from the income side.

Having constructed a model, we can solve it to look at what determines the level of output—how output changes in response to, say, a change in government spending. Solving a model means not only solving it **algebraically**, but also understanding why the results are what they are. In this lecture, solving a model will also mean characterizing the results using **graphs**—sometimes skipping the algebra altogether—and describing the results and the mechanisms in **words**.

Economists use these three tools to *solve* a model:

1. Algebra to make sure that the logic is correct
2. Graphs to build the intuition
3. Words to explain the results

#### 11.3.4 The model using algebra

The equilibrium equation can be manipulated to derive some important terms. Let us solve  $Y = c_0 + c_1(Y - T) + \bar{I} + G$  to  $Y$ :

$$Y = \underbrace{\frac{1}{1 - c_1}}_{\text{multiplier}} \left[ \underbrace{c_0 + \bar{I} + G - c_1 T}_{\text{autonomous spending}} \right]$$

The result can be understood by identifying two components:

**Autonomous spending** here means that it is independent of output as all variables are given (exogenous).

**The multiplier** is greater than one because the propensity to consume ( $c_1$ ) is between zero and 1.

The closer ( $c_1$ ) is to 1, the larger the multiplier. Thus, if autonomous spending increases by one unit output increases by more than one unit.

#### FAQ:

##### Where does the multiplier effect come from?

- From [Equation 11.2](#) we know that more an increase in  $c_0$  increases demand. The increase in demand then leads to an increase in production. The increase in production leads to an equivalent increase in income (remember the two are identically equal). The increase in income further increases consumption, which further increases demand, and so on.
- We can think of the original increase in demand as triggering successive increases in production, with each increase in production leading to an increase in income, which leads to an increase in demand, which leads to a further increase, which leads ... and so on.
- The multiplier is the sum of successive increases in production resulting from an increase in demand.
- When demand is, say, \$1 billion higher, the total increase in production after  $n$  rounds of increase in demand equals \$1 billion times:

$$1 + c_1 + c_1^2 + \cdots + c_1^n = \frac{1}{1 - c_1}$$

This sum is called a geometric series.<sup>a</sup>

##### Is the Government omnipotent?

- Changing government spending or taxes is not always easy.
- The responses of consumption, investment, imports, etc, are hard to assess with much certainty.
- Anticipations are likely to matter.

- Achieving a given level of output can come with unpleasant side effects.
- Budget deficits and public debt may have adverse implications in the long run.

### How Long Does It Take for Output to Adjust?

- In response to an increase in consumer spending, output does not jump to the new equilibrium, but rather increases over time. The adjustment depends on how and how often firms revise their production schedule.
- Describing formally the adjustment of output over time is what economists call the dynamics of adjustment.

**What is the value of the multiplier in the real World?** To estimate the value of the multiplier, and more generally, to estimate behavioral equations and their parameters, economists use econometrics—a set of statistical methods used in economics. That is not trivial and the results vary substantially depending on several circumstances.

Ramey (2019) concludes his survey on the effects on spendings during the financial crisis as follows:

Reviewing the estimates, I come to the surprising conclusion that the bulk of the estimates for average spending and tax change multipliers lie in a fairly narrow range, 0.6 to 1 for spending multipliers and -2 to -3 for tax change multipliers. However, I identify economic circumstances in which multipliers lie outside those ranges.

<sup>a</sup>If you need some help here, feel free to have a look on the mathematical appendix on page ??f.

#### 11.3.5 The model using graphs

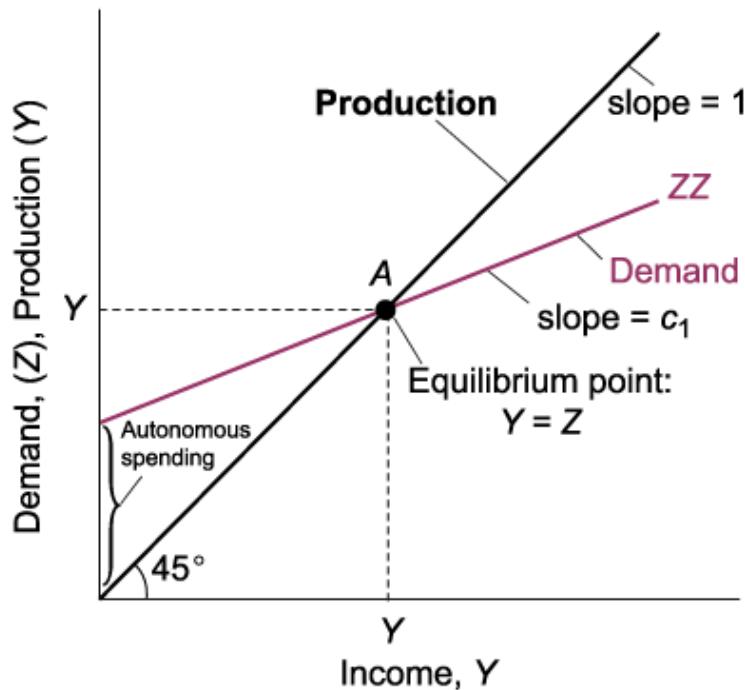


Figure 11.9: Equilibrium in the goods market: The Keynesian cross  
Source: Taken from [Blanchard and Johnson \(2013, p. 51\)](#)

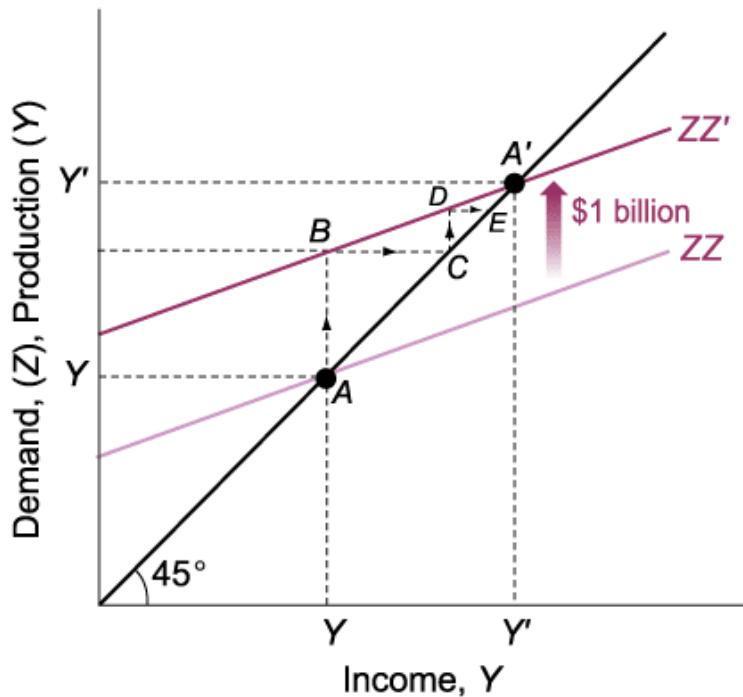


Figure 11.10: The effects of an increase in autonomous spending on output  
Source: Taken from *Blanchard and Johnson* (2013, p. 52)

### 11.3.6 The model using words

- This first-round increase in demand leads to an equal increase in production, or \$1 billion, which is also shown by the distance AB.
- This first-round increase in production leads to an equal increase in income, shown by the distance BC, also equal to \$1 billion.
- The second-round increase in demand, shown by the distance CD, equals \$1 billion (the increase in income in the first round) times the propensity to consume,  $c_1$  – hence,  $\$c_1$  billion.
- This second-round increase in demand leads to an equal increase in production, also shown by the distance CD, and thus an equal increase in income, shown by the distance DE.
- The third-round increase in demand equals  $\$c_1$  billion (the increase in income in the second round), times  $c_1$ , the marginal propensity to consume; it is equal to  $\$c_1 \cdot c_1 = c_1^2$  billion \$, and so on.
- An increase in autonomous spending has a more than one-for-one effect on equilibrium output.
- An increase in demand leads to an increase in production and a corresponding increase in income. The end result is an increase in output that is larger than the initial shift in demand, by a factor equal to the multiplier.

## 11.4 The goods market and the investment-savings (IS) relation

**Recall:** Equilibrium in the goods market exists when production,  $Y$ , is equal to the demand for goods,  $Z$ . In the simple model developed above, the interest rate did not affect the demand for goods. The equilibrium condition was given by:

$$Y = C(Y - T) + I + G$$

### 11.4.1 The derivation of the IS curve

Now, let us loosen the assumption that investments are exogenous by capturing the effects of two determinants of investment:

- The level of sales,  $Y$ , is positively associated with investments ( $\frac{\partial I}{\partial Y} > 0$ )
- The interest rate,  $i$ , is negatively associated with investments ( $\frac{\partial I}{\partial i} < 0$ )

$$I = I(Y, i)$$

Taking into account the investment relation above, the equilibrium condition in the goods market becomes:

$$Y = C(Y - T) + I(Y, i) + G$$

#### Exercise 11.1 — Determinants of investments

(Solution → p. 173)

Explain the intuition behind our assumptions that  $\frac{\partial I}{\partial Y} > 0$  and  $\frac{\partial I}{\partial i} < 0$ .

#### Solution to Exercise 11.1 — Determinants of investments

(Exercise → p. 173)

*Consider a firm facing an increase in sales and needing to increase production. To do so, it may need to buy additional machines or build an additional plant. In other words, it needs to invest. A firm facing low sales will feel no such need and will spend little, if anything, on investment.*

*Consider a firm deciding whether or not to buy a new machine. Suppose that to buy the new machine, the firm must borrow. The higher the interest rate, the less attractive it is to borrow and buy the machine.*

### 11.4.2 Shifts of the IS curve

$G$ ,  $I$  and  $T$  can shift the IS curve. For example, an increase in taxes shifts the IS curve to the left.

#### Exercise 11.2 — Shifting the IS curve

(Solution → p. ??)

How does  $G$ ,  $I$ , and  $T$  shifts the IS curve?

### 11.4.3 Investment equals savings

Savings is the sum of private plus public savings.

**Private saving ( $S$ )** is saving by consumers:

$$S \equiv Y - T - C$$

**Public saving** equals taxes minus government spending:

- If  $T > G$ , the government is running a budget surplus—public saving is positive.
- If  $T < G$ , the government is running a budget deficit—public saving is negative.

$$\begin{aligned} Y &= C + I + G \\ \Leftrightarrow \underbrace{Y - T - C}_{S} &= I + G - T \\ \Leftrightarrow S &= I + G - T \\ \Leftrightarrow I &= \underbrace{S}_{\text{private savings}} + \underbrace{(T - G)}_{\text{public savings}} \end{aligned}$$

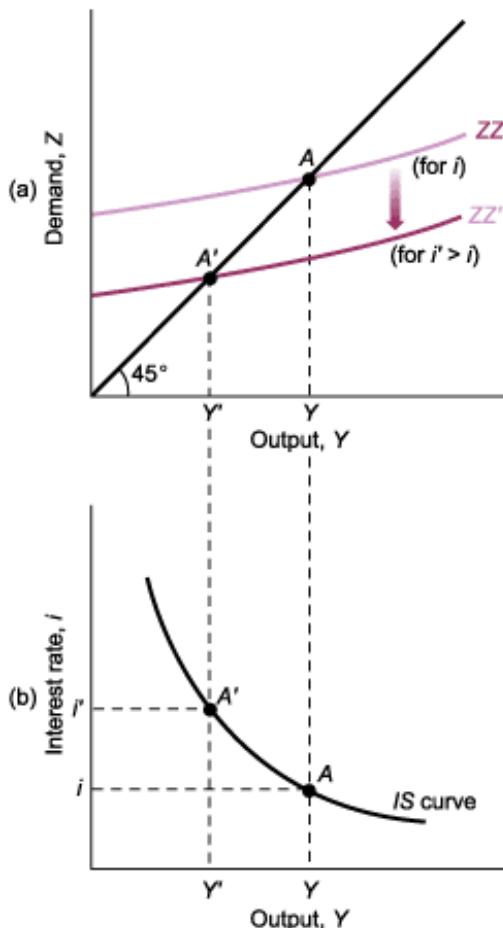


Figure 11.11: IS curve derivation

Source: Taken from [Blanchard and Johnson \(2013, p. 88\)](#)

- Thus, if  $T = G$  then  $I = S$ .
- The equation above states that equilibrium in the goods market requires that investment equals saving—the sum of private plus public saving.
- This equilibrium condition for the goods market is called the IS relation.
- IS stands for *investments equals savings*.
- What firms want to invest must be equal to what people and the government want to save.

## 11.5 Summary

What you should remember about the components of GDP:

- GDP is the sum of consumption, investment, government spending, inventory investment, and exports minus imports.
- Consumption ( $C$ ) is the purchase of goods and services by consumers. Consumption is the largest component of demand.
- Investment ( $I$ ) is the sum of nonresidential investment— the purchase of new plants and new machines by firms- and of residential investment—the purchase of new houses or apartments by people.
- Government spending ( $G$ ) is the purchase of goods and services by federal, state, and local governments.

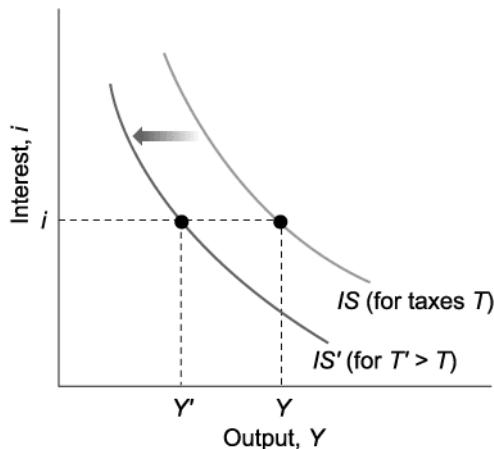


Figure 11.12: Shifts of the IS curve

Source: Taken from [Blanchard and Johnson \(2013, p. 89\)](#)

- Exports ( $X$ ) are purchases of U.S. goods by foreigners.
- Imports ( $Im$ ) are purchases of foreign goods by U.S. consumers, U.S. firms, and the U.S. government.
- Inventory investment is the difference between production and purchases. It can be positive or negative.

What you should remember about our first model of output determination:

- In the short run, demand determines production. Production is equal to income. Income in turn affects demand.
- The consumption function shows how consumption depends on disposable income. The propensity to consume describes how much consumption increases for a given increase in disposable income.
- Equilibrium output is the level of output at which production equals demand. In equilibrium, output equals autonomous spending times the multiplier. Autonomous spending is that part of demand that does not depend on income. The multiplier is equal to  $\frac{1}{(1-c_1)}$ , where  $c_1$  is the propensity to consume.
- Increases in consumer confidence, investment demand, government spending, or decreases in taxes all increase equilibrium output in the short run.

**Key terms that should be familiar to you:** consumption (C), investment (I), fixed investment, nonresidential investment, government spending (G), government transfers, Imports (IM), exports (X), net exports ( $X - IM$ ), trade balance, trade surplus, trade deficit, inventory investment, identity, disposable income ( $Y_D$ ), consumption function, behavioral equation, linear equation, parameter, propensity to consume ( $c_1$ ), fiscal policy, endogenous variables, exogenous variables, equilibrium, equilibrium in the goods market, equilibrium condition,

# Chapter 12

## Economies in the short run: The financial market

### In this chapter, we learn...

- ...the basic functioning of the money market.
- ...that money supply and money demand determines the interest rate.
- ...that central banks influence money demand by influencing the interest rate.
- ...the effects of a monetary expansion.
- ...how to derive the building blocks of our short-run model: the LM-curve.

Recommended readings:

 [Blanchard and Johnson \(2013, Chapter 4\).](#)

Required readings:

 [Blanchard and Johnson \(2013, Chapter 5\).](#)

### 12.1 Semantic traps: Money, income, and wealth

Words such as *money* or *wealth* have very specific meanings in economics, often not the same meanings as in everyday conversations.

**Income** is what you earn from working plus what you receive in interest and dividends. It is a flow—that is, it is expressed per unit of time.

**Saving** is that part of after-tax income that is not spent. It is also a flow. Savings is sometimes used as a synonym for wealth (a term we will not use in this book).

**Financial wealth**, or simply **wealth**, is the value of all your financial assets minus all your financial liabilities. In contrast to income or saving, which are flow variables, financial wealth is a **stock** variable.

**Investment** is a term economists reserve for the purchase of new capital goods, from machines to plants to office buildings. When you want to talk about the purchase of shares or other financial assets, you should refer them as a financial investment.

#### Money

- can be used for transactions, but pays no interest
- two types of money:

- currency(coins and bills)
- checkable deposits (the bank deposits on which you can write checks)

**Bonds** pay a positive interest rate,  $i$ , but cannot be used for transactions

### Exercise 12.1 — Don't say I have a lot of money

(Solution → p. ??)

Read the following text which is taken from [Blanchard and Johnson \(2013, p.65\)](#). Do you understand the difference in the meaning of the terms *money*, *income*, and *wealth*?

In everyday conversation, we use *money* to denote many different things. We use it as a synonym for income: “making money”. We use it as a synonym for wealth: “She has a lot of money”. In economics, you must be more careful. Here is a basic guide to some terms and their precise meanings in economics.

Money is what can be readily used to pay for transactions. Money is currency and checkable deposits at banks. Income is what you earn from working plus what you receive in interest and dividends. It is a flow—something expressed in units of time: weekly income, monthly income, or yearly income, for example. J. Paul Getty was once asked what his income was. Getty answered: “\$1,000”. He meant but did not say: \$1,000 per minute!

Saving is that part of after-tax income that you do not spend. It is also a flow. If you save 10% of your income, and your income is \$3,000 per month, then you save \$300 per month. Savings (plural) is sometimes used as a synonym for wealth—the value of what you have accumulated over time. To avoid confusion, we will not use *savings* in this course.

Your financial wealth, or simply wealth, is the value of all your financial assets minus all your financial liabilities. In contrast to income or saving, which are flow variables, financial wealth is a stock variable. It is the value of wealth at a given moment in time.

At a given moment in time, you cannot change the total amount of your financial wealth. It can only change over time as you save or dissave, or as the value of your assets and liabilities change. But you can change the composition of your wealth; you can, for example, decide to pay back part of your mortgage by writing a check against your checking account. This leads to a decrease in your liabilities (a smaller mortgage) and a corresponding decrease in your assets (a smaller checking account balance); but, at that moment, it does not change your wealth.

Financial assets that can be used directly to buy goods are called money. Money includes currency and checkable deposits—deposits against which you can write checks. Money is also a stock. Someone who is wealthy might have only small money holdings—say, \$1,000,000 in stocks but only \$500 in a checking account. It is also possible for a person to have a large income but only small money holdings—say, an income of \$10,000 monthly but only \$1,000 in his checking account.

Investment is a term economists reserve for the purchase of new capital goods, from machines to plants to office buildings. When you want to talk about the purchase of shares or other financial assets, you should refer them as a financial investment.

Learn how to be economically correct:

Do not say “I am making a lot of money”; say “I have a high income”.

Do not say “I have a lot of money”; say “I am very wealthy”.

## 12.2 The demand for money

### Exercise 12.2 — Money or bonds

(Solution → p. ??)

How much will you hold of either? What determines your decision? What quantity of bonds would you hold if the interest rate was equal to zero?

The demand for money comes from households, firms, and governments that use money as a means of exchange and a store of value. The law of demand holds: as the interest rate increases, the quantity of money demanded decreases because the interest rate represents an **opportunity cost of holding money**. When interest rates are higher, in other words, money is less effective as a store of value.

The *demand for money* in an economy depends on the overall level of transactions in the economy and on the interest rate. While the overall level of transactions in the economy is hard to measure, it is likely to be roughly proportional to nominal income. So we describe the demand for money as follows:

$$M^d = \$Y \underbrace{L(i)}_{\frac{\partial L(i)}{\partial i} < 0}$$

Read this equation in the following way: The demand for money  $M^d$  is equal to nominal income  $\$Y$  times a function of the interest rate  $i$ , with the function denoted by  $L(i)$ . We assume that an increase in the interest rate decreases the demand for money because people put more of their wealth into bonds when interest rates go up.

For a given level of nominal income, a lower interest rate increases the demand for money. At a given interest rate, an increase in nominal income shifts the demand for money to the right. See [Figure 12.1](#).

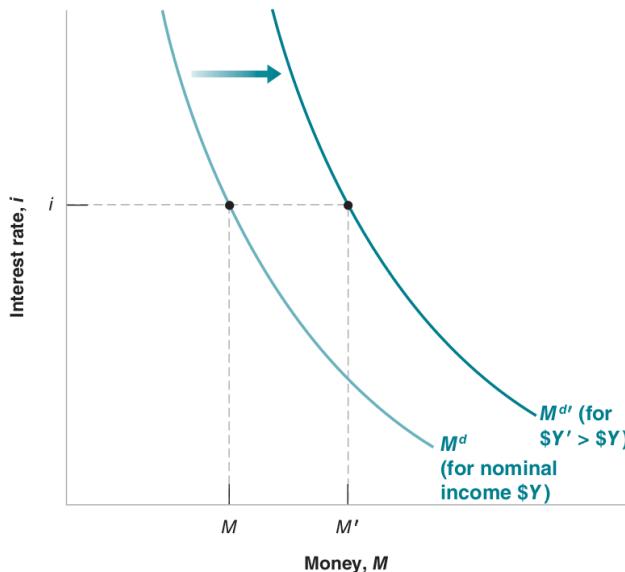


Figure 12.1: The demand for money<sup>1</sup>

## 12.3 The supply of money and the equilibrium

To find the equilibrium in financial markets of money we need to understand that the price of money is the interest rate. Like on any market, an equilibrium is where demand and supply meets. To simplify things, let us assume that monetary authority, i.e., central banks, supply money and determine the interest rates. Thus, a central bank can either choose the money supply and letting the interest rate be determined at the point where money supply equals money demand or, a central bank chooses the interest rate and then adjusting the money supply so as to achieve the interest rate it has chosen.

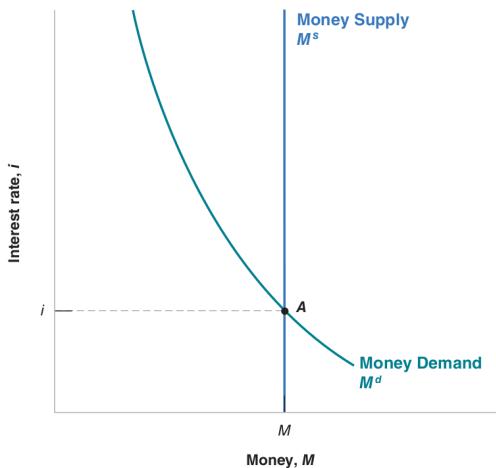


Figure 12.2: The determination of the interest rate<sup>3</sup>

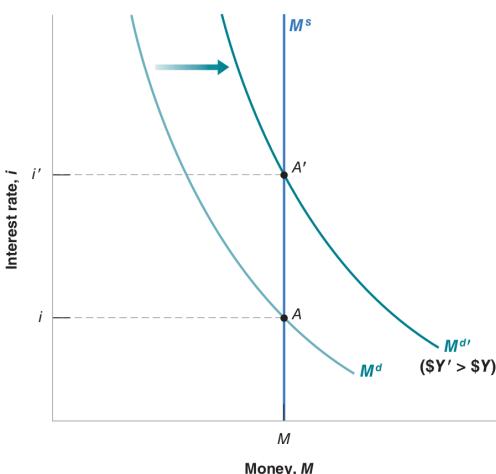


Figure 12.3: The effects of an increase in nominal income on the interest rate<sup>4</sup>

The equilibrium requires money supply to be equal to money demand,  $M = M^d$ :

$$\underbrace{M}_{\text{money supply}} = \underbrace{\$Y L(i)}_{\text{money demand}}$$

This equilibrium relation is called the LM relation where LM stands for Liquidity and Money.<sup>2</sup>

- The interest rate must be such that the supply of money (which is independent of the interest rate) is equal to the demand for money (which does depend on the interest rate). See Figure 12.2.
- An increase in nominal income leads to an increase in the interest rate as shown in Figure 12.3.
- As already mentioned, a decision by the central bank to lower the interest rate from  $i$  to  $i'$  is equivalent to increasing the money supply as shown in Figure 12.4.

## 12.4 The derivation of the LM Curve

### 12.4.1 Using algebra

Let us assume that money demand function is linear and that the function is

$$M^d = Y - hi \quad \text{with } h > 0.$$

<sup>2</sup>Economists use liquidity as a measure of how easily an asset can be exchanged for money. Money is fully liquid; other assets less so.

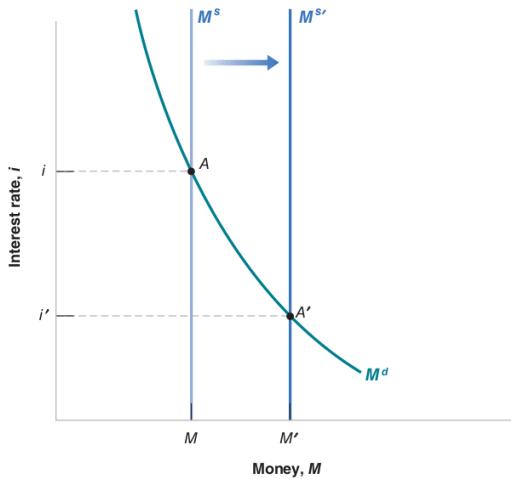


Figure 12.4: The effects of an increase in the money supply on the interest rate<sup>5</sup>

The parameter  $h$  represents how much demand for real money balances decreases when the interest rate rises. Money supply ( $M$ ) is set by the central bank of a country and we assume it to remain constant for a period. Solving the equation last for the interest rate, we get the LM curve

$$i = \frac{1}{h} (Y - M)$$

#### 12.4.2 Using graphs

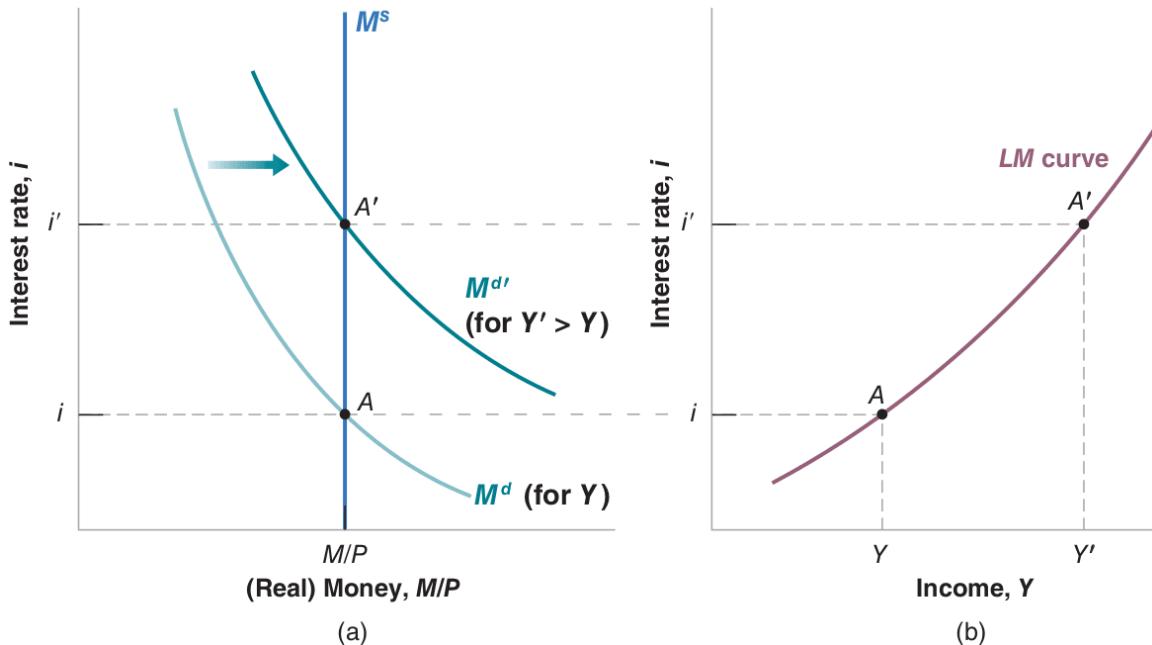


Figure 12.5: Equilibrium in the goods market<sup>6</sup>

- (a) An increase in income leads, at a given interest rate, to an increase in the demand for money. Given the money supply, this increase in the demand for money leads to an increase in the equilibrium interest rate.
- (b) Equilibrium in the financial markets implies that an increase in income leads to an increase in the interest rate. The LM curve is therefore upward sloping.

## 12.5 Taylor rule

- The Taylor rule stems from empirical insights how the central bank operates.
- It can substitute the LM-curve in the IS-LM Model. It is then called the IS-TR Model.
- It is actually a formula that predicts how central banks alter interest rates due to changes in the economy.
- The Taylor rule recommends that the Federal Reserve raise interest rates when inflation or GDP growth levels are higher than desired.
- Critics believe that the Taylor principle is unable to account for sudden shocks in the economy.
- For more information on the Taylor rule, I recommend the Wikipedia entry: [https://en.wikipedia.org/wiki/Taylor\\_rule](https://en.wikipedia.org/wiki/Taylor_rule)
- Formally, the rule can be expressed as follows:

$$i_t = \pi_t + r_t^* + a_\pi(\pi_t - \pi_t^*) + a_y(y_t - \bar{y}_t).$$

In this equation,

- $i_t$ , is the target short-term nominal interest rate,
- $\pi_t$ , is the rate of inflation as measured by the GDP deflator,
- $\pi_t^*$  is the desired rate of inflation (*target inflation rate*),
- $r_t^*$  is the assumed equilibrium real interest rate,
- $y_t$ , is the logarithm of real GDP, and
- $\bar{y}_t$  is the logarithm of potential output, as determined by a linear trend.<sup>7</sup>

Empirics showed that it actually looks like this for central banks like the ECB and the FED:

$$i_t = \pi_t + 2 + 0.5(\pi_t - 2\%) + 0.5(y_t - \bar{y}_t). \quad (12.1)$$

### Exercise 12.3 — Taylor rule

(Solution → p. ??)

Using [Equation 12.1](#), calculate for the following inflation rates,  $\pi_t$ , the expected interest rate set by the central bank. Apply therefore the Taylor Rule.

- 4%
- 1%
- 0%
- -2% (Deflation)

Sketch the Taylor Rule in a two-way plot with  $i$  on the y-axis and  $Y$  on the x-axis.

<sup>7</sup>**Technical note on growth rates and logarithm:** In the Taylor rule, we calculate  $y_t - \bar{y}_t$ . This is actually a linear approximation to a growth rate because the growth rate from time  $t = 0$  to  $t = 1$  in  $x$  is approximately equal to  $\ln x_0 - \ln x_1$ :  $\frac{x_1 - x_0}{x_0} \approx \ln x_0 - \ln x_1$

# Chapter 13

## Goods and financial markets: The IS-LM model

### In this chapter, we learn...

- ...the power of fiscal and monetary policy in a general equilibrium.
- ...that the IS-LM model describes how aggregate markets for real goods and financial markets interact to balance the rate of interest and total output in an economy.
- ...that investment is the key channel through which changes in real interest rates affect GDP in the short run.
- ...that the government or the central bank can do a lot to increase aggregate demand and fight a bust, a.k.a. an economic crisis.

Required readings:

■ [Blanchard and Johnson \(2013, Chapter 5\).](#)

### 13.1 Putting the IS and the LM relations together

The IS relation follows from the condition that the supply of goods must be equal to the demand for goods. It tells us how the interest rate affects output. The LM relation follows from the condition that the supply of money must be equal to the demand for money. It tells us how output in turn affects the interest rate. We now put the IS and LM relations together. At any point in time, the supply of goods must be equal to the demand for goods, and the supply of money must be equal to the demand for money. Both the IS and LM relations must hold. Together, they determine both output and the interest rate.

**The equilibrium in the goods market** implies that an increase in the interest rate leads to a decrease in output. This is represented by the IS curve in [Figure 13.1](#).

$$\text{IS relation: } Y = C(Y - T) + I(Y, i) + G$$

**The Equilibrium in financial markets** implies that an increase in output leads to an increase in the interest rate. This is represented by the LM curve in [Figure 13.1](#).

$$\text{LM relation: } M/P = YL(i)$$

Only at point A, which is on both curves, are both goods and financial markets in equilibrium.

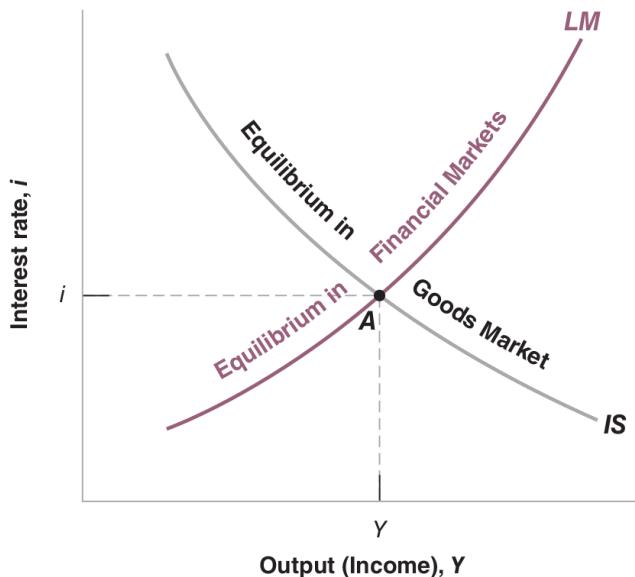


Figure 13.1: The IS-LM model<sup>1</sup>

Maybe you've noticed that I write here the LM relation in *real* terms so that it is a relation of real money (that is, money in terms of goods), real income (that is, income in terms of goods), and the interest rate. We already know that the nominal GDP = Real GDP multiplied by the GDP deflator:  $\$Y = Y \cdot P$ . And equivalently: Real GDP = Nominal GDP divided by the GDP deflator:  $\frac{\$Y}{P} = Y$ .

## 13.2 Monetary policy

A **monetary expansion** leads to higher output and a lower interest rate. Of course, the reverse holds true for a monetary contraction. See [Figure 13.2](#)

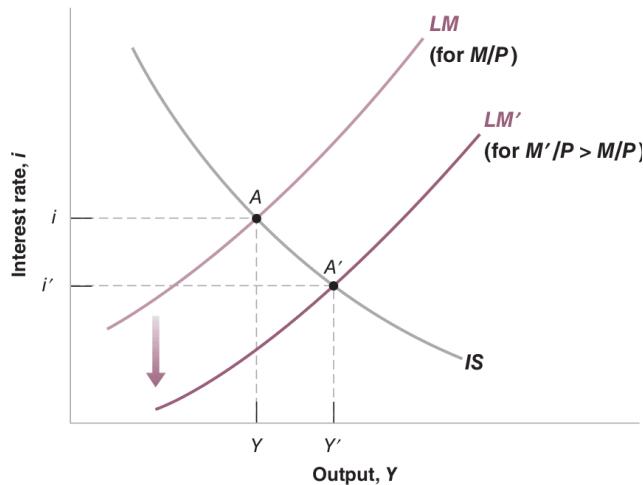


Figure 13.2: The effects of a monetary expansion<sup>2</sup>

**Fiscal Policy** **Fiscal contraction**, or fiscal consolidation, refers to fiscal policy that reduces the budget deficit. An increase in the deficit is called a **fiscal expansion**. Taxes and government spending, affect the IS curve, but not the LM curve. In contrast an increase or a decrease in money has an impact on the LM curve but not on the IS curve. [Figure 13.3](#) provides an overview on the effects of fiscal and monetary policy in the IS-LM model.

	<b>Shift of IS</b>	<b>Shift of LM</b>	<b>Movement in Output</b>	<b>Movement in Interest Rate</b>
<b>Increase in taxes</b>	<b>left</b>	<b>none</b>	<b>down</b>	<b>down</b>
<b>Decrease in taxes</b>	<b>right</b>	<b>none</b>	<b>up</b>	<b>up</b>
<b>Increase in spending</b>	<b>right</b>	<b>none</b>	<b>up</b>	<b>up</b>
<b>Decrease in spending</b>	<b>left</b>	<b>none</b>	<b>down</b>	<b>down</b>
<b>Increase in money</b>	<b>none</b>	<b>down</b>	<b>up</b>	<b>down</b>
<b>Decrease in money</b>	<b>none</b>	<b>up</b>	<b>down</b>	<b>up</b>

Figure 13.3: The effects of fiscal and monetary policy in the IS-LM model<sup>3</sup>

### Exercise 13.1 — Fiscal contraction

(Solution → p. 184)

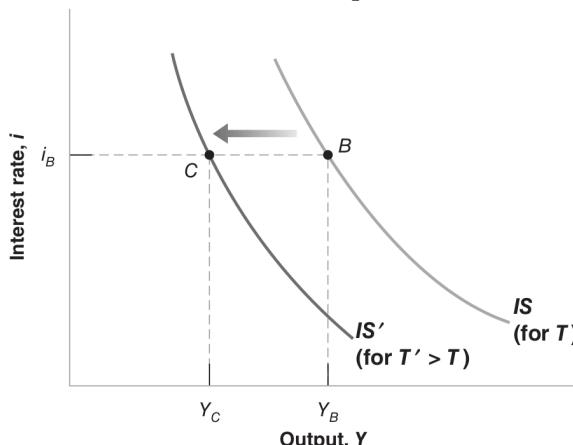
- What are the effects of this fiscal contraction on output, on its composition, and on the interest rate?
- What are the effects of a monetary expansion?

### Solution to Exercise 13.1 — Fiscal contraction

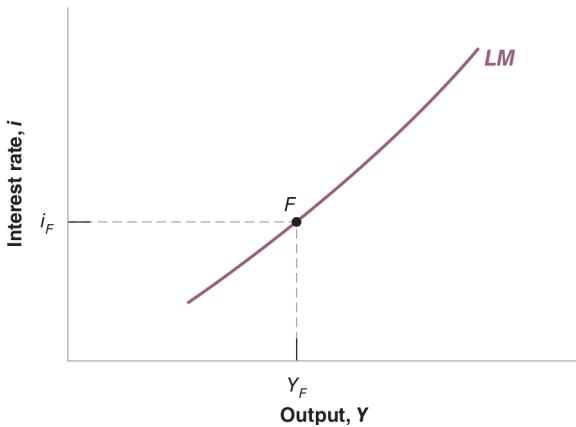
(Exercise → p. 184)

When you answer this or any question about the effects of changes in policy, always go through the following three steps:

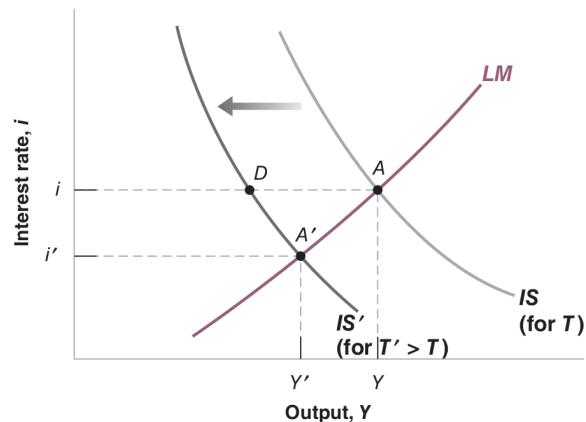
- Ask how the change affects equilibrium in the goods market and how it affects equilibrium in the financial markets. Put another way: How does it shift the IS and/or the LM curves?
  - Characterize the effects of these shifts on the intersection of the IS and the LM curves. What does this do to equilibrium output and the equilibrium interest rate?
  - Describe the effects in words.
- a) 1. *The effects of a fiscal contraction on output<sup>a</sup>*



1. *The effects of a fiscal contraction on financial markets<sup>b</sup>*

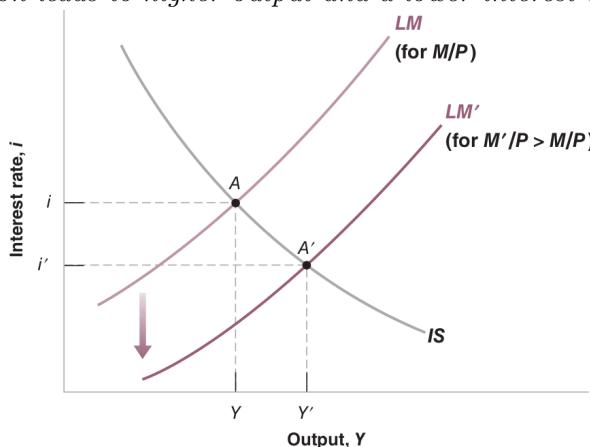


**2. The effects of a fiscal contraction overall<sup>c</sup>**



**3. In Words** The increase in taxes leads to lower disposable income, which causes people to decrease their consumption. This decrease in demand leads, in turn, to a decrease in output and income. At the same time, the decrease in income reduces the demand for money, leading to a decrease in the interest rate. The decline in the interest rate reduces but does not completely offset the effect of higher taxes on the demand for goods.

b) A monetary expansion leads to higher output and a lower interest rate.<sup>d</sup>



<sup>a</sup>Source: Blanchard and Johnson (2013, p. 95)

<sup>b</sup>Source: Blanchard and Johnson (2013, p. 95)

<sup>c</sup>Source: Blanchard and Johnson (2013, p. 95)

<sup>d</sup>Source: Blanchard and Johnson (2013, p. 97)

### 13.3 Limitations of the IS-LM model

- It is built upon simplistic and unrealistic assumptions about the macroeconomy. In fact, Sir John Richard Hicks (1904-1989)<sup>4</sup> proclaimed that the model's flaws were fatal, and it was probably best used as "*a classroom gadget, to be superseded, later on, by something better.*" However, since then, subsequent revisions have taken place for so-called *new* or *optimized* IS-LM frameworks.
- The model is a limited policy tool, as it cannot explain how tax or spending policies should be formulated with any specificity. This significantly limits its functional appeal.
- It has very little to say about inflation, rational expectations, or international markets, although later models do attempt to incorporate these ideas. The model also ignores the formation of capital and labor productivity.

#### Hayek vs. Keynes:

Friedrich August Hayek (1899-1992) did not believe in Keynesian policy; he rather believed in the power of the free market and its inherent price system to diminish bust and boom cycles. In a nutshell, his point of view was that business cycles and economic crisis can only be avoided by believing in the free market and trying to avoid the boom itself. The clash of the two schools of economic thinking (Keynesian and Classical or Austrian School) is often paraphrased by Keynes vs. Hayek analogies.

#### Exercise 13.2 — Rap battle

(Solution → p. 187)

Watch  *Fear the Boom and Bust: Keynes vs. Hayek - The Original Economics Rap Battle!*

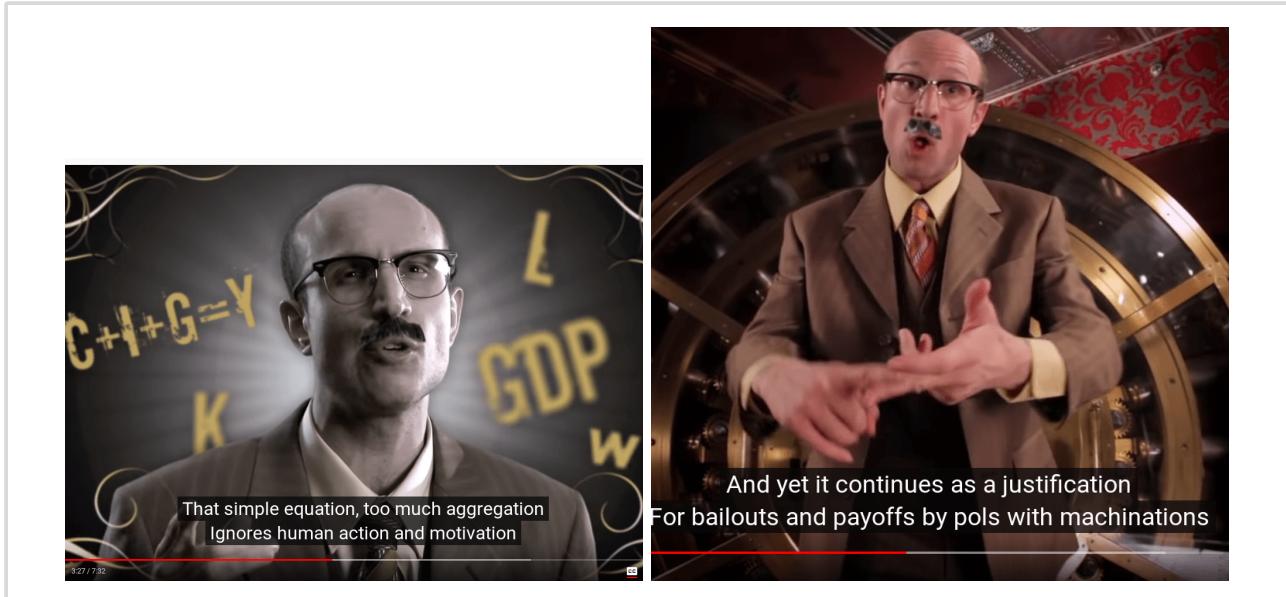
<https://youtu.be/d0nERTFo-Sk>

Read the lyrics and comments on  <https://genius.com/1367063>. To access the comments click on the shaded text.

Explain the Keynesian strategy to fight bust and boom cycles. Explain the strategy of Friedrich Hayek and the Austrian school to fight bust and boom cycles.



<sup>4</sup>British economist who can be considered as one of the most important and influential economists of the twentieth century. See: [https://en.wikipedia.org/wiki/John\\_Hicks](https://en.wikipedia.org/wiki/John_Hicks)



### Solution to Exercise 13.2 — Rap battle

(Exercise → p. 186)

The **Keynesian** economic strategy for fighting bust and boom cycles, also known as economic recessions and expansions, is based on the ideas of economist John Maynard Keynes and focuses on using government intervention to stabilize the economy. According to Keynesian economics, bust and boom cycles are a natural part of the business cycle and can be caused by a variety of factors such as changes in consumer demand, changes in the availability of credit, or changes in government policy.

To fight bust and boom cycles, Keynesian economists recommend using fiscal and monetary policies to stabilize the economy and promote economic growth. Fiscal policy involves the use of government spending and taxation to influence the level of economic activity. For example, during an economic recession, the government can increase spending on infrastructure projects or social welfare programs to stimulate demand and boost economic growth. On the other hand, during an economic expansion, the government can decrease spending or increase taxes to cool down the economy and prevent overheating.

Monetary policy, on the other hand, involves the use of interest rates and the money supply to influence economic activity. During an economic recession, the central bank can decrease interest rates to encourage borrowing and investment, and increase the money supply by purchasing government bonds or other assets. This can help stimulate demand and boost economic growth. On the other hand, during an economic expansion, the central bank can increase interest rates and decrease the money supply to curb inflation and prevent the economy from overheating.

Overall, the Keynesian strategy for fighting bust and boom cycles involves using a combination of fiscal and monetary policies to stabilize the economy and promote economic growth.

**Friedrich Hayek** was a Austrian economist who advocated for a different approach to fighting bust and boom cycles than the Keynesian strategy. Hayek argued that the root cause of bust and boom cycles was the manipulation of money and credit by governments and central banks, and that these interventions were themselves the cause of economic instability.

According to Hayek, the best way to fight bust and boom cycles was to allow the market to function freely and without interference. This meant that the government should not use fiscal or monetary policies to try to manipulate the economy, but rather should allow the market to self-correct and adjust to changing economic conditions.

Hayek argued that the business cycle was the result of "malinvestment," which occurs when the supply of money and credit is artificially expanded, leading to an overinvestment in certain sectors of the economy. When the expansion of credit inevitably comes to an end, the malinvestments are revealed as unsustainable and the economy experiences a bust.

Hayek believed that the best way to prevent these bust and boom cycles was to maintain a stable

and fixed money supply, rather than allowing the central bank to manipulate the supply of money and credit. He also argued that the government should not engage in deficit spending or try to stimulate demand through increased government spending, as this would only lead to further instability and malinvestment.

Overall, Hayek's strategy for fighting bust and boom cycles was to allow the market to function freely and without interference, and to maintain a stable and fixed money supply. This approach is known as the Austrian School of economics.

### Exercise 13.3 — IS-curve (0)

(Solution → p. ??)

The following equations describe an economy:

$$C = 10 + 0.5 Y \text{ (Consumption function)}$$

$$I = 190 - 20i \text{ (Investment function)}$$

$$G = 0$$

Derive the equations for IS curve and represent it graphically.

### Exercise 13.4 — IS-curve again

(Solution → p. ??)

The following equations describe an economy:

$$C = 100 + 0.75Y_d$$

$$I = 50 - 25i$$

$$T = G = 50$$

where  $C$  is aggregate consumption,  $Y_d$  is disposable income,  $I$  is aggregate investment,  $T$  is taxes,  $G$  is government purchases and  $i$  is the interest rate. Derive the  $IS$  curve for the economy.

### Exercise 13.5 — IS-curve (1)

(Solution → p. ??)

Suppose that the economy is characterized by the following behavioral equations

$$C = 160 + 0.6Y_D$$

$$I = 150$$

$$G = 150$$

$$T = 100$$

Solve for the following variables.

- a) Equilibrium GDP ( $Y$ )
- b) Disposable income ( $Y_D$ )
- c) Consumption spending ( $C$ )

### Exercise 13.6 — IS-curve (2)

(Solution → p. ??)

Use the economy as given above.

- a) Solve for equilibrium output. Compute total demand. Is it equal to production? Explain.
- b) Assume that  $G$  is now equal to 110. Solve for equilibrium output. Compute total demand. Is it equal to production? Explain.
- c) Assume that  $G$  is equal to 110, so output is given by your answer to (b). Compute private plus public saving. Is the sum of private and public saving equal to investment? Explain

**Exercise 13.7 — Automatic Stabilizers**

(Solution → p. ??)

So far, we have assumed that the fiscal policy variables  $G$  and  $T$  are independent of the level of income. In the real world, however, this is not the case. Taxes typically depend on the level of income and so tend to be higher when income is higher. In this problem, we examine how this automatic response of taxes can help reduce the impact of changes in autonomous spending on output.

Consider the following behavioral equations:

$$C = c_0 + c_1 Y_D$$

$$T = t_0 + t_1 Y$$

$$Y_D = Y - T$$

$G$  and  $I$  are both constant. Assume that  $t_1$  is between 0 and 1.

- a) Solve for equilibrium output.
- b) What is the multiplier? Does the economy respond more to changes in autonomous spending when  $t_1$  is 0 or when  $t_1$  is positive? Explain.
- c) Why is fiscal policy in this case called an automatic stabilizer

**Exercise 13.8 — IS-LM**

(Solution → p. ??)

Consider the IS / LM model. Consumption function:

$$C = 200 + 0.25(Y - T)$$

Investment function:

$$I = 150 + 0.25Y - 1000i$$

Fiscal policy:

$$G = 250$$

$$T = 200$$

Real money demand:

$$\left(\frac{M}{P}\right)^d = 2Y - 8000i$$

Real money supply:

$$\frac{M}{P} = 1600$$

Given the information above, please answer the following questions:

- a) Derive the IS curve.
- b) Derive the LM curve.
- c) Solve for  $Y^*$ .
- d) Solve for  $i^*$ .
- e) Solve for  $C^*, I^*$ .
- f) Let  $\frac{M}{P} = 1840$ ; repeat parts (a) through (e). Comment on the direction of movement for equilibrium variables relative to the initial case  $\frac{M}{P} = 1600$ .
- g) Let  $\frac{M}{P} = 1600, G = 400$ ; repeat parts (a) through (e). Comment on the direction of movement for equilibrium variables relative to the initial case  $G = 250$ .

**Exercise 13.9 — Foreign multiplier**

(Solution → p. ??)

The major macro aggregates for an economy are given as follows:

$$C = 60 + 0.8Y_D,$$

$$I = 100 - 5i,$$

$$i = 0.06,$$

$$G = 76,$$

$$T = 15,$$

$$TR = 60,$$

$$X = 70,$$

$$M = 12 + 0.2Y,$$

where  $TR$  denotes transfer payments,  $X$  denotes exports, and  $M$  denotes imports.  $TR$  are payments by the government that positively affects the disposable income,  $Y_D = Y - T + TR$ .

- a) Derive the IS curve using the above data.
- b) Calculate the equilibrium level of income.
- c) Calculate the *foreign trade multiplier* and compare it with the *multiplier* when we would ignore foreign trade. Interpret the impact of foreign trade on Keynesian policy.

# Chapter 14

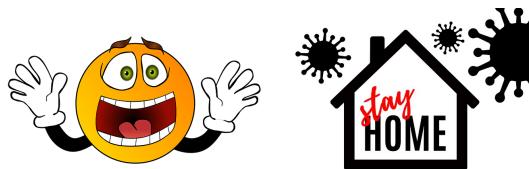
## AS-AD Model

### Recommended videos

- Macro: Unit 2.1 – Aggregate Demand, siehe: <https://youtu.be/AmX0gaLDiPo>
- Macro: Unit 2.2 – Short-Run Aggregate Supply, siehe: <https://youtu.be/Gg0ttANWops>

### 14.1 The first lockdown at 23 March 2020...

... was a **shock<sup>1</sup>**:



#### Exercise 14.1 — Economic consequences

(Solution → p. 192)



Open the link:  <https://t1p.de/covid123> and list what you consider to be the most important economic effects of the first lockdown.

<sup>1</sup>Wikipedia (2022, Entry: Shock (economics)): “In economics, a shock is an unexpected or unpredictable event that affects an economy, either positively or negatively. Technically, it is an unpredictable change in exogenous factors—that is, factors unexplained by an economic model—which may influence endogenous economic variables.”

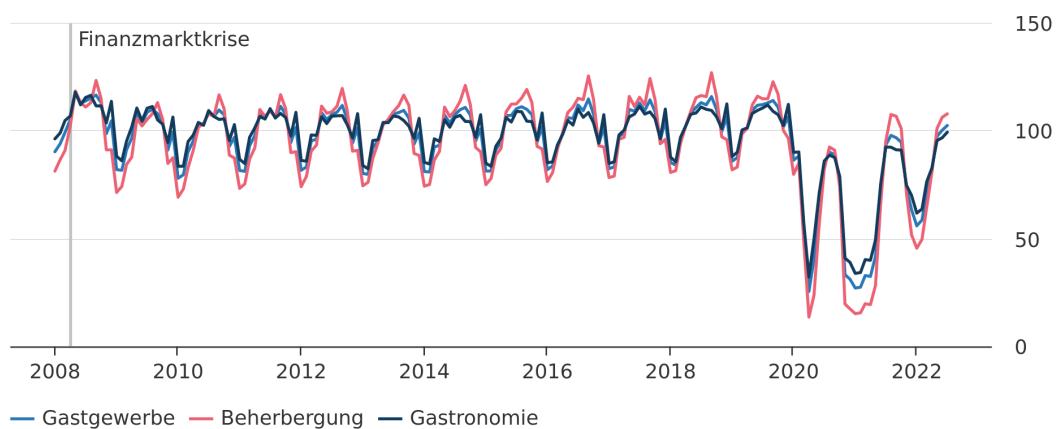
Many things can be mentioned here, for example:

- -4.9 % in gross domestic product: Economic output collapses significantly in 2020
- 4.2 % deficit ratio: Second-highest government deficit since German unification
- 74.5 % fewer air passengers - lowest figure since German unification
- 4.6 % less consumer spending by private households - sharpest decline in decades
- 27.8 % increase in online retail sales since outbreak of pandemic
- 0 % Population growth in Germany - first since 2011
- 21 % Fewer foreign university entrants in the 2020 academic year
- -1.1 % in real wages - sharpest decline since survey began
- 10.7 % fewer traffic fatalities - lowest level in almost 70 years
- 47 % electricity from renewable energies - a record high

Source: Destatis (2021), for more information about the above facts see <https://www.destatis.de/DE/Themen/Querschnitt/Corona/Wirtschaft/kontextinformationen-wirtschaft.html>  
and here: [https://www.destatis.de/DE/Themen/Querschnitt/\\_inhalt.html](https://www.destatis.de/DE/Themen/Querschnitt/_inhalt.html)

### Umsatz des Gastgewerbes

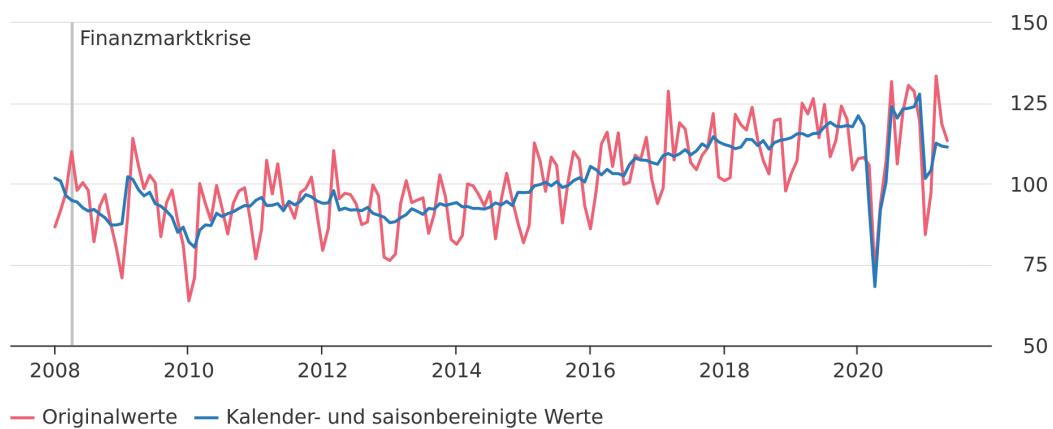
in konstanten Preisen (real), Originalwert, 2015=100



© Statistisches Bundesamt (Destatis), 2022

### Umsätze im Handel mit Kfz (Gesamtgewicht bis 3,5 t) , Kfz-teilen und -zubehör

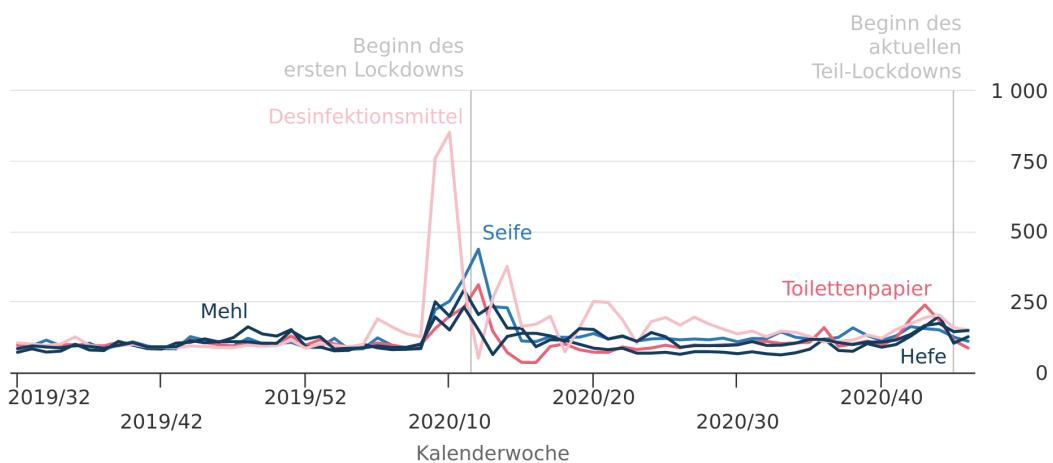
2015=100



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### Absatzindex von ausgewählten Verbrauchsgütern

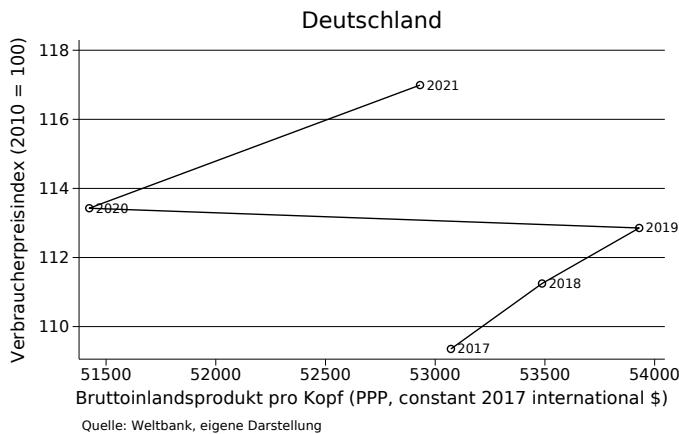
Durchschnitt von 32. KW 2019 bis 5. KW 2020 = 100



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## 14.2 Value added and price level

- During the Corona crisis, massive changes occurred in various markets.
- The **Gross Domestic Product** is the most important indicator of a country's value added and prosperity, subsumes many different economic effects and is the result of aggregate demand and aggregate supply.



The **Gross Domestic Product** indicates the total value of all goods and services produced as final goods and services within the national borders of an economy during one year, after deduction of all intermediate consumption.

The **price level** is an economic indicator that shows how many monetary units must be paid in an economy for the prices of certain goods and services in a basket of goods.

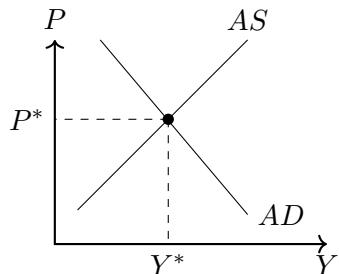
### 14.3 How did GDP fall while price levels remained roughly constant?

- Less was bought/sold (value added  $\downarrow$ ).
- But why? Was there less demand or were fewer offered?

For example, is the lower hospitality sales the result of guests staying away (demand  $\downarrow$ ), of business closures being ordered (supply  $\downarrow$ ), or of both?

- Apart from anecdotal evidence, it is difficult to capture all the effects empirically. In markets, usually only the price and the quantity successfully demanded can be observed.
- Solution: Theory  $\rightarrow$  The AS-AD Model!

**General equilibrium** The interplay of supply and demand determines the equilibrium on the market.



## 14.4 Aggregated Demand (AD)

The AD curve represents the total demand for goods (goods and services) by everybody for goods and services as a function of the price level in a given period.

In an economy, the aggregate demand is equal to the sum of

- consumer goods demand  $C$ ,
- investments  $I$ ,
- government expenditure  $G$  and
- net exports  $NEX$ , that is, demand from abroad  $EX$  minus domestic demand for foreign goods,  $IM$

$$Y^D = C + G + I + \underbrace{EX - IM}_{NEX}$$

→ As prices rise, demand falls (*ceteris paribus*).

→ If  $Y^D$  decreases (and  $P$  remains constant), the curve shifts to the left.

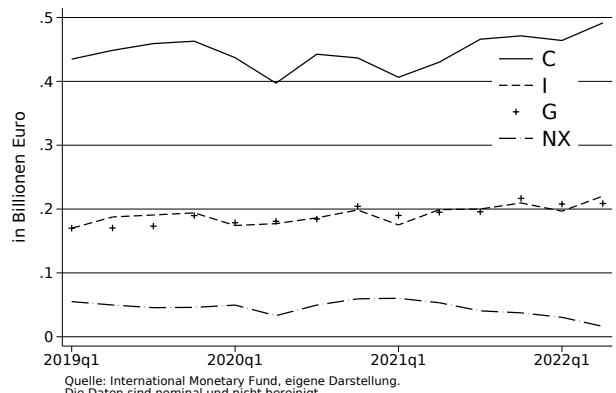
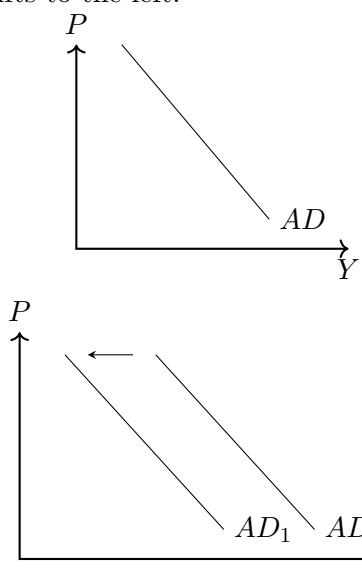


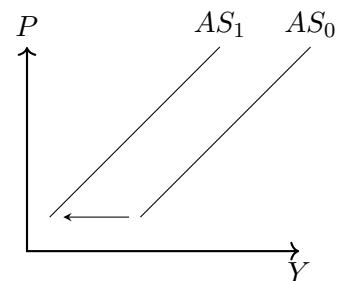
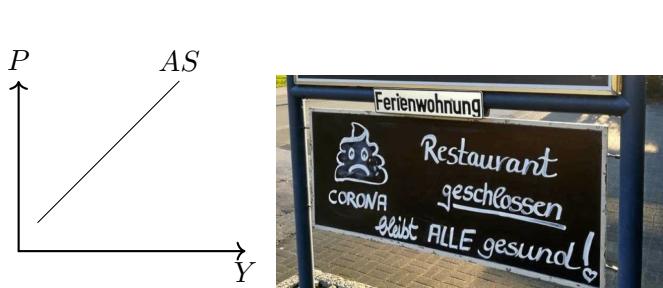
Figure 14.1: Components of demand in Germany

During the first lockdown, consumer goods demand and net exports fell. Government demand and demand for capital goods remained virtually unchanged

## 14.5 Aggregated Supply (AS)

The AS curve describes the value of goods that all suppliers can provide in a given period, depending on the price level.

→ Supply usually increases with prices and the first lockdown certainly caused a leftward shift in the AS curve.



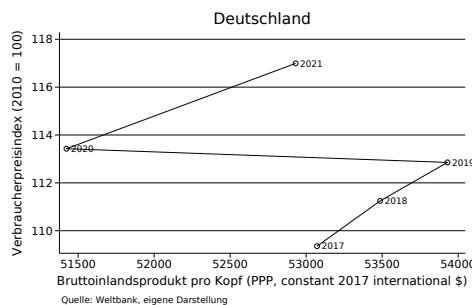
**Factors influencing supply** Anything that increases production costs decreases supply at the same price.

- Resources (input prices, availability) ← pandemic, war, natural disasters, international politics, ....
- regulation ← taxes, laws, subsidies, ....
- labor costs ← unions, minimum wages, taxes, ...
- productivity ← technology, research, management practices, ...

### Exercise 14.2 — Effects of the lockdown on equilibrium

(Solution → p. 196)

Discuss what effects the lockdown had on aggregate supply and demand in the economy. Sketch, the equilibrium of the AS and AD curves in a price-output diagram before the lockdown and after. Aim to describe the actual changes from GDP and the price level for Germany.



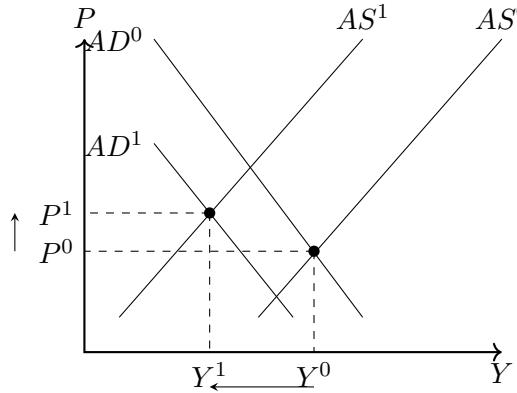
### Solution to Exercise 14.2 — Effects of the lockdown on equilibrium (Exercise → p. 196)

**AS-curve:** It can be assumed that the lockdown increased production costs (additional precautions at the workplace), or important production factors were not available (microprocessors were stuck in China, people were not allowed to work or were restricted, certain events were prohibited). Ergo: the AS curve should have shifted to the left due to the lockdown. Due to ongoing delivery problems of many inputs, it can be assumed that this shift persists.

**AD curve:** There was increased demand for individual groups of goods (toilet paper, noodles, hygiene), and demand was also boosted by government intervention and transfers (see: [https://www.esrb.europa.eu/home/search/coronavirus/countries/html/esrb\\_covidpmc\\_germany.en.html](https://www.esrb.europa.eu/home/search/coronavirus/countries/html/esrb_covidpmc_germany.en.html) (VAT reduction, short-time allowance, etc.). This would suggest a rightward shift of the AD curve. At the same time, however, demand for many goods has plummeted, especially for goods that require spatial mobility or human proximity (tourism, cars, restaurants, events, etc.). This would lead to a leftward shift of the AD curve. Overall, we initially assume that the demand-reducing effects dominated in the first few months. After some time, it could be assumed, demand returned to normal. This is consistent with the data from Figure 14.1.

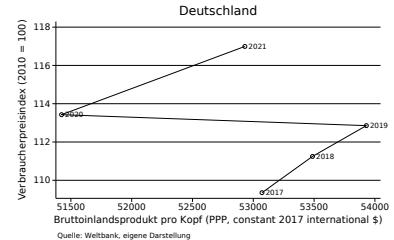
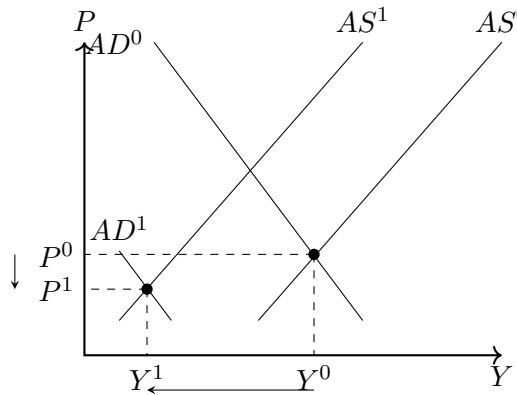
Two possible short-term scenarios:

1. Demand decreases a bit:

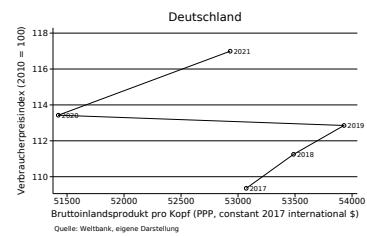
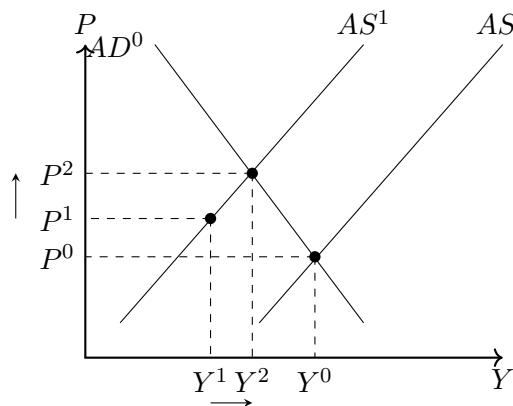


In scenario 1, output decreases and prices **increase**. In scenario 2, output decreases more and prices **decrease**.

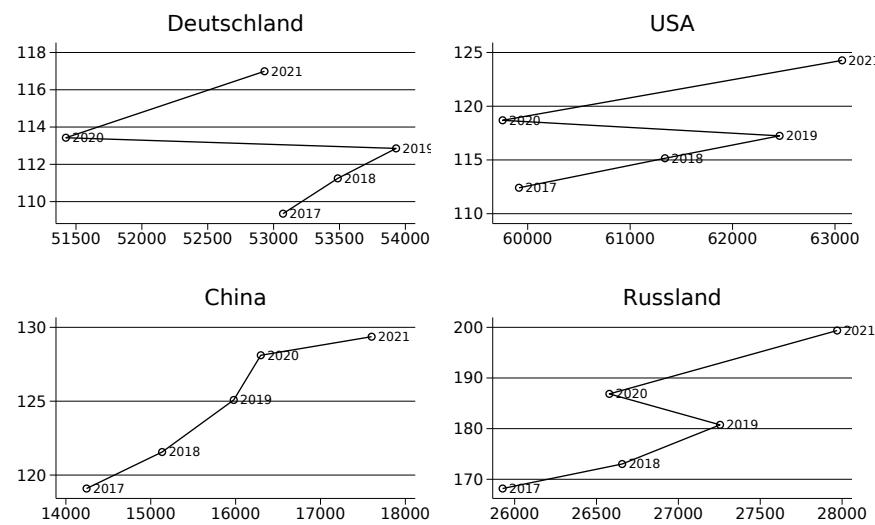
2. Demand decreases a lot:



In the medium term, demand may have returned to the old level, in which case it would be stylized in the AS-AD model as follows:



## 14.6 International data



Quelle: Weltbank, eigene Darstellung

### 14.6.1 Summary

- Aggregate demand results from the interplay of supply and demand.
- Policymakers can take measures to mitigate the negative economic effects of exogenous shocks:
  - Increase government spending and cut taxes to boost consumption, investment and exports.
  - Take away fears to improve consumption and investment.
  - Reduce production costs by taking over production costs (short-time allowance, subsidized loans), reducing entrepreneurial risk (guarantees, insolvency law), promoting productivity (taking over research and development costs).
- The AS-AD model can be helpful to understand, anticipate and analyze macroeconomic ratios.

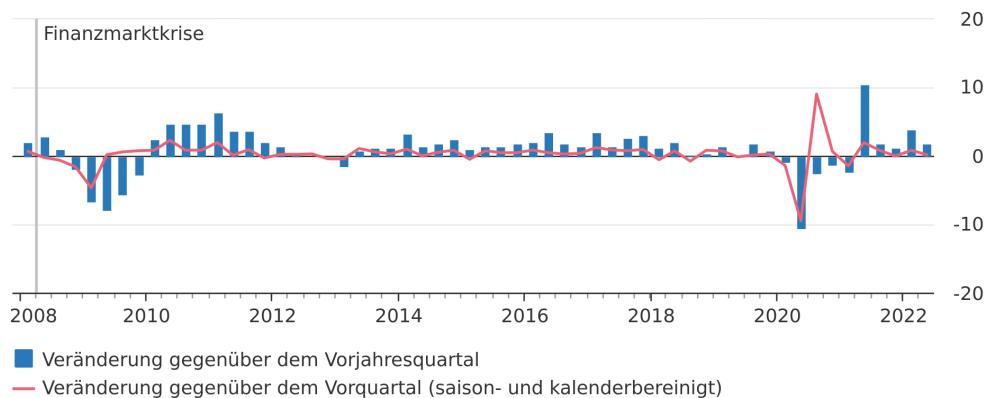
#### Exercise 14.3 — Comparing the financial crisis to the Corona crisis (Solution → p. 199)

Study the two graphs shown below and read [Bundesministerium für Wirtschaft und Klimaschutz \(2022\)](#), see: <https://www.bmwi.de/Redaktion/DE/Schlaglichter-der-Wirtschaftspolitik/2022/04/13-ist-krise-gleich-krise.html>.

Discuss how far the 2009 financial crisis differs from the 2020 Corona crisis in terms of aggregate supply and demand. In doing so, address the components of demand in both crises. Using the AS-AD model, explain why general price increases were largely absent in the financial crisis—despite expansionary fiscal and monetary policies—but prices rose in the corona crisis.

### Entwicklung des Bruttoinlandsprodukts

preisbereinigt, in %



© Statistisches Bundesamt (Destatis), 2022

### Preisentwicklung im Überblick

2015 = 100



© Statistisches Bundesamt (Destatis), 2022

**Solution to Exercise 14.3 — Comparing the financial crisis to the Corona crisis**  
(Exercise → p. 198)

*Please discuss that in class.*

# Chapter 15

## Negative interest rates policy

**Learning objectives** Students will learn to explain and evaluate the goals and the effectiveness of a monetary policy with negative interest rates policy (NIRP).

**Outline of the lecture** In this short lecture, I will thrive the following questions:

- What is the objective of ECB's NIRP?
- How can ECB's NIRP effect economies?
- What is so special on a NIRP from a macroeconomic perspective?
- Can negative central bank policy rates transmit into negative deposit rates or into negative lending interest rate (the cost of debt for the borrower)?
- The key question for macroeconomic monetary policy (and this lecture) is therefore whether lowering interest rates below zero can be an effective tool for stimulating aggregate demand.
- What are the cons of a NIRP?

**Abstract** In recent years, the European Central Bank (ECB) and some other central banks engaged in a radical new policy experiment by setting negative policy rates. This course discusses whether negative interest rates policy (NIRP) is an effective tool for stimulating aggregate demand and hence keep prices at a stable inflation of 2%. In particular, I present aggregate and bank-level data to document that once the policy rate turns negative the pass-through to deposit and lending rates seems to be limited.



Figure 15.1: How do negative interest rates work? Badly.

Source: <https://app.hedgeye.com/insights/65863-the-folly-of-negative-nominal-interest-rates>

## 15.1 My stamps taught me a lot



Figure 15.2: Stamps and inflation

I was about 10 years old and passionate about collecting stamps when I discovered an interesting stamp in an album I had received as a gift. Curious, I asked my father if I was now a double millionaire (see [Figure 15.2](#)). Unfortunately, he had to disappoint me.

**Lesson 1:** Currencies can disappear and their value over time is not fixed.

Starting in 2002, Deutsche Post refused to accept all my mint stamps denominated in pfennigs. The ECB stamp is denominated in pennies and cannot now be used.

**Lesson 2:** Currency reforms can occur without war or hyperinflation, and assets can be lost with them.

Even if the ECB stamp were still accepted, its current value in pennies would not be enough to mail a letter. Today, it costs 156 pfennigs, or 80 cents, to send a letter. That means sending a letter has become 40 percent more expensive.

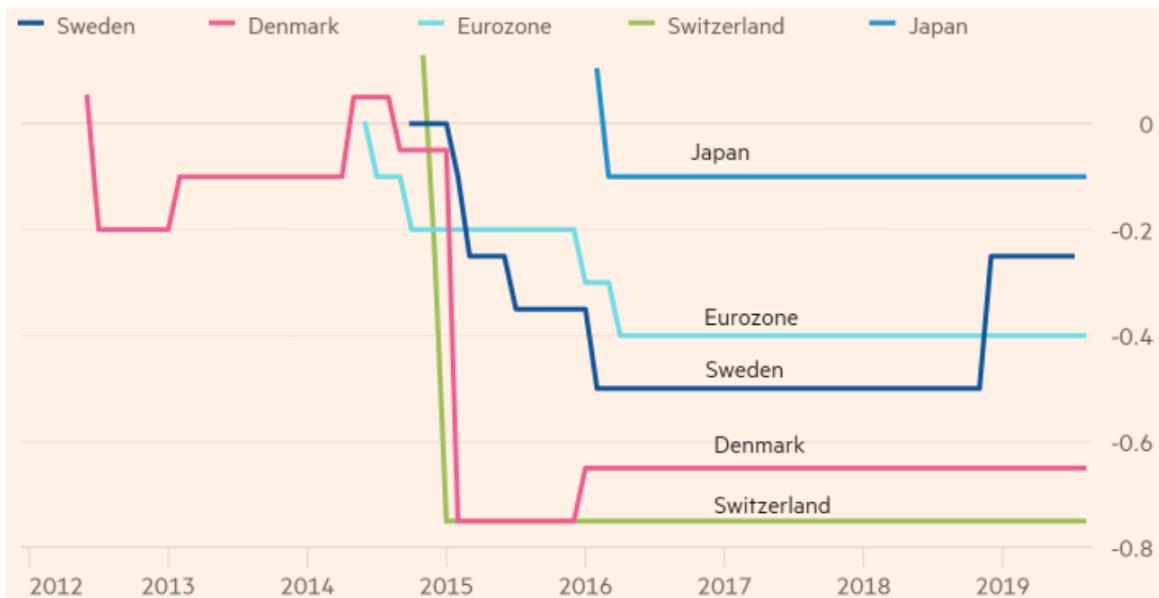
**Lesson 3:** Inflation still exists.

## 15.2 Put money in a bank account and get rich

My parents always told me: “Stop buying that many stamps. Better take your money to a bank and get rich from the deposit interest.” I doubt, however, if this strategy is actually a valid strategy in times when the ECB and some other central banks set negative key interest rates, see [Figure 15.3](#). Negative interest rate policies were long considered unthinkable because economists believed in the so-called *Zero Lower Bound (ZLB)*. This refers to the widely held notion that a NIRP is ineffective because private banks cannot charge negative deposit rates because people would otherwise withdraw their cash and keep it privately. As some have recently learned, there are indeed some banks that have charged negative interest rates on customer deposits without any bank runs.

It must be said, however, that commercial banks charge negative interest rates only on a small scale. Most banks charge negative interest rates only on part of the deposited assets, only for companies or only for (short-term) assets above a certain amount. Accordingly to a survey of Verivox (see <https://www.verivox.de/geldanlage/themen/negativzinsen/>) from 2022 June 07:

- 451 banks have published negative interest rates for retail customers on their websites or in their online price lists.
- 23 banks charge fees for the usually free overnight deposit account. This creates a de facto negative interest rate.



Source: Refinitiv; ©FT, see: <https://www.ft.com/content/82c4d584-bce3-11e9-89e2-41e555e96722>

Figure 15.3: Five negative central bank policy rates

- According to media reports, some banks and savings banks charge negative interest rates but do not publish them online.

## 15.3 European Central Bank

### 15.3.1 Objective

The primary objective of the European Central Bank (ECB) is to maintain price stability within the Eurozone, that is, an inflation<sup>1</sup> of under 2%. In particular, the goal is to have “a year-on-year increase in the Harmonised Index of Consumer Prices (HICP)<sup>2</sup> for the euro area of below 2%”<sup>3</sup>. Moreover, the ECB “shall support the general economic policies in the Union” (see Article 127(1) TFEU).

In Figure 15.4, I present inflation rates and inflation expectations from 1990 onwards. The figure shows, inflation rate circulated more or less around the 2% and that this holds, although the Eurozone was hit by some serious economic turbulences in the last decades. Thus, we can say that the ECB was successful in achieving their main objective.

### 15.3.2 Monetary policy instruments

In recent years, the ECB has deployed an innovative, multi-pronged approach in the design of its policy stance. In a nutshell, the current policy mix basically includes four elements: (i) pushing the policy rate into negative territory, (ii) forward guidance on the future policy path, (iii) the asset purchase programmes, and (iv) the targeted longer-term refinancing operations (TLTROs). Importantly, these measures work as a package, with significant complementarities across the different instruments. However, we do not aim discuss these instruments here. Instead, we focus on the most recognized instrument, that is, the central bank interest/policy rate (CBPR).

<sup>1</sup>Inflation is an increase in the general price level of goods and services. When there is inflation in an economy, the value of money decreases because a given amount will buy fewer goods and services than before.

<sup>2</sup>The HICP is a weighted average of consumer price indices of member states who have adopted the euro.

<sup>3</sup>see: <https://www.ecb.europa.eu/mopo/strategy/pricestab/html/index.en.html>

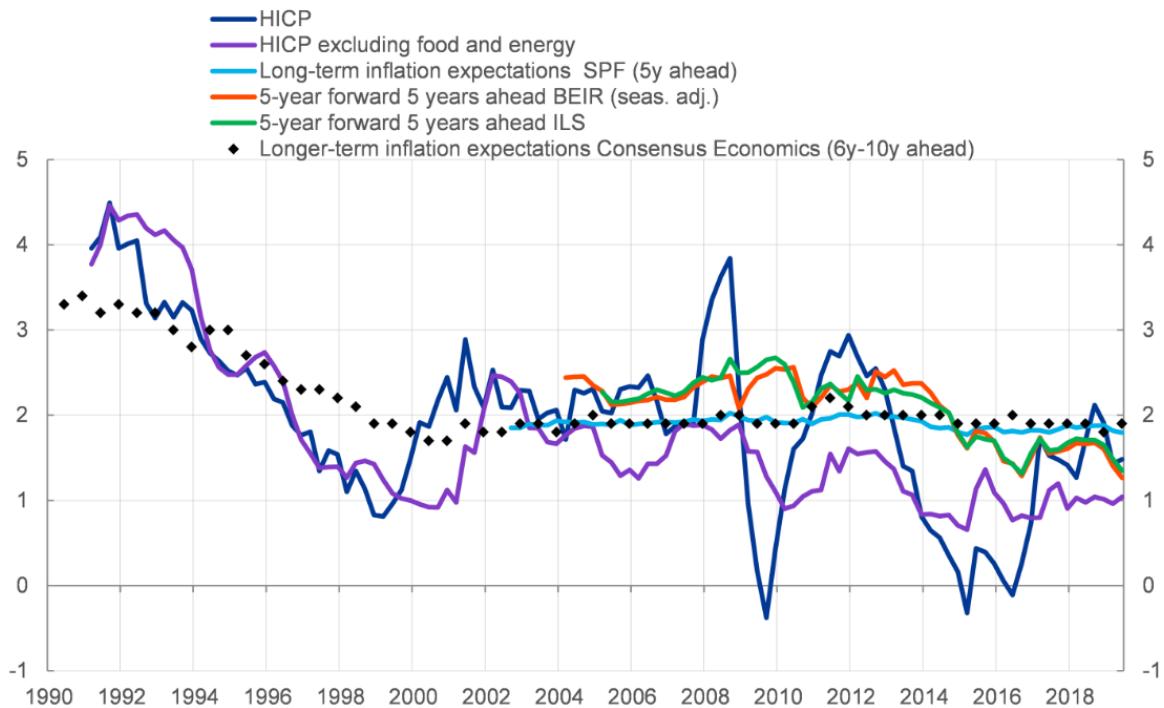


Figure 15.4: Euro area HICP inflation and inflation expectations

Source: ECB, Consensus Economics, Thomson Reuters, ECB calculations.

### 15.3.3 Central bank interest/policy rate (CBPR)

When people talk about the **central bank interest/policy rate (CBPR)** they usually refer to the deposit facility rate, which is actually one of the three interest rates<sup>4</sup> the ECB sets every six weeks. The rate defines the interest banks receive for depositing money with the central bank overnight.

**The textbook economics of the CBPR** All major introductory macroeconomic textbooks assume that investments increase when interest rates decrease and vice versa. This *investment function* is shown in panel (a) of the Figure 15.5. An increase of investments transmits into higher aggregate demand and output through the IS curve as illustrated in Mankiw's macroeconomics textbook.<sup>5</sup> It doesn't need a formal model to understand that higher aggregate demand and output yields higher prices.

However, most textbooks refrain from discussing how the investment function behaves when interest rates become close to zero or even negative. The reason is that NIRP was unthinkable for a long time as a quote of Warren Buffet shows:

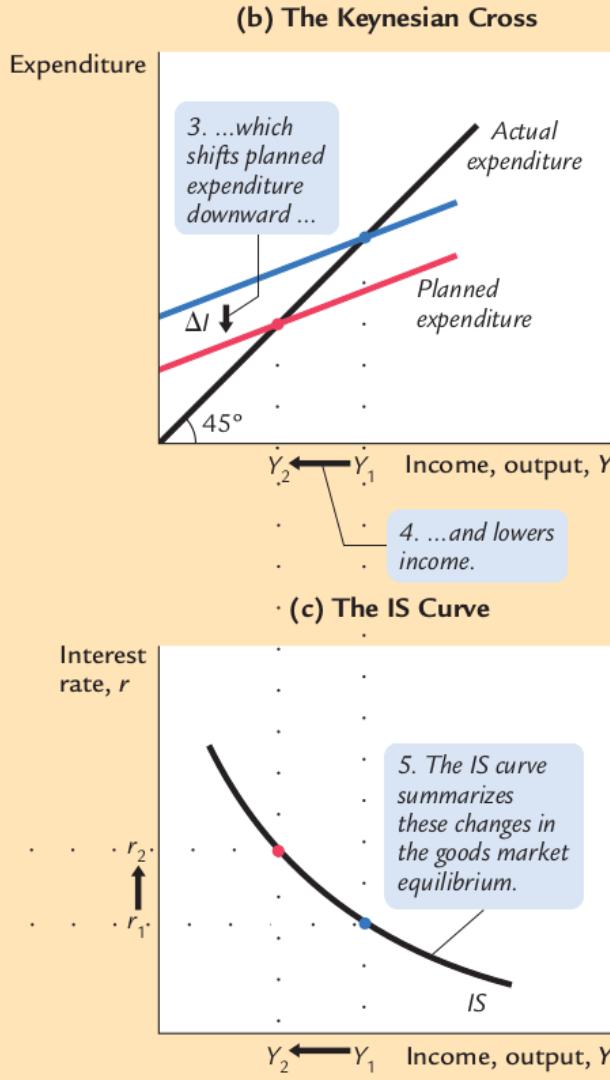
“Whats happened with interest rates is really extraordinary. I mean, you can go back and read everything, Keynes, Adam Smith, Ricardo, Galbraith, Paul Samuelson, or you name. You won’t see a word in my view anything I’ve ever seen about sustained negative interest rates. I mean, we are doing something the world hasn’t seen.” Warren Buffet in an CNBC interview 2016 (<https://www.youtube.com/watch?v=q862lngj034>)

Instead, the so-called **Zero Lower Bound (ZLB)** was dominant. It says that a short-term nominal interest rate of zero cause a liquidity trap and limit the capacity of central banks to stimulate economic growth. The main argument is that it is difficult to encourage investors to deposit money at zero or negative interest rates. Thus, economist thought that central banks will not reduce interest rates below this bound. As already mentioned, they were wrong.

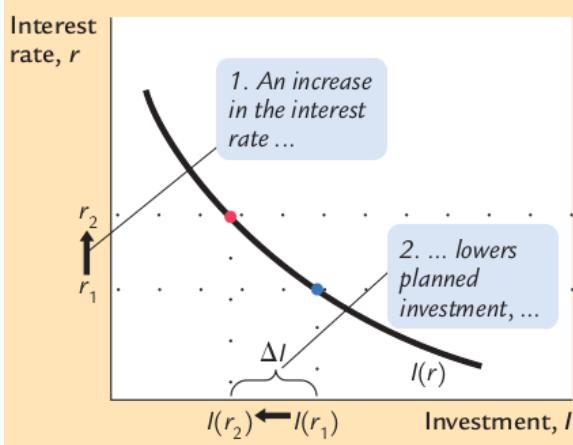
<sup>4</sup>The other two are called marginal lending facility rate, main refinancing operation rate.

<sup>5</sup>For simplicity, I refrain from discussing the LM curve which closes the IS-LM model and is used to determine equilibrium in the money market.

**Deriving the IS Curve** Panel (a) shows the **investment function**: an increase in the interest rate from  $r_1$  to  $r_2$  reduces planned investment from  $I(r_1)$  to  $I(r_2)$ . Panel (b) shows the Keynesian cross: a decrease in planned investment from  $I(r_1)$  to  $I(r_2)$  shifts the planned-expenditure function downward and thereby reduces income from  $Y_1$  to  $Y_2$ . Panel (c) shows the **IS curve** summarizing this relationship between the interest rate and income: the higher the interest rate, the lower the level of income.



**(a) The Investment Function**



Source: Mankiw (2010): Macroeconomics, 7th Edition, p. 299.

Figure 15.5: The investment function and the IS curve when interest rate is zero



Figure 15.6: Research on NIRP is a growing but underdeveloped literature strand  
 Source: <https://www.investmentnews.com/article/20160221/FREE/302219997/what-happens-if-the-fed-goes-negative>

We should re-investigate the investment function. As NIRP exists, we should discuss whether NIRP is an effective tool for stimulating investments and increase prices.

Basically, four ways exist how NIRP can increase investments:

1. Banks can lend more to households and companies, rather than holding on to cash, which has now become costly.
2. Businesses can invest more, as funding investment is now cheaper.
3. Households could save less, or borrow to spend more.
4. Demand for the currency could fall. This might lead to a depreciation of the currency, an increase in the price of imported goods and growing demand for the country's exports which are now cheaper for foreign buyers.

If we abstract from the fourth way, the effectiveness of NIRP hinges on whether the policy rates pass-through to deposit and lending rates. In the next box, I will present the work of Eggertsson et al. (2017) to answer that question. This was one of a few studies available at the time of writing this notes, see Figure 15.6.

**Limited Pass-Through to Deposit Rates** In Figure 15.7, I plot aggregate deposit rates for six economic areas in which the policy rate is negative. The red vertical lines mark the month in which policy rates became negative. The Swedish central bank lowered its key policy rate below zero in February 2015. Deposit rates, which in Sweden are usually below the policy rate, did not follow the central bank rate into negative territory. Instead, deposit rates for both households and firms remain stuck at, or just above, zero. A similar picture emerges for Denmark who crossed the ZLB twice. As was in Sweden, the negative policy rate has not been transmitted to deposit rates. The deposit rates of Switzerland and Japan were already very low for some time when the ZLB was passed. However, even then the other rates did not follow the policy rate into negative territory.

The ECB hit the ZLB in June 2014. As aggregate deposit rates are high in the Euro Area and therefore have more room to fall before reaching the zero lower bound. Moreover, the deposit rate does not normally follow the policy rate as closely as in the other cases. One reason for this is the heterogeneity of the Euro Area. Looking at Germany only, a similar pattern emerges as in the other cases. That is, despite negative policy rates, the deposit rate appears bounded by zero.

Limited Pass-Through to Deposit Rates. Overall, the presented aggregate evidence indicates that the impact of policy rates on deposit rates was limited and is strongly suggestive of a lower bound on deposit rates

**Limited Pass-Through to Lending Rates** In Figure 15.8, I plot lending rates for the six economic areas with negative policy rates. While lending rates usually follow the policy rate closely, there appears to be a disconnect once the policy rate breaks the ZLB. Lending rates in Sweden, Denmark and Switzerland seem less sensitive to the respective policy rates once they become negative. The Euro Area is somewhat of an outlier, as lending rates appear to have decreased. This is not surprising in light of the higher-than-zero deposit rates I document above. Again, for the case of Germany, in which the zero lower bound on the deposit rate is binding, lending rates appear less responsive.

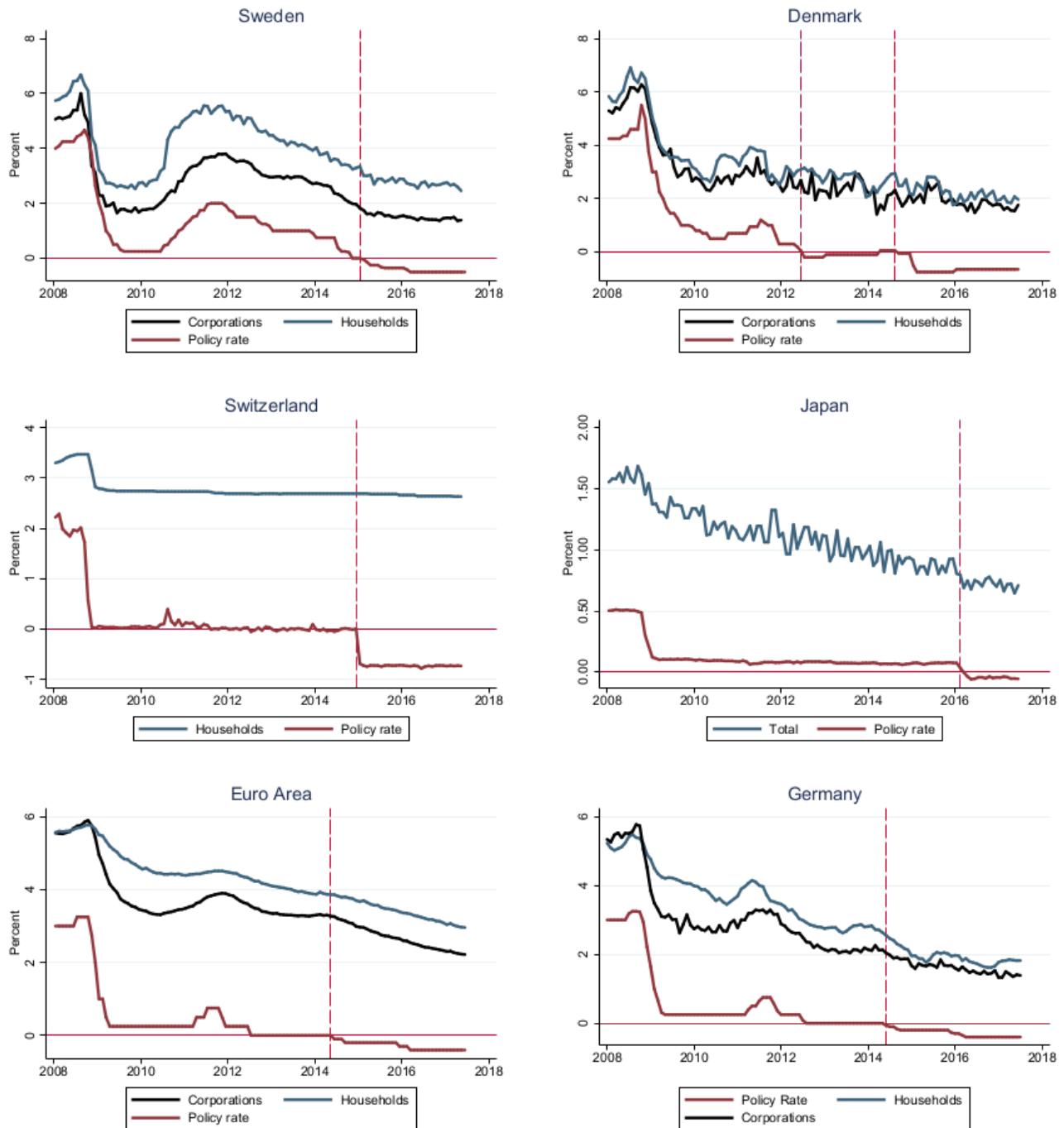


Figure 15.8: Aggregate lending and policy rates  
Source: Eggertsson et al. (2017).

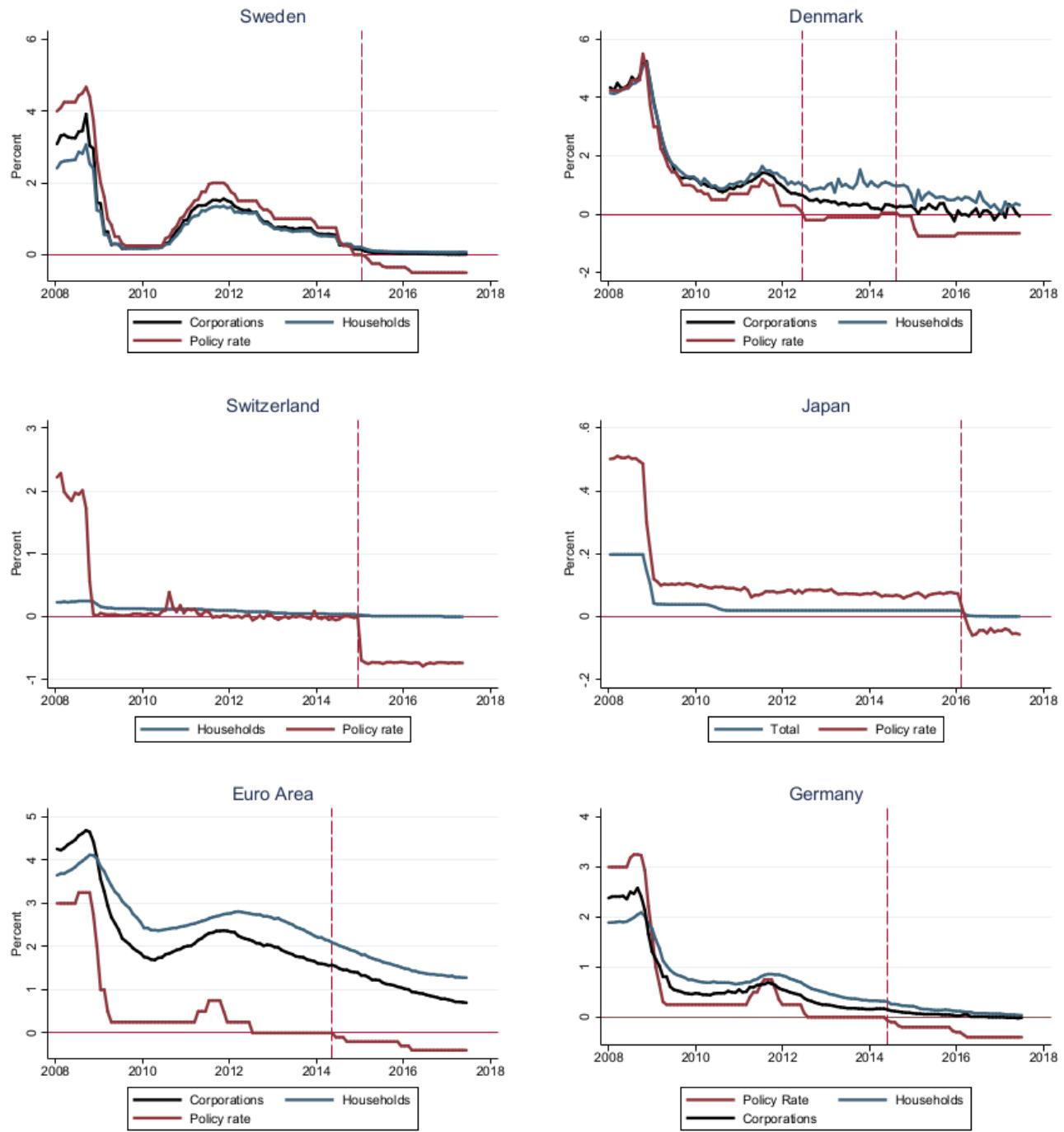


Figure 15.7: Aggregate deposit and policy rates  
Source: Eggertsson et al. (2017).

To investigate the behavior of banks with respect to lending rates further, I present daily bank-level data for thirteen Swedish credit institutions in Figure 15.9. In the left panel, the bank-level mortgage rates for thirteen banks or credit institutions are plotted. The first two dashed lines capture policy rate reductions in positive territory. On both occasions, there is an immediate and homogeneous decline in bank lending rates. The same holds true when the policy rate passes the ZLB (solid line). Around the three proceeding dashed lines, which represent reductions in negative territory, the bank lending rates are strikingly different: While there is some initial reduction in lending rates, most of the rates increase again shortly thereafter. Thus, the total impact on lending rates seems to be limited. Moreover, there is a substantial increase in dispersion, with several banks keeping their lending rate roughly unchanged despite repeated interest rate reductions below zero.

In the right panel the minimum and maximum bank lending rate are plotted, along with the policy rate (the dashed black line). The increase in dispersion after the policy rate turned negative is clearly visible. It is remarkably that the minimum bank lending rate has stayed constant since the first quarter of 2015, despite three policy rate reductions in negative territory.

**Limited Pass-Through to Lending Rates.** While the evidence is not as clear as for deposit rates, the impact of policy rates on lending rates seems to be limited once the ZLB has passed. Moreover, the dispersion of lending rates within a territory was increased when the policy rate was negative and some banks even increased (!) their lending rates when the policy rate was negative.

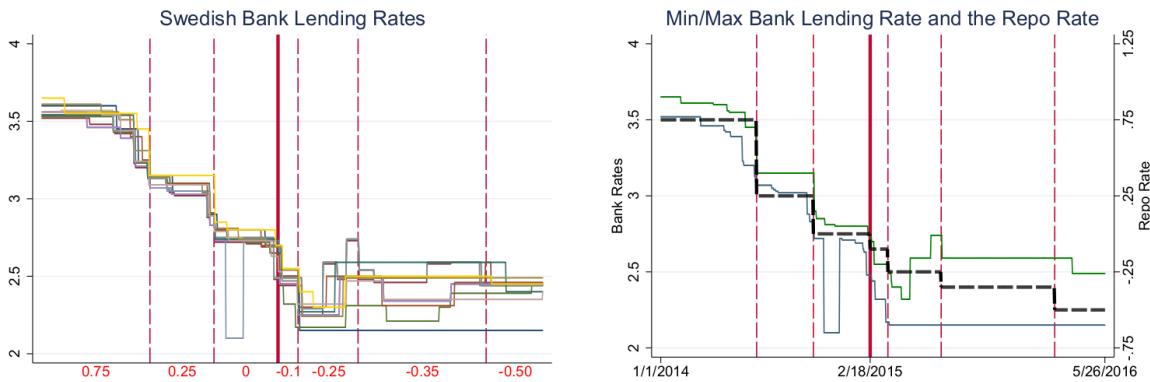


Figure 15.9: Bank Level Lending Rates Sweden  
Source: Eggertsson et al. (2017).

**Does NIRP work?** Overall, there is a lack of research that evaluates the impact of NIRP empirically. Considering the fact that NIRP is a rather new phenomena, that is not a big surprise. Moreover, the NIRP is hard to evaluate as there is no counterfactual and the policy rate instrument is just one out of many monetary instruments that have been used by the ECB in recent years. Thus, it is hard to find an empirical identification strategy that allows a sort of *ceteris paribus* interpretation.

The ECB was heavily criticized for the NIRP. While I cannot list all points of scepticism, I'd like to mention some reasonable ones here:

- Private banks cannot pass through negative interest rates to their customer. That lowers the profitability of private banks which are likely to raise lending rates to save their interest margin. We saw this in Sweden where banks increased rates for mortgages and loans to stay profitable. Of course, this weakens policy effectiveness.
- If lending rates become very low, more risky investments get financed which, in turn, brings economic uncertainties to the market.
- Finally, a NIRP may harm the reputation of the Euro because people may flee into other (financial) assets or alternative currencies like bitcoins.

## Exercise 15.1 — Sparkassen CEO criticizes the ECB policy

(Solution → p. ??)

Printed below, you find an open letter from the Sparkassen-CEO Helmut Schleweis to the ECB president Mario Draghi published in the BILD Zeitung a week ago. Read it and try to answer or discuss the following questions:

1. Name the main objective of the ECB.
2. Discuss what Mr. Schleweis wants the ECB to take care of.
3. Comment on the following statement “Anyone who invests money with you must even pay something.” In particular, discuss who ‘invests’ money in the ECB.
4. High interest rates are usually good for those who have money and bad for those who want to borrow money, right? Moreover, believing in the words of Mr. Schleweis, those who have money can flee ‘into real estate with their money’ in cases where interest rates are low. Having that in mind, isn’t it that those who have money always win?
5. The ECB set negative interest rates primarily to increase aggregate demand and prices. Discuss if Europe would ‘move closer’ or if some states would ‘reduce their debts’ faster with high interest rates and deflation.



Dear Mario Draghi,

First and foremost, allow us to state that we have great respect for the difficult task you face in keeping the euro stable and Europe united.

However, what you are doing is wrong. For years, you have been throwing more and more money at the market. You have abolished the interest rate. And you have loaned money in unimaginable dimensions to states that are highly indebted.

By doing this, you are gradually changing Europe, Germany, and the lives of millions of people – not for the better, but, in the long term, for the worse. It no longer costs anything to take on debts. Saving money no longer generates any interest. Anyone who invests money with you must even pay something.

You are thereby turning the rules of the economy upside down. People who are able to are fleeing into real estate with their money – prices and rents for which are on the rise. The retirement provisions of millions of people are melting like snow in the sun. Social insurances, pension funds, and foundations are all losing great amounts of money every day, and thus losing their capacities. For years, we have taught Germany’s children that saving money makes sense, because one has to provide for bad times during crises. You are undermining that culture. All of this cannot end well in the long term.

And what is it all for? Have European states that are in a crisis used the bought time to reduce their debts? Has Europe moved closer together? Your monetary policy has achieved none of this.

If one is in a dead-end street, one should not increase the speed. It is time to turn around – step by step. Now!

Best wishes, Helmut Schleweis

## Chapter 16

# International economics

Please read the lecture note that you find here:

<https://hubchev.github.io/ie/>

The PDF of these lecture notes can be downloaded here:

<https://hubchev.github.io/ie/International-Economics.pdf>

# Chapter 17

## Financial mathematics

### 17.1 Financial literacy

You are financially literate if you understand and manage personal finances effectively. It involves having a basic understanding of financial concepts, such as budgeting, saving, investing, and managing debt. Financial literacy also includes knowledge of financial products and services, such as bank accounts, credit cards, loans, and insurance. Being financially literate means having the skills and knowledge to make informed financial decisions, and being able to assess risks and opportunities when it comes to managing money. It is an important life skill that can help individuals achieve their financial goals, build wealth, and avoid financial pitfalls.

Being better-educated was always associated with having more financial knowledge (Figure 1) across the countries we examined,<sup>3</sup> yet we also found that education is not enough. That is, even well-educated people are not necessarily savvy about money.

Unfortunately, financial illiteracy is widespread. While being better-educated is associated with making better financial decisions on average, “even well-educated people are not necessarily savvy about money” (Mitchell and Lusardi, 2015, p. 3).

There are various attempts to assess the levels of financial literacy. See <https://www.oecd.org/finance/financial-education/measuringfinancialliteracy.htm> for example.

#### Exercise 17.1 — How to measure financial literacy

(Solution → p. 223)

One example of a comprehend way to measure financial literacy stems from the *Standard & Poor’s Ratings Services Global Financial Literacy Survey* (see Klapper and Lusardi, 2020). They ask the following multiple-choice questions:

1. Suppose you have some money. Is it safer to put your money into one business or investment, or to put your money into multiple businesses or investments?
  - (a) One business or investment
  - (b) Multiple businesses or investments
  - (c) Don’t know
  - (d) Refused to answer
2. Suppose over the next 10 years the prices of the things you buy double. If your income also doubles, will you be able to buy less than you can buy today, the same as you can buy today, or more than you can buy today?
  - (a) Less
  - (b) The same
  - (c) More
  - (d) Don’t know
  - (e) Refused to answer

3. Suppose you need to borrow \$100. Which is the lower amount to pay back: \$105 or \$100 plus 3%?
  - (a) \$105
  - (b) \$100 plus 3%
  - (c) Don't know
  - (d) Refused to answer
4. Suppose you put money in the bank for 2 years and the bank agrees to add 15% per year to your account. Will the bank add more money to your account the second year than it did the first year, or will it add the same amount of money both years?
  - (a) More
  - (b) The same
  - (c) Don't know
  - (d) Refused to answer
5. Suppose you had \$100 in a savings account and the bank adds 10% per year to the account. How much money would you have in the account after 5 years if you did not remove any money from the account?
  - (a) More than \$150
  - (b) Exactly \$150
  - (c) Less than \$150
  - (d) Don't know
  - (e) Refused to answer

These questions cover four fields of financial literacy, i.e., risk diversification, inflation and purchasing power, numeracy (simple calculations related to interest rates), and compound interest (interest payments increase exponentially over time). Knowledge in these concepts is important to make good financial decisions and to manage risk.

Try to answer these questions and compare your performance with the results shown in [Klapper and Lusardi \(2020\)](#).

### Exercise 17.2 — The big three questions

(Solution → p. 223)

Referring to [Mitchell and Lusardi \(2015\)](#), only 21.7% of individuals in Germany with a lower secondary education and 72% of those with tertiary education can correctly answer all three of the following questions. Try it yourself!

1. Suppose you had \$100 in a savings account and the interest rate was 2% per year. After 5 years, how much do you think you would have in the account if you left the money to grow?
  - a) More than \$102
  - b) Exactly \$102
  - c) Less than \$102
  - d) Do not know
  - e) Refuse to answer
2. Imagine that the interest rate on your savings account was 1% per year and inflation was 2% per year. After 1 year, how much would you be able to buy with the money in this account?
  - a) More than today
  - b) Exactly the same
  - c) Less than today
  - d) Do not know
  - e) Refuse to answer
3. Please tell me whether this statement is true or false: “Buying a single company's stock usually provides a safer return than a stock mutual fund.”
  - a) True

- b) False
- c) Do not know
- d) Refuse to answer

These three questions are designed to measure [Lusardi and Mitchell \(2014\)](#) reports that in many countries the financial illiteracy is considerably high as the following table shows:

Table 17.1: Financial literacy around the World

	% all correct	% none correct
Germany	57	10
Netherlands	46	11
United States	35	10
Italy	28	20
Sweden	27	11
Japan	27	17
New Zealand	27	4
Russia	3	28

## 17.2 Common investment mistakes

Investing can be a daunting task, but avoiding some common investment mistakes can help set you on the right path to financial success. The following list shows according to [Stammers \(2016\)](#) the *Top 20 common investment mistakes* without the explanations provided in the paper:

- Expecting too much or using someone else's expectations
- Not having clear investment goals
- Failing to diversify enough
- Focusing on the wrong kind of performance
- Buying high and selling low
- Trading too much and too often
- Paying too much in fees and commissions
- Focusing too much on taxes
- Not reviewing investments regularly
- Taking too much, too little, or the wrong risk
- Not knowing the true performance of your investments
- Reacting to the media
- Chasing yield
- Trying to be a market timing genius
- Not doing due diligence
- Working with the wrong adviser
- Letting emotions get in the way
- Forgetting about inflation
- Neglecting to start or continue

- Not controlling what you can

### Exercise 17.3 — Common investment mistakes

(Solution → p. 223)

Read the paper and summarize the 20 mistakes.

## 17.3 Simple financial mathematics

I discuss financial mathematics in the following chapter just briefly. If you want to gather a deeper understanding, I recommend the open textbook of Dahlquist et al. (2022) or the respective chapters of Wilkinson (2022).

### 17.3.1 Simple Interest

Suppose  $r$  denotes annual interest rates,  $P$  denotes the initial deposit which earns the interest,  $A$  denotes the value of the deposit at the end of an investment. Then, the relationship of these for a single year is

$$A = P + Pr = P(1 + r)$$

and for many years,  $t$ , it is

$$A = P(1 + rt)$$

which is the simple interest formula. It gives the amount due when the annual interests does not become part of the deposit  $P$ .

### 17.3.2 Compound interest

If the annual interest,  $P(1 + r)$ , is added to  $P$ , we need a formula that takes this into account, and for two periods this is

$$A = P \cdot [(1 + r) \cdot (1 + r)] = P(1 + r)^2$$

and for  $t$  periods

$$A = P(1 + r)^t.$$

Compound interest is the addition of interest to the principal sum of a loan or deposit, or in other words, interest on principal plus interest. It is the result of reinvesting interest, or adding it to the loaned capital rather than paying it out, or requiring payment from borrower, so that interest in the next period is then earned on the principal sum plus previously accumulated interest.

$$A = P \left(1 + \frac{r}{n}\right)^{nt}$$

### **Example**

Suppose a principal amount of \$1,500 is deposited in a bank paying an annual interest rate of 4.3%, compounded quarterly. Then the balance after 6 years is found by using the formula above, with  $P = 1500$ ,  $r = 0.043$  (4.3%),  $n = 4$ , and  $t = 6$ :

$$A = 1500 \times \left(1 + \frac{0.043}{4}\right)^{4 \times 6} \approx 1938.84$$

So the amount  $A$  after 6 years is approximately \$1,938.84.

Subtracting the original principal from this amount gives the amount of interest received:  $1938.84 - 1500 = 438.84$

#### **17.3.3 Continuously compounded interest**

As  $n$ , the number of compounding periods per year, increases without limit, the case is known as continuous compounding, in which case the effective annual rate approaches an upper limit of  $e^r - 1$ , where  $e$  is a mathematical constant that is the base of the natural logarithm.

Continuous compounding can be thought of as making the compounding period infinitesimally small, achieved by taking the limit as  $n$  goes to infinity. The amount after  $t$  periods of continuous compounding can be expressed in terms of the initial amount  $P$  as

$$A = Pe^{rt}$$

#### **17.3.4 Present value**

The present is the value of an expected income stream determined as of the date of valuation. The present value is usually less than the future value because money has interest-earning potential, a characteristic referred to as the time value of money, except during times of zero- or negative interest rates, when the present value will be equal or more than the future value. Time value can be described with the simplified phrase, “A dollar today is worth more than a dollar tomorrow”. Here, ‘worth more’ means that its value is greater than tomorrow. A dollar today is worth more than a dollar tomorrow because the dollar can be invested and earn a day’s worth of interest, making the total accumulate to a value more than a dollar by tomorrow.

$$P = Ae^{-rt}$$

### **17.4 Net present value and internal rate of return**

When making decisions about financial products such as investments or loans, it is important to consider their long-term impact on your finances. *Net Present Value* (NPV) and *Internal Rate of Return* (IRR) are two key indicators that can help guide decision making and determine whether a financial product is a good investment.

Net Present Value (NPV) is the difference between the present value of all cash inflows and the present value of all cash outflows over a given time period. The formula to calculate NPV is:

$$NPV = \sum_{n=1}^N \frac{C_n}{(1+r)^n} - C_0$$

where  $C_n$  denotes net cash inflow during the period  $n$ ,  $r$  the discount rate, or the cost of capital,  $n$  the number of periods, and  $C_0$  the initial investment.

In other words, NPV helps determine the current value of future cash flows, adjusted for the time value of money. A positive NPV indicates that an investment is expected to generate a return greater than the cost of capital, while a negative NPV suggests that the investment is likely to result in a loss.

Internal Rate of Return (IRR), on the other hand, is the discount rate that makes the NPV of all cash inflows equal to the NPV of all cash outflows. The formula to calculate IRR is:

$$0 = \sum_{n=0}^N \frac{C_n}{(1 + IRR)^n}$$

where  $C_n$  denotes the net cash inflow during the period  $n$ ,  $IRR$  the internal rate of return,  $n$  the number of periods, and  $C_0$  the initial investment.

IRR can be thought of as the rate of return an investment generates over time, taking into account the time value of money. When comparing different investment opportunities, a higher IRR generally indicates a more profitable investment.

Both NPV and IRR are important tools to help individuals make informed decisions about financial products. By comparing the NPV and IRR of different investment options, individuals can determine which investments are likely to generate the greatest returns over time, and which products may not be worth the initial investment.

It is worth noting that while NPV and IRR are useful indicators for decision making, they are not the only factors to consider. Individuals should also consider other important factors such as risk, liquidity, and diversification when evaluating different financial products. By taking a holistic approach and considering all relevant factors, individuals can make informed decisions that are best suited to their financial goals and circumstances.

#### Exercise 17.4 — Investment case

(Solution → p. 226)

You deposit 1,000 euros today into a savings account with an annual interest rate of 5% for 2 years. What is the balance after 2 years with annual, semi-annual (4 interest payments per year), and continuous compounding?

#### Exercise 17.5 — Present value

(Solution → p. 226)

You want to have 100,000 in 10 years, and you can save money with an interest rate of 5% p.a. How much do you need to invest today for annual, semi-annual (4 interest periods), and continuous compounding to achieve your goal?

#### Exercise 17.6 — Invest in A or B

(Solution → p. 227)

You are considering investing in project A or B.

**Project A:** It costs 50,000 today and is expected to generate cash flows of 20,000 per year for the next 5 years. You have a required rate of return of 8%.

**Project B:** It costs 50,000 today and you get 100,000 back in 5 years.

Calculate the value of your invest after five years. Which investment is the better one?

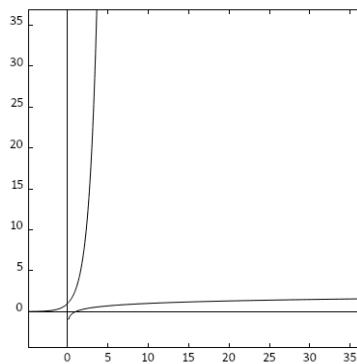


Figure 17.1: Logarithmic and exponential function

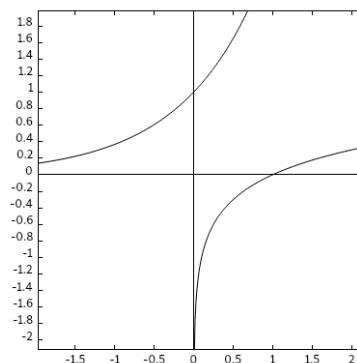


Figure 17.2: Logarithmic and exponential function zoomed in

### Exercise 17.7 — Net present value

(Solution → p. 227)

You are considering investing in project A or B.

**Project A:** It costs 50,000 today and is expected to generate cash flows of 20,000 per year for the next 5 years. You have a required rate of return of 8%.

**Project B:** It costs 50,000 today and you get 100,000 back in 5 years.

Calculate the net present value of both projects and decide where to invest.

### Exercise 17.8 — Internal rate of return

(Solution → p. 228)

You are considering investing in project A or B.

**Project A:** It costs 50,000 today and is expected to generate cash flows of 20,000 per year for the next 5 years. You have a required rate of return of 8%.

**Project B:** It costs 50,000 today and you get 100,000 back in 5 years.

Calculate the internal rate of return of both projects with the help of a software package such as *Excel* or *Libre Calc* and decide where to invest.

### Exercise 17.9 — Rule of 70

(Solution → p. 228)

The *Rule of 70* is often used to approximate the time required for a growing series to double. To understand this rule calculate how many periods it takes to double your money when it growth at a constant rate of 1% each period.

## 17.5 Logarithmic and exponential function

### 17.5.1 Logarithmic function

Maybe you have heard about the logarithm, and I'm quite sure you know the 'log' button on your calculator. If you wonder what it actually is and why it is so important for calculating with growth rates, this section is for you.

Consider the following equations and then explain to me what the logarithm is:

$$2 \cdot 2 \cdot 2 \cdot 2 = 16$$

$$2^4 = 16$$

$$2 = 16^{\frac{1}{4}}$$

$$\log_2 16 = 4$$

Now, let us abstract from that concrete example and generalize things a bit:

$$x^n = y$$

$$\log_x y = n$$

$$\log x^n = \log y$$

$$n \cdot \log x = \log y$$

$$n = \frac{\log y}{\log x}$$

Here are some more examples:

$$4 = \frac{\log 16}{\log 2}$$

$$\log_{10} 16 = 1.20411998265592$$

$$\log_{10} 2 = 0.301029995663981$$

$$\log 16 = 1.20411998265592$$

$$\log 2 = 0.301029995663981$$

#### Exercise 17.10 — Calculate with log

(Solution → p. 229)

Calculate a logarithmic function without a calculator. Hint: The result is an integer.

- $\log_2 16 = ?$
- $\log_3 243 = ?$
- $\log_5 125 = ?$
- $\log_3 81 = ?$
- $\log_2 \left(\frac{1}{8}\right) = ?$

### 17.5.2 Exponential function

#### Definition

Let us consider the function  $f(x) = 2^x$  in table Table 1 and figure 17.3.

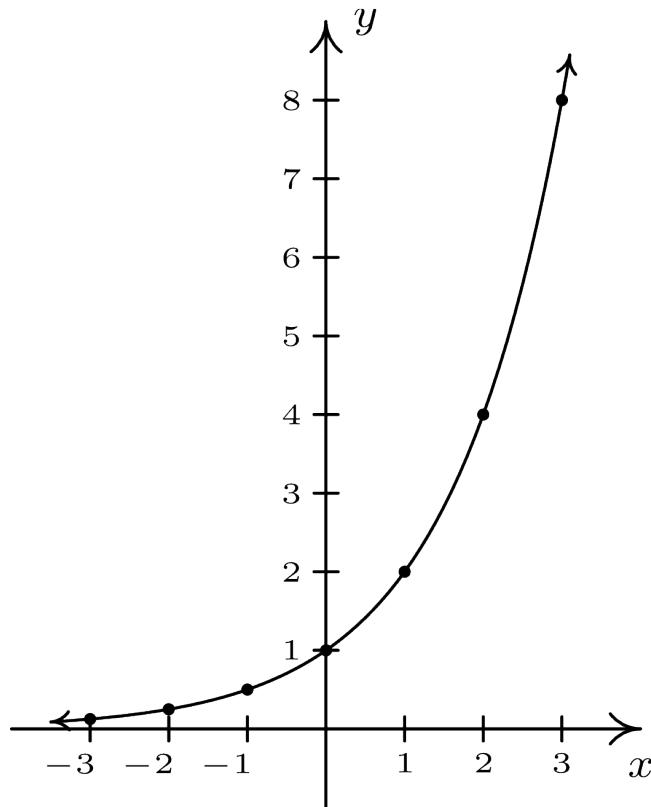


Figure 17.3: The exponential function  $2^x$  visualized

Table 17.2: Table 1: The exponential function  $2^x$  in a table

$x$	$f(x)$	$(x, f(x))$
-3	$2^{-3} = \frac{1}{8}$	$(-3, \frac{1}{8})$
-2	$2^{-2} = \frac{1}{4}$	$(-2, \frac{1}{4})$
-1	$2^{-1} = \frac{1}{2}$	$(-1, \frac{1}{2})$
0	$2^0 = 1$	$(0, 1)$
1	$2^1 = 2$	$(1, 2)$
2	$2^2 = 4$	$(2, 4)$
3	$2^3 = 8$	$(3, 8)$

A function of the form  $f(x) = b^x$  where  $b$  is a fixed real number,  $b > 0$ ,  $b \neq 1$  is called a **base  $b$  exponential function**.

- Therefore,  $b$  is the factor by which  $f(x)$  increases or decreases when  $x$  increases by one unit.
- For  $b > 1$ , the function  $f(x)$  is strictly increasing.
- For  $0 < b < 1$ , the function  $f(x)$  is strictly decreasing.

### The number $e$

The most important base for exponential functions is the irrational number

$$e \approx 2.71828182845904523536028747135266249775724709369995$$

It is sometimes called *Euler's number*, after the Swiss mathematician Leonhard Euler (1707-1783). It can be expressed as:

- $e = \sum_{n=0}^{\infty} \frac{1}{n!} = 1 + \frac{1}{1} + \frac{1}{1 \cdot 2} + \frac{1}{1 \cdot 2 \cdot 3} + \dots$

$n$	$\left(1 + \frac{1}{n}\right)^n$	$e$	Maximum	Continuous compounding growth period
1	2			(100% growth)
2	2.25			$\sim 2.718$
4	2.441			
12	2.613			$\sim 2.718$
365	2.7146	$e^{rt}$		
1000	2.7169			200%, 5 years
10000	2.7184	$r \rightarrow \text{rate}$		
100000	2.718268	$t \rightarrow \text{number of time periods}$		$e^{2 \times 5} = e^{10}$
1000000	2.7182804			

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#Logarithms #EulerNumber #EulerIdentity

Logarithms - What is e? | Euler's Number Explained | Don't Memorise

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Figure 17.4: Euler's number explained

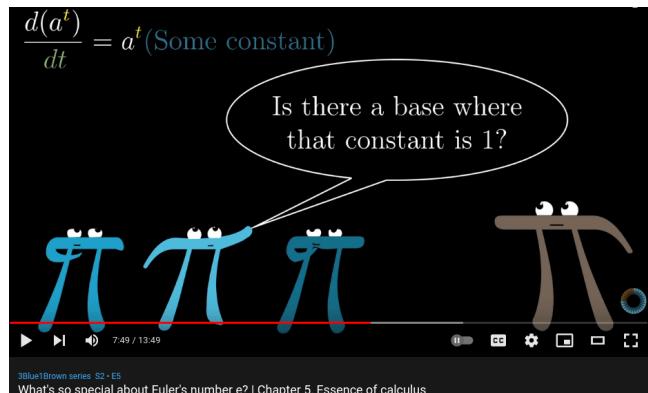


Figure 17.5: What's so special about Euler's number e?

- $e^x = 1 + \frac{x}{1!} + \frac{x^2}{2!} + \frac{x^3}{3!} + \dots = \sum_{n=0}^{\infty} \frac{x^n}{n!}$
- $e^k = \lim_{n \rightarrow \infty} \left(1 + \frac{k}{n}\right)^n$

Watch the YouTube clips [Logarithms - What is e? | Euler's Number Explained | Don't Memorise](#) by *Infinity Learn Class 9&10* (see figure 17.4) and [What's so special about Euler's number e? | Chapter 5, Essence of calculus](#) by *3Blue1Brown* (see figure 17.5).

## 17.6 A note on growth rates and the logarithm

Most data are recorded for discrete periods of time (e.g., quarters, years). Consequently, it is often useful to model economic dynamics in discrete periods of time. A good linear approximation to a growth rate from time  $t = 0$  to  $t = 1$  in  $x$  is  $\ln x_1 - \ln x_0$ :

$$\frac{x_1 - x_0}{x_0} \approx \ln x_1 - \ln x_0$$

Let us prove that with some numbers of per capita real GDP for the US and Japan in 1950 and 1989:

	1950	1950	1989
US	8611	18317	
Japan	1563	15101	

What are the annual average growth rates over this period for the US and Japan? Here is one way to answer this question:

$$Y_{1989} = (1 + g)^{39} \cdot Y_{1950}$$

Consequently,  $g$  can be calculated as:

$$(1 + g) = \left( \frac{Y_{1989}}{Y_{1950}} \right)^{\frac{1}{39}}$$

Yielding  $g = 0.0195$  for the US and  $g = 0.0597$  for Japan. The US grew at an average growth rate of about 2% annually over the period, while Japan grew at about 6% annually.

The following method gives a close approximation to the answer above and will be useful in other contexts. A useful approximation is that for any small number  $x$ :  $\ln(1 + x) \approx x$

Now, we can take the natural log of both sides of:

$$\frac{Y_{1989}}{Y_{1950}} = (1 + g)^{39}$$

to get:

$$\ln(Y_{1989}) - \ln(Y_{1950}) = 39 \cdot \ln(1 + g)$$

which rearranges to:

$$\ln(1 + g) = \frac{\ln(Y_{1989}) - \ln(Y_{1950})}{39}$$

and using our approximation:

$$g \approx \frac{\ln(Y_{1989}) - \ln(Y_{1950})}{39}$$

In other words, log growth rates are good approximations for percentage growth rates. Calculating log growth rates for the data above, we get  $g \approx 0.0194$  for the US and  $g \approx 0.0582$  for Japan. The approximation is close for both.

## Plotting growth using the logarithm

Recall that, with a constant growth rate  $g$  and starting from time 0, output in time  $t$  is:

$$Y_t = (1 + g)^t \cdot Y_0$$

Taking natural logs of both sides, we have:

$$\ln Y_t = \ln Y_0 + t \cdot \ln(1 + g)$$

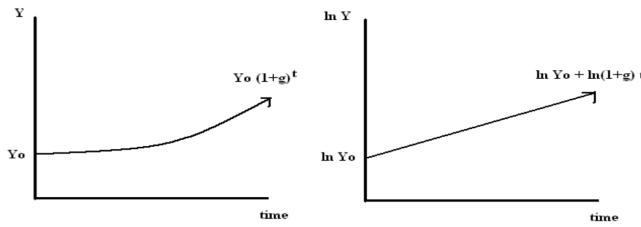


Figure 17.6: Log Plot

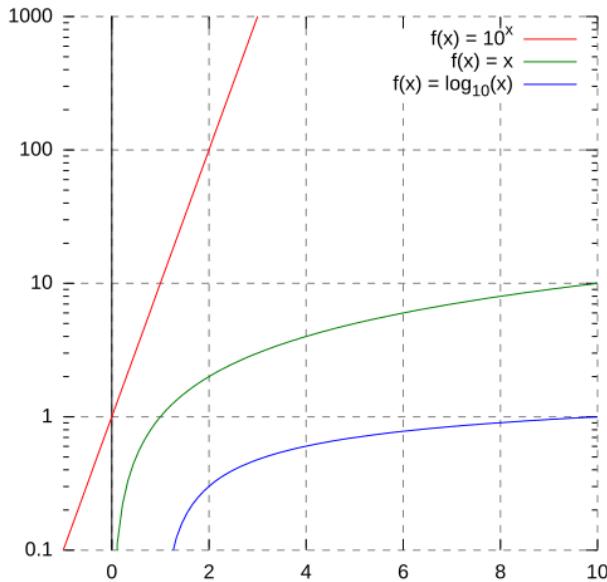


Figure 17.7: Log-Lin Scale

We see that log output is linear in time. Thus, if the growth rate is constant, a plot of log output against time will yield a straight line. Consequently, plotting log output against time is a quick way to **eyeball** whether growth rates have changed over time.

In figure 17.6 and 17.7 you see a semi-logarithmic plot that has one axis on a logarithmic scale and the other on a linear scale. It is useful for data with exponential relationships, where one variable covers a large range of values, or to zoom in and visualize that what seems to be a straight line in the beginning is, in fact, the slow start of a logarithmic curve that is about to spike, and changes are much bigger than thought initially.

#### Exercise 17.11 — Investments over time

(Solution → p. 229)

Describe the formulas to describe the growth process of an investment over time when time is discrete and when time is continuous.

#### Exercise 17.12 — Exponential growth

(Solution → p. 229)

Sketch a timeline for each of the following series:

- $a_t = a_{t-1} + g$
- $\ln(a_t)$
- $b_t = b_{t-1} \cdot (1 + g)$
- $\ln b_t$

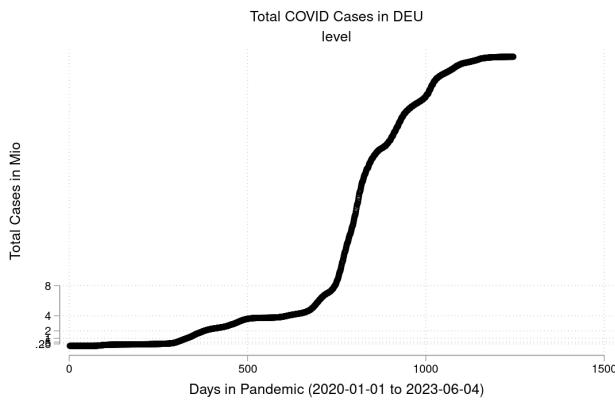


Figure 17.8: Total Cases

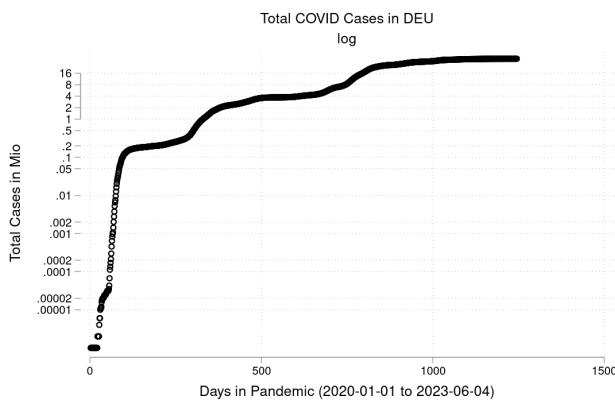


Figure 17.9: Total Cases 2

### Exercise 17.13 — COVID and how to plot it

(Solution → p. ??)

I downloaded the complete **Our World in Data COVID-19** dataset from [ourworldindata.org](https://ourworldindata.org). I created some graphs which I will show you below. Can you discuss the scaling and how to interpret them? What is your opinion on these graphs? Are some of them a bit misleading (at least if you don't look twice)?

## 17.7 Solutions

### Solution to Exercise 17.1 — How to measure financial literacy (Exercise → p. 211)

*Correct answers are: 1b, 2b, 3b, 4a, 5a.*

### Solution to Exercise 17.2 — The big three questions

(Exercise → p. 212)

*Correct answers are:*

*1a, 2c, 3b*

### Solution to Exercise 17.3 — Common investment mistakes

(Exercise → p. 214)

- ***Expecting too much or using someone else's expectations:*** *Nobody can tell you what a reasonable rate of return is without having an understanding of you, your goals, and your current asset allocation.*

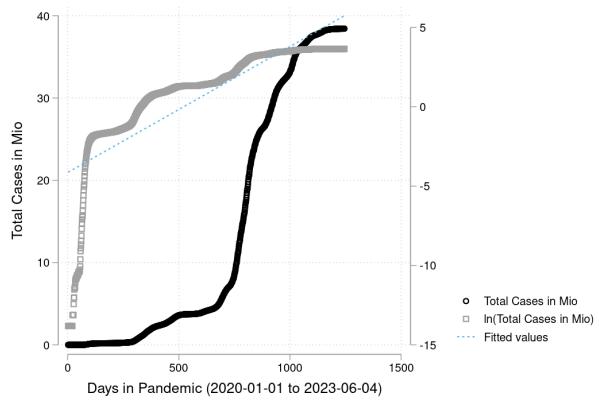


Figure 17.10: Total Cases 3

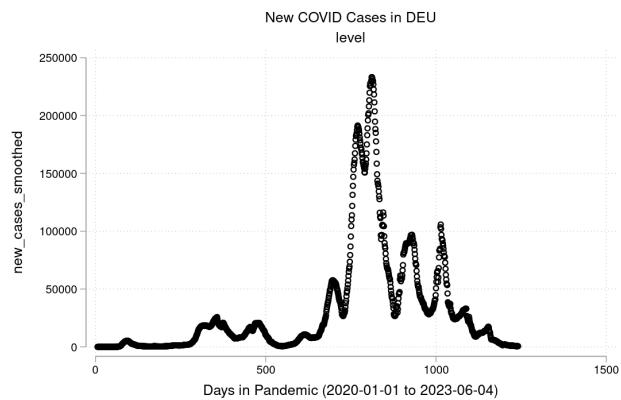


Figure 17.11: New Cases

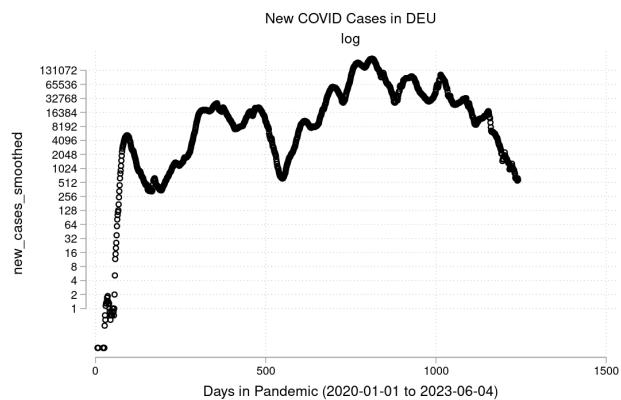


Figure 17.12: New Cases 2

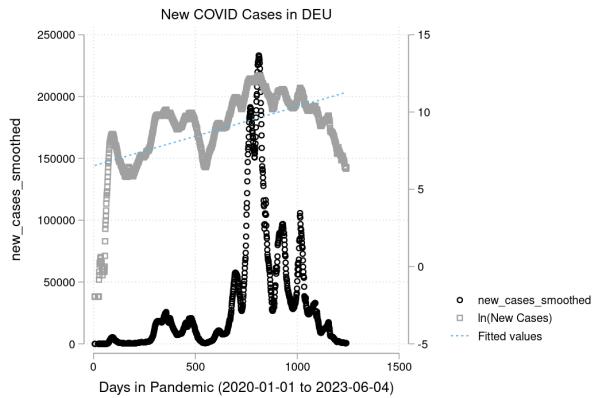


Figure 17.13: New Cases 3

- **Not having clear investment goals:** Too many investors focus on the latest investment fad or on maximizing short-term investment return instead of designing an investment portfolio that has a high probability of achieving their long-term investment objectives.
- **Failing to diversify enough:** The best course of action is to find a balance. Seek the advice of a professional adviser.
- **Focusing on the wrong kind of performance:** If you find yourself looking short term, refocus.
- **Buying high and selling low:** Instead of rational decision making, many investment decisions are motivated by fear or greed.
- **Trading too much and too often:** You should always be sure you are on track. Use the impulse to reconfigure your investment portfolio as a prompt to learn more about the assets you hold instead of as a push to trade.
- **Paying too much in fees and commissions:** Look for funds that have fees that make sense and make sure you are receiving value for the advisory fees you are paying.
- **Focusing too much on taxes:** It is important that the impetus to buy or sell a security is driven by its merits, not its tax consequences.
- **Not reviewing investments regularly:** Check in regularly to make sure that your investments still make sense for your situation and that your portfolio doesn't need rebalancing.
- **Taking too much, too little, or the wrong risk:** Make sure that you know your financial and emotional ability to take risks and recognize the investment risks you are taking.
- **Not knowing the true performance of your investments:** Many investors do not know how their investments have performed in the context of their portfolio. You must relate the performance of your overall portfolio to your plan to see if you are on track after accounting for costs and inflation.
- **Reacting to the media:** Using the news channels as the sole source of investment analysis is a common investor mistake. Successful investors gather information from several independent sources and conduct their own proprietary research and analysis.
- **Chasing yield:** High-yielding assets can be seductive, but the highest yields carry the highest risks. Past returns are no indication of future performance. Focus on the whole picture and don't get distracted while disregarding risk management.
- **Trying to be a market timing genius:** Market timing is very difficult and attempting to make a well-timed call can be an investor's undoing. Consistently contributing to your investment portfolio is often better than trying to trade in and out in an attempt to time the market.
- **Not doing due diligence:** Check the training, experience, and ethical standing of the people managing your money. Ask for references and check their work on the investments

they recommend. Taking the time to do due diligence can help avoid fraudulent schemes and provide peace of mind.

- **Working with the wrong adviser:** An investment adviser should share a similar philosophy about investing and life in general. The benefits of taking extra time to find the right adviser far outweigh the comfort of making a quick decision.
- **Letting emotions get in the way:** Investing can bring up significant emotional issues that can impede decision-making. A good adviser can help construct a plan that works no matter what the answers to important financial questions are.
- **Forgetting about inflation:** It's important to focus on real returns after accounting for fees and inflation. Even if the economy is not in a massive inflationary period, some costs will still rise, so it's important to focus on what you can buy with your assets, rather than their value in dollar terms.
- **Neglecting to start or continue:** Investment management requires continual effort and analysis to be successful. It's important to start investing and continue to invest over time, even if you lack basic knowledge or have experienced investment losses.
- **Not controlling what you can:** While you can't control what the market will bear, you can control how much money you save. Continually investing capital over time can have as much influence on wealth accumulation as the return on investment and increase the probability of reaching your financial goals.

#### Solution to Exercise 17.4 — Investment case

(Exercise → p. 216)

- Annual compounding:

$$1,000\text{€} \cdot (1 + 0.05)^2 = 1,102.50\text{€}$$

- Semi-annual compounding:

$$1,000\text{€} \cdot \left(1 + \frac{0.05}{4}\right)^{2 \cdot 4} = 1,104.49\text{€}$$

- Continuous compounding:

$$1,000\text{€} \cdot e^{0.05 \cdot 2} = 1,105.17\text{€}$$

#### Solution to Exercise 17.5 — Present value

(Exercise → p. 216)

- Annual compounding:

The formula for the future value of a present amount with annual compounding is:

$$V_{\text{future}} = V_{\text{present}} \cdot (1 + i)^t$$

To calculate the present value, we need to rearrange the above formula for Present Value:

$$V_{\text{present}} = \frac{V_{\text{future}}}{(1 + i)^t}$$

$$V_{\text{present}} = \frac{100,000}{(1 + 0.05)^{10}} \approx 61,391$$

- Semi-annual compounding (4 interest periods per year):

The formula for the future value of a present amount with semi-annual compounding is:

$$V_{\text{future}} = V_{\text{present}} \cdot \left(1 + \frac{i}{p}\right)^{p \cdot t}.$$

To calculate the present value, we need to rearrange the above formula for Present Value:

$$V_{\text{present}} = \frac{V_{\text{future}}}{\left(1 + \frac{i}{p}\right)^{p \cdot t}}$$

$$\frac{100,000}{\left(1 + \frac{0.05}{4}\right)^{4 \cdot 10}} \approx 60,841$$

- Continuous compounding:

The formula for the future value of a present amount with continuous compounding is:

$$V_{\text{future}} = V_{\text{present}} \cdot e^{i \cdot t}$$

To calculate the present value, we need to rearrange the above formula for present value:

$$V_{\text{present}} = \frac{V_{\text{future}}}{e^{i \cdot t}}$$

$$V_{\text{present}} = \frac{100,000}{e^{0.05 \cdot 10}} \approx 60,653$$

### Solution to Exercise 17.6 — Invest in A or B

(Exercise → p. 216)

$$V_A^{t=5} \approx 117,332$$

$$V_B^{t=5} = 100,000$$

Thus, we should prefer project A.

### Solution to Exercise 17.7 — Net present value

(Exercise → p. 217)

Assuming that the cash flows occur at the end of each year, we can use the following formula to calculate the NPV of the project:

$$NPV = \sum_{n=1}^N \frac{C_n}{(1+r)^n} - C_0$$

$$NPV_A = -50,000 + \frac{20,000}{(1+0.08)^1} + \frac{20,000}{(1+0.08)^2} + \frac{20,000}{(1+0.08)^3} + \frac{20,000}{(1+0.08)^4} + \frac{20,000}{(1+0.08)^5}$$

$$NPV_A = -50,000 + 18,518.52 + 17,146.77 + 15,876.64 + 14,700.59 + 13,611.66 \approx 29,854$$

$$NPV_B = -50,000 + \frac{100,000}{(1+0.08)^5} = -50,000 + 68058,31 \approx 18058$$

Since the  $NPV_A > NPV_B$ , we should invest in project A.

### Solution to Exercise 17.8 — Internal rate of return

(Exercise → p. 217)

Assuming that the cash flows occur at the end of each year, we can use the following formula to calculate the  $IRR$  of the project:

$$0 = \sum_{n=0}^N \frac{C_n}{(1 + IRR)^n}$$

$$0 = -50,000 + \frac{20,000}{(1 + IRR)^1} + \frac{20,000}{(1 + IRR)^2} + \frac{20,000}{(1 + IRR)^3} + \frac{20,000}{(1 + IRR)^4} + \frac{20,000}{(1 + IRR)^5}$$

Solving for  $IRR$  is not that easy. Using a spreadsheet program, we get  $IRR_A \approx 28.68$  and  $IRR_B \approx 14.87$ . Thus, project A seems to be better.

### Solution to Exercise 17.9 — Rule of 70

(Exercise → p. 217)

What is the time required for a growing variable to double?

Let  $X$  be the initial value of a growing variable, and  $Y$  denote the terminal value at time  $t + n$ . The relationship between the two is given by

$$Y = X(1 + g)^n$$

where  $g$  is the annual growth rate. As we are interested in the time span required for  $X$  to double,  $Y = 2$ , and

$$2 = (1 + g)^n$$

Taking natural logarithms (logarithm to the base of  $e$ ), we get

$$\ln 2 = n \ln(1 + g)$$

and hence

$$n = \frac{\ln 2}{\ln(1 + g)} \quad (*).$$

This is the exact number of time periods required for a growing variable to double its size. One can approximate  $n$  using the definition of  $e^x$ :

$$e^x = 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \dots + \frac{x^n}{n!} + R_n$$

where the remainder term  $R_n \rightarrow 0$  as  $n \rightarrow \infty$ . Ignoring high-order terms, for small  $x$ , it may be approximated by

$$e^x \approx 1 + x$$

Taking logarithms of both sides, we get

$$x \approx \ln(1 + x) \quad (**).$$

Using (\*\*), equation (\*) may be approximated as

$$n \approx \frac{\ln 2}{g} = \frac{0.693147}{g} \approx \frac{70}{g\%}$$

This is the origin of the Rule of 70.

Using the number  $e$  right away is simpler:

$$\begin{aligned}(e^r)^t &= 2 \\ \ln e^{rt} &= \ln 2 \\ rt &= \ln 2 \\ t &= \frac{\ln 2}{r} \\ t &\approx \frac{0.693147}{r}\end{aligned}$$

### Solution to Exercise 17.10 — Calculate with log

(Exercise → p. 218)

- $\log_2 16 = 4$  because  $2^4 = 16$
- $\log_3 243 = 5$  because  $3^5 = 243$
- $\log_5 125 = 3$  because  $5^3 = 125$
- $\log_3 81 = 4$  because  $3^4 = 81$
- $\log_2 \left(\frac{1}{8}\right) = -3$  because  $2^{-3} = \frac{1}{8}$

### Solution to Exercise 17.11 — Investments over time

(Exercise → p. 222)

The formula under discrete time is:

$$Y_t = Y_0 \cdot (1 + g)^t$$

The formula under continuous time is:

$$Y_t = Y_0 \cdot e^{gt}$$

### Solution to Exercise 17.12 — Exponential growth

(Exercise → p. 222)

Figure 17.14 provides the solution.

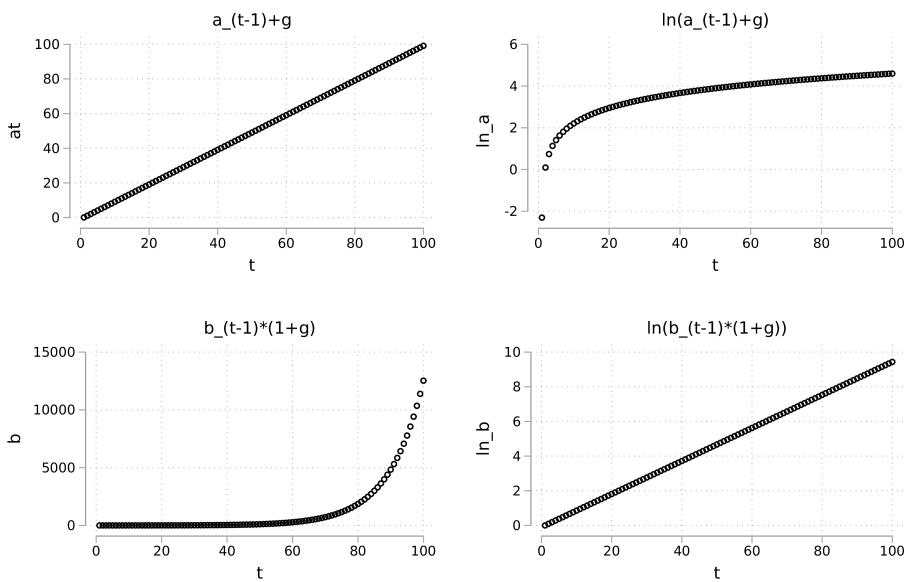
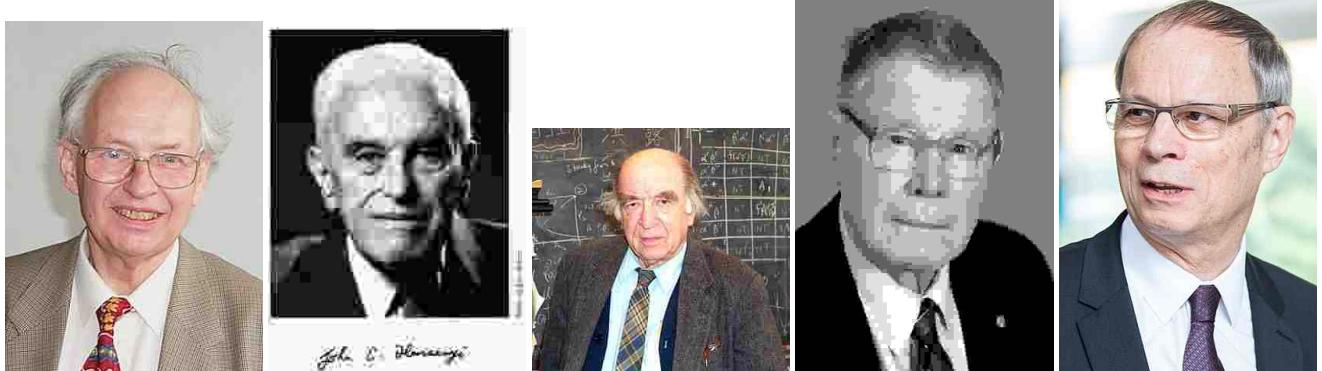


Figure 17.14: Various growth functions

# Chapter 18

## Game theory and behavioral economics



Reinhard Selten, John Harsanyi, Leonid Hurwicz, Thomas Schelling, Jean Tirole

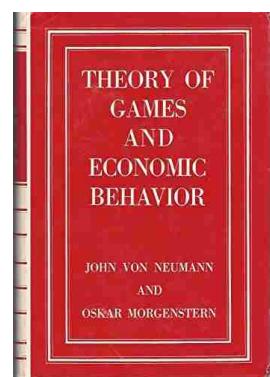
### 18.1 Game theory

#### 18.1.1 Introduction

Game theory is the study of mathematical models of **strategic interaction among rational decision-makers**. It has applications in all fields of social science, as well as in logic, systems science and computer science. In the 21st century, game theory applies to a wide range of behavioral relations, and is now an umbrella term for the science of logical decision making in humans, animals, and computers.

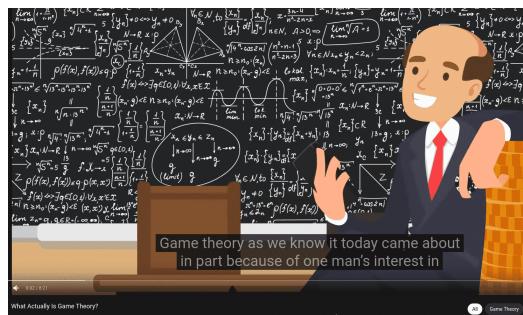
Modern game theory began with the idea of mixed-strategy equilibria in two-person zero-sum games and its proof by *John von Neumann*. His work and in particular his jointly written with *Oskar Morgenstern* from 1944 *Theory of Games and Economic Behavior* which considered cooperative games of several players was the beginning of modern game theory. The second edition of this book provided an axiomatic theory of expected utility, which allowed mathematical statisticians and economists to treat decision-making under uncertainty.

Game theory has been widely recognized as an important tool in many fields. As of 2014, with the Nobel Memorial Prize in Economic Sciences going to game theorist *Jean Tirole*, **eleven game theorists have won the economics Nobel Prize** including *Reinhard Selten* from Germany together with *John Harsanyi* and *John Nash* in 1994.



The reference list of John Nash's doctoral thesis:

- Bibliography
- (1) von Neumann, Oskar, 1944, "Theory of Games and Economic Behavior", Princeton University Press, 1944.
  - (2) J. F. Nash, Jr., "Equilibrium Points in N-Person Games", *Proc. Natl. Acad. Sci. USA*, 36 (1950) 48-49.



- ▶ <https://youtu.be/YueJukoFBMU> — Game Theory Explained in One Minute
- ▶ <https://youtu.be/9uDv1TpGxI> — What Actually Is Game Theory?

- Game theory is the analysis of strategic interactions between two or more players.
- It analyzes behavior when some **players** make **strategic decisions** – their actions affect others **payoff** and, in turn, others' actions affect their **payoffs**.
- It can be applied to real market situations as well as to many different interactions between people.
- It is based on the assumption that players act rationally and maximize their own benefit, and enables economic research through experiments in a lab or from the field.

### 18.1.2 Representation of a game: the normal form

The matrix provided is a normal-form representation of a game in which players move simultaneously (or at least do not observe the other player's move before making their own) and receive the payoffs as specified for the combinations of actions played.

		Person B	
		work	shirk
Person A	work	10 ; 10	5 ; 11
	shirk	11 ; 5	6 ; 6

Here, shirking from work is the **dominant strategy** for both players.

### 18.1.3 Homo economicus

In **game theory**, *homo economicus* is often modeled through the assumption of perfect rationality. It assumes that agents always act in a way that maximize utility (as a consumer) and profit (as a producer), and are capable of arbitrarily complex deductions towards that end. That means, it is assumed that they will always be capable of thinking through all possible outcomes and choosing that course of action which will result in the best possible result.

Obviously, assuming a *homo economicus* is heroic and I doubt that serious economist ever thought that is an assumption that we find in reality one to one. However, it is an assumption that helps to make predictions and explain behavior of people and societies to some extend. I mean, what would happen if microeconomics would go to the other extreme, that is, assuming irrational acting individuals. The results would be more or less that we cannot make any predictions and the future would be a random walk.

Nevertheless, economist and those who make, apply, or want to think about economic theory, should be aware of all the pitfalls that occur in our decision making and how our ability to act rational is limited. In real life, we often use *heuristics* to solve problems and make decisions. A heuristic is any approach to solve a problem that employs a practical method that is not guaranteed to be optimal, perfect, or rational. However, an heuristic should –at best– be sufficient for reaching an immediate, short-term goal or approximation. Overall, people use heuristics because they either cannot act completely rational or want to act rational but they do not have the time that would be needed to *calculate* the perfect

solution. Additionally, often it is probably not worth the effort or is simply not possible given the time constraints under which the problem needs to be solved.

Game theory is the study of mathematical models of strategic interaction among rational decision-makers. It is the study of the ways in which *interacting choices* of *economic agents* produce outcomes with respect to the *preferences* (or *utilities*) of those agents, where the outcomes in question might have been intended by none of the agents. The meaning of this statement will not be clear until each of the italicized words and phrases has been explained and featured in some examples. We will do that later on in this course.

#### 18.1.4 Nash equilibrium

**John Forbes Nash Jr. (1928–2015)**



- ▶ <https://youtu.be/jE24tzle1m8> — Dr. John Nash on his life before and after the Nobel Prize
- ▶ <https://youtu.be/ZoZe2tPd3Hk> — What is Nash Equilibrium?
- ▶ [https://youtu.be/2d\\_dtTZQyUM](https://youtu.be/2d_dtTZQyUM) — Nash Equilibrium (taken from *A Beautiful Mind*)
- ☞ [https://library.princeton.edu/special-collections/sites/default/files/Non-Cooperative\\_Games\\_Nash.pdf](https://library.princeton.edu/special-collections/sites/default/files/Non-Cooperative_Games_Nash.pdf)

#### Identifying a Nash equilibrium

To find a Nash equilibrium in a normal form game, we can look for the best responses for both players in a game. We do so by putting a star to the payoff attained by the best response of a player for all the strategies of the other player. For example, we put a star in the top left corner next to the 4 because S1 is the best response by player B to the action S1 of player A.

Notice that the bottom right corner box has a particular feature: it shows that the strategies of played by all the (two) players and resulting in that outcome are best responses to the others' players best responses. That defines a **Nash equilibrium**.

		Person B		
		S1	S2	S3
Person A	S1	0 ; 4*	4* ; 0	5 ; 3
	S2	4* ; 0	0 ; 4*	5 ; 3
	S3	3 ; 5	3 ; 5	6* ; 6*

The Nash equilibrium is a concept of game theory where the optimal outcome of a game is one where no player has an incentive to deviate from his chosen strategy after considering an opponent's choice.

#### 1994 — Nobel Price award ceremony speech

Presentation Speech by Professor Karl-Göran Mäler of the Royal Swedish Academy of Sciences:<sup>1</sup>

<sup>1</sup>Taken from  <https://www.nobelprize.org/prizes/economic-sciences/1994/ceremony-speech/>

Your Majesties, Your Royal Highnesses, Ladies and Gentlemen,

Many situations in society, from everyday life to high-level politics, are characterized by what economists call strategic interactions. When there is strategic interaction, the outcome for one agent depends not only on what that agent does, but also very largely on how other agents act or react. A firm that decreases its price to attract more customers will not succeed in this strategy if the other major firms in the market use the same strategy. Whether a political party will be successful in attracting more votes by proposing lower taxes or increased spending will depend on the proposals from other parties. The success of a central bank which is trying to fight inflation by maintaining a fixed exchange rate depends – as we know – on decisions on fiscal policy, and also on reactions in markets for labor and commodities.

A simple economic example of strategic interaction is where two firms are competing with identical products on the same market. If one firm increases its production, this will make the market price fall and therefore reduce profits for the other firm. The other firm will obviously try to counteract this, for example by increasing its production and so maintaining its market share but at the cost of further reduction in market price. The first company must therefore anticipate this countermove and possible further countermoves when it makes its decision to increase production. Can we predict how the parties will choose their strategies in situations like this?

As early as the 1830s the French economist Auguste Cournot had studied the probable outcome when two firms compete in the same market. Many economists and social scientists subsequently tried to analyze the outcome in other specific forms of strategic interaction. However, prior to the birth of game theory, there was no toolbox that gave scholars access to a general but rigorous method of analyzing different forms of strategic interaction. The situation is totally different now. Scientific journals and advanced textbooks are filled with analyses that build on game theory, as it has been developed by this year's Laureates in economics, John Nash, John Harsanyi and Reinhard Selten.

Non-cooperative game theory deals with situations where the parties cannot make binding agreements. Even in very complicated games, with many parties and many available strategies, it will be possible to describe the outcome in terms of a so-called Nash equilibrium – so named after one of the Laureates. John Nash has shown that there is at least one stable outcome, that is an outcome such that no player can improve his own outcome by choosing a different strategy when all players have correct expectations of each other's strategy. Even if each party acts in an individually rational way, the Nash equilibrium shows that strategic interaction can quite often cause collective irrationality: trade wars or excessive emission of pollutants that threaten the global environment are examples in the international sphere. One should also add that the Nash equilibrium has been important within evolutionary ecology – to describe natural selection as a strategic interaction within and between species.

In many games, the players lack complete information about each other's objective. If the government, for example, wants to deregulate a firm but does not know the cost situation in the firm, while the firm's management has this knowledge, we have a game with incomplete information. In three articles published toward the end of the 1960s, John Harsanyi showed how equilibrium analysis could be extended to handle this difficulty, which game theorists up to that time had regarded as insurmountable. Harsanyi's approach has laid an analytical basis for several lively research areas including information economics which starts from the fact that different decision makers, in a market or within an organization, often have access to different information. These areas cover a broad range of issues, from contracts between shareholders and a company's management to institutions in developing countries.

One problem connected with the concept of Nash equilibrium is that there may be several

equilibria in non-cooperative games. It may thus be difficult – both for the players and an outside analyst – to predict the outcome. Reinhard Selten has, through his “perfection” concepts, laid the foundations for the research program that has tried to exclude improbable or unreasonable equilibria. Certain Nash equilibria can, in fact, be such that they are based on threats or promises intended to make other players choose certain strategies. These threats and promises are often empty because it is not in the player’s interest to carry them out if a situation arises in which he has threatened to carry them out. By excluding such empty threats and promises Selten could make stronger predictions about the outcome in the form of socalled perfect equilibria.

Selten’s contributions have had great importance for analysis of the dynamics of strategic interaction, for example between firms trying to reach dominant positions on the market, or between private agents and a government that tries to implement a particular economic policy.

Professor John Harsanyi, the analysis of games with incomplete information is due to you, and it has been of great importance for the economics of information.

Dr John Nash, your analysis of equilibria in non-cooperative games, and all your other contributions to game theory, have had a profound effect on the way economic theory has developed in the last two decades. Professor Reinhard Selten, your notion of perfection in the equilibrium analysis has substantially extended the use of non-cooperative game theory.

It is an honour and a privilege for me to convey to all of you, on behalf of the Royal Swedish Academy of Sciences, our warmest congratulations. I now ask you to receive your prizes from the hands of his Majesty the King.

### 18.1.5 The prisoner’s dilemma

The *prisoner’s dilemma* is the most well-known example of game theory. It shows why two completely rational individuals might not cooperate, even if it appears that it is in their best interests to do so.

 <https://youtu.be/9uDUv1TpGxI?t=158> — What Actually Is Game Theory?

Consider the example of two criminals arrested for a crime. Prosecutors have no hard evidence to convict them. However, to gain a confession, officials remove the prisoners from their solitary cells and question each one in separate chambers. Neither prisoner has the means to communicate with each other. The criminals are now confronted by the officials with four possible scenarios.

1. If both confess, they will each receive a eight-year prison sentence.
2. If Prisoner 1 confesses, but Prisoner 2 does not (he aims to *cooperate* with Prisoner 1), Prisoner 1 will get free and Prisoner 2 will get twenty years.
3. If Prisoner 2 confesses, but Prisoner 1 does not (he aims to *cooperate* with Prisoner 1), Prisoner 1 will get twenty years, and Prisoner 2 will get free.
4. If neither confesses, each will serve two years in prison.

#### The prisoner’s dilemma

---

		Person B	
		Confess	Cooperate
Person A	Confess	8 years ; 8 years	0 years ; 20 years
	Cooperate	20 years ; 0 years	2 years ; 2 years

---

Let us now look how individuals would rationally think what to do:

- If A assumes that B confesses, A would also confess.

- If A assumes that B cooperates, A would confess.

As the same logic applies for B, we can say that the strategy of choice is to confess while the most favorable strategy for both would be to cooperate. The game theoretical equilibrium (both confess) of this game can be called a **Nash equilibrium** because it suggests that both players will make the move that is best for them individually even if it is worse for them collectively.

## 18.2 Structure of games

### 18.2.1 Elements of games

- Number of players
- Number of strategies and alternative actions, respectively
- Payoff functions
- State of information (who knows what)
- Timing of actions and information

### 18.2.2 Classes of games

- cooperative vs. non-cooperative
- Static vs. dynamic
- one-shot vs. repeated
- non-zero-sum vs. zero-sum
- perfect information vs. non-perfect information
- symmetric information vs. asymmetric information
- deterministic vs. non-deterministic payoffs (random)

## 18.3 Representation of a game: The extensive-form

An representation allows the explicit representation of a number of key aspects, like the sequencing of players' possible moves, their choices at every decision point, the (possibly imperfect) information each player has about the other player's moves when they make a decision, and their payoffs for all possible game outcomes. Extensive-form games also allow for the representation of incomplete information in the form of chance events modeled as *moves by nature*.

### Exercise 18.1 — Matching pennies (random and simultaneous version) (Solution → p. 237)

Write down the following game in the normal form:

*Matching pennies (random and simultaneous version)* is a game with two players (1, 2). Both players flip simultaneously a penny high. Each penny falls down and shows either head up or tail up. If the two pennies match (either both heads up or both tails up) player 2 wins and player 1 must pay him a Euro. If the two pennies do not match player 1 wins and player 2 must pay him a Euro.

Describe the elements of the game and the class of this game.

### Exercise 18.2 — Matching pennies (random version)

(Solution → p. 237)

Write down the following game in the extensive form:

*Matching pennies (random and simultaneous version)* is a game with two players (1, 2). **Player 1 starts by flipping a fair penny high, catches it and then turns it over into the other hand so that the result is hidden to the other player. Then, player 2 flips the coin.** If the two pennies match (either both heads up or both tails up) player 2 wins and player 1 must pay him a Euro. If the two pennies do not match player 1 wins and player 2 must pay him a Euro.

### Exercise 18.3 — Matching pennies (strategic version)

(Solution → p. 238)

Write down the following game in the extensive form and discuss the strategies of both:

*Matching pennies (strategic version)* is a game with two players (1, 2). Player 1 starts and decides whether to put a coin with either head up or tail up onto a table. Player 2 can see the decision of player 1. Then, player 2 decides whether to put a coin with head or table on the table. If the two pennies match (either both heads up or both tails up) player 2 wins and player 1 must pay him a Euro. If the two pennies do not match player 1 wins and player 2 must pay him a Euro.

### Solution to Exercise 18.1 — Matching pennies (random and simultaneous version) (Exercise → p. 236)

*It is a game that belongs to the following classes:*

- non-cooperative,
- static,
- one-shot,
- zero-sum,
- perfect information
- symmetric information
- non-deterministic payoffs

*Elements of the game:*

- Number of players: 2
- Number of strategies: No strategies as whether head or tail shows up is random
- Payoff functions:

$$\text{Player 1} = \begin{cases} 1, & \text{if } (T, T) \text{ or } (H, H) \\ -1, & \text{otherwise} \end{cases}$$

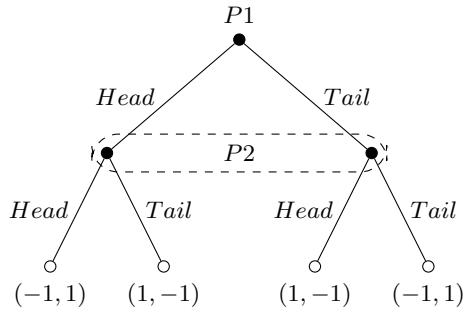
$$\text{Player 2} = \begin{cases} 1, & \text{if } (H, T) \text{ or } (T, H) \\ -1, & \text{otherwise} \end{cases}$$

- State of information: Everybody knows the rules and is perfectly informed
- Timing of actions and information: both throw the coin at the same time and see the result at the same time

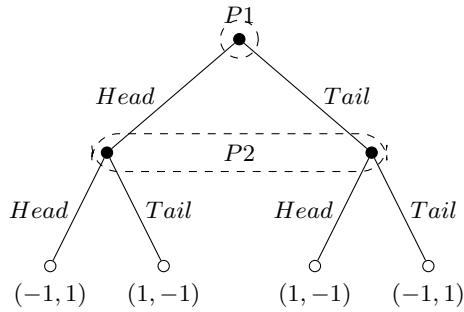
		Person 2	
		Head	Tail
Person 1	Head	-1 ; 1	1 ; -1
	Tail	1 ; -1	-1 ; 1

### Solution to Exercise 18.2 — Matching pennies (random version) (Exercise → p. 236)

*As player 2 has no idea what player 1 has chosen, he cannot come up with any strategy that increases his winning rate.*

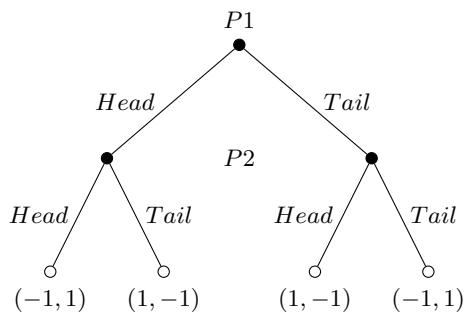


The dashed circled line indicates that player 2 actually is not informed about whether P1 decided head or tail. As we have now introduced how to graphically show that some players have a restricted information set, we can draw the extensive form also for the random and simultaneous version of the matching pennies game. Please note that the dashed circle around player 1 is redundant and hence it is a convention not to draw it sometimes.



### Solution to Exercise 18.3 — Matching pennies (strategic version) (Exercise → p. 237)

As player 2 has complete information about the decision of player 1, he cannot always come up with the choice that makes him win. That is, if player 1 chooses head(/tail) player one will also choose head(/tail).



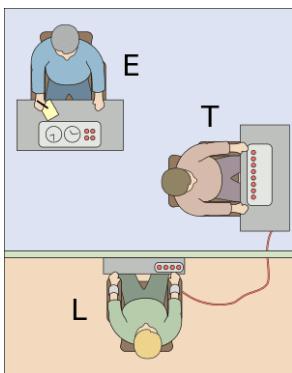
## 18.4 Behavioral economics

### 18.4.1 Behavioral experiments

Behavioral experiments are important in economics because they enable validating economic theories in a controlled environment. For example, experiment can help

- to select the right theories for the respective question,
- to test the robustness of models w.r.t. certain circumstances, or
- to calibrate of parameters such as risk aversion.

Moreover, experiments can provide new empirical insights on which new theories can be grounded.



### Milgrim experiment (starting 1961)

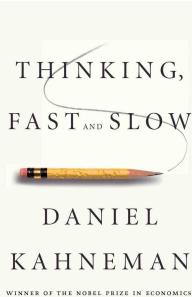
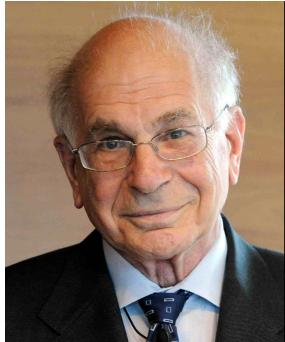
To see how behavioral experiments actually works, or better worked because of ethnical reasons, let us look at the old, controversial and infamous **Milgrim Experiment**

► <https://youtu.be/3Y0ox59J0Bk> — The Milgrim Experiment - Shock Study on Obedience Conclusions

► <https://youtu.be/m0UEC5YXV8U> — Milgrim Experiment (original recordings)

## 18.4.2 Behavioral economic experiments

### Tversky and Kahneman's judgment under uncertainty



► <https://www.youtube.com/watch?v=3IjIVD-KYF4> — An Introduction to Tversky and Kahneman's Work

- Behavioral Economics studies the effects of psychological, cognitive, emotional, cultural and social factors on the decisions of individuals and institutions and how those decisions vary from those implied by classical economic theory.
- It is primarily concerned with the bounds of rationality of economic agents. Behavioral models typically integrate insights from psychology, neuroscience and microeconomic theory. The study of behavioral economics includes how market decisions are made and the mechanisms that drive public choice.
- Behavioral Economic studies have proven that many people **do not act as assumed by theories in microeconomics**. In most of these theories it is claimed that the individuals act rational. That means like a *homo economicus*. This economic man is the portrayal of humans as agents who are consistently rational, narrowly self-interested, and who pursue their subjectively-defined ends optimally.

### Exercise 18.4 — Should Lisa be worried?

(Solution → p. 240)

Answer the following question. Therefore, please go online and type in your answer

<https://pingo.coactum.de/>

Lisa is thirty-three and is pregnant for the first time. She is worried about birth defects such as Down syndrome. Her doctor tells her that she need not worry too much because there is only a 1 in 1,000 chance that a woman of her age will have a baby with Down syndrome. Nevertheless, Lisa remains anxious about this possibility and decides to obtain a test, known as the Triple Screen, that can detect Down syndrome. The test is moderately accurate: When a baby has Down syndrome, the test delivers a positive result 86 percent of the time. There is, however, a small 'false positive' rate: 5 percent of babies produce a positive result despite not having Down syndrome. Lisa takes the Triple Screen and obtains a positive result for Down syndrome. Given

this test result, what are the chances that her baby has Down syndrome?

- a) 0-20 percent chance
- b) 21-40 percent chance
- c) 41-60 percent chance
- d) 61-80 percent chance
- e) 81-100 percent chance

### Solution to Exercise 18.4 — Should Lisa be worried?

(Exercise → p. 239)

At the beginning of the Inferential Statistics course at summer 2020, I also asked student this question. Here are the results of the 16 students who participated:

Option	Frequency of answers	Percentage
a)	3	19%
b)	2	13%
c)	2	13%
d)	3	19%
e)	6	38%

How did they reach their answers? Like most people, they decided that Lisa has a substantial chance of having a baby with Down syndrome. The test gets it right 86 percent of the time, right? That sounds rather reliable, doesn't it? Well it does, but we should not rely on our feelings here and better do the math because the correct result would be that there is **just a 1.7 percent chance of the baby having a Down syndrome**.

Now, let us proof the result that there is just a 1.7 percent chance of the baby having a Down syndrome using Bayesian Arithmetic.

► Watch the two videos linked here:

- Bayes theorem <https://youtu.be/HZCCoVF3YvM> and
- The quick proof of Bayes' theorem [https://youtu.be/U\\_85TaXbeIo](https://youtu.be/U_85TaXbeIo)

Also, consider this interactive tool: <https://www.skobelevs.ie/BayesTheorem/>

**Solution:** <sup>a</sup> Let A be the event of the Baby has a Down syndrom and B the test is positive. Then,

$$\begin{aligned}P(A) &= 0.001 \\P(B | A) &= 0.86 \\P(B | \neg A) &= 0.05 \\P(B) &= \frac{999 \cdot 0.05}{1000} + \frac{1 \cdot 0.86}{1000} = \frac{50.81}{1000} = 0.05081 \\P(A | B) &= \frac{P(B | A)P(A)}{P(B)} = \frac{0.86 \cdot 0.001}{0.05081} = 0.016925802\end{aligned}$$

<sup>a</sup>See the Appendix ?? for more information on probability theory and Bayes Theorem.

### 18.4.3 Common biases in decision making

The goal of the chapter is to help you unfreeze your decision-making patterns by showing you how easily heuristics become biases when improperly applied. Once you are able to spot these biases, you will be able to improve the quality of your decisions.

#### Heuristics

The **availability heuristic/bias** is a mental shortcut that relies on immediate examples that come to a given person's mind when evaluating a specific topic, concept, method or decision. The availability

heuristic operates on the notion that if something can be recalled, it must be important, or at least more important than alternative solutions which are not as readily recalled. Subsequently, under the availability heuristic, people tend to heavily weigh their judgments toward more recent information, making new opinions biased toward that latest news.

The **representativeness heuristic/bias** is used when making judgments about the probability of an event under uncertainty. That means, when making a judgement about an individual, for example, people tend to look for traits that an individual may have that correspond with previously formed stereotypes.

The **affect heuristic/bias** is a mental shortcut that allows people to make decisions and solve problems quickly and efficiently, in which current emotion—fear, pleasure, surprise, etc. influences decisions. In other words, it is a type of heuristic in which emotional response, or *affect* in psychological terms, plays a lead role. It is a subconscious process that shortens the decision-making process and allows people to function without having to complete an extensive search for information. It is shorter in duration than a mood, occurring rapidly and involuntarily in response to a stimulus. Reading the words "lung cancer" usually generates an affect of dread, while reading the words "mother's love" usually generates a feeling of affection and comfort. The affect heuristic is typically used while judging the risks and benefits of something, depending on the positive or negative feelings that people associate with a stimulus. It is the equivalent of *going with your gut*.

The **confirmation heuristic/bias** is the tendency to search for, interpret, favor, and recall information in a way that confirms or supports one's prior beliefs or values. People tend to unconsciously select information that supports their views, but ignoring non-supportive information. People also tend to interpret ambiguous evidence as supporting their existing position. The effect is strongest for desired outcomes, for emotionally charged issues, and for deeply entrenched beliefs.

### Exercise 18.5 — Heuristics can fail

(Solution → p. 244)

💡 Respond to the following problems which are taken from [Bazerman and Moore \(2009](#), p. 15f). In class, we will discuss your answers and how it matches with the mathematically correct solutions to these problems.

▶ After having answered the 12 questions, please watch this video: [https://youtu.be/wEwGBIr\\_RIw](https://youtu.be/wEwGBIr_RIw)

**Problem 1** Please rank order the following causes of death in the United States between 1990 and 2000, placing a 1 next to the most common cause, 2 next to the second most common, etc.

- Tobacco
- Poor diet and physical inactivity
- Motor vehicle accidents
- Firearms (guns)
- Illicit drug use

Now estimate the number of deaths caused by each of these five causes between 1990 and 2000.

**Problem 2** Estimate the percentage of words in the English language that begin with the letter "a."

**Problem 3** Estimate the percentage of words in the English language that have the letter "a" as their third letter.

**Problem 4** Lisa is thirty-three and is pregnant for the first time. She is worried about birth defects such as Down syndrome. Her doctor tells her that she need not worry too much because there is only a 1 in 1,000 chance that a woman of her age will have a baby with Down syndrome. Nevertheless, Lisa remains anxious about this possibility and decides to obtain a test, known as the Triple Screen, that can detect Down syndrome. The test is moderately accurate: When a

baby has Down syndrome, the test delivers a positive result 86 percent of the time. There is, however, a small "false positive" rate: 5 percent of babies produce a positive result despite not having Down syndrome. Lisa takes the Triple Screen and obtains a positive result for Down syndrome. Given this test result, what are the chances that her baby has Down syndrome?

- a) 0-20 percent chance
- b) 21-40 percent chance
- c) 41-60 percent chance
- d) 61-80 percent chance
- e) 81-100 percent chance

**Problem 5** A certain town is served by two hospitals. In the larger hospital, about forty-five babies are born each day. In the smaller hospital, about fifteen babies are born each day. As you know, about 50 percent of all babies are boys. However, the exact percentage of boys born varies from day to day. Sometimes it may be higher than 50 percent, sometimes lower. For a period of one year, each hospital recorded the days on which more than 60 percent of the babies born were boys. Which hospital do you think recorded more such days?

- a) The larger hospital
- b) The smaller hospital
- c) About the same (that is, within 5 percent of each other)

**Problem 6** You and your spouse have had three children together, all of them girls. Now that you are expecting your fourth child, you wonder whether the odds favor having a boy this time. What is the best estimate of your probability of having another girl?

- a) 6.25 percent (1 in 16), because the odds of getting four girls in a row is 1 out of 16
- b) 50 percent (1 in 2), because there is roughly an equal chance of getting each gender
- c) A percentage that falls somewhere between these two estimates (6.25-50 percent)

**Problem 7** You are the manager of a Major League Baseball team, and the 2005 season has just ended. One of your most important jobs is to predict players' future performance. Currently, your primary interest lies in predicting batting averages for nine particular players. A measure of a player's performance, batting averages range from 0 to 1. Larger numbers reflect better batting performance. You know the nine players' 2005 batting averages, and must estimate each one's 2006 batting average. Please fill in your guesses in the right-hand column.

Player	2005	Estimated 2006 Batting Average
1	.215	
2	.242	
3	.244	
4	.258	
5	.261	
6	.274	
7	.276	
8	.283	
9	.305	

**Problem 8** Linda is thirty-one years old, single, outspoken, and very smart. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and she participated in antinuclear demonstrations. Rank the following eight descriptions in order of the probability (likelihood) that they describe Linda:

- a) Linda is a teacher in an elementary school.
- b) Linda works in a bookstore and takes yoga classes.
- c) Linda is active in the feminist movement.
- d) Linda is a psychiatric social worker.

- e) Linda is a member of the League of Women Voters.
- f) Linda is a bank teller.
- g) Linda is an insurance salesperson.
- h) Linda is a bank teller who is active in the feminist movement.

**Problem 9** Take the last three digits of your phone number. Add the number one to the front of the string, so that now you have four digits. Think of that number as a year. Now try to estimate the year that the Taj Mahal was completed. Was it before or after the date made by your phone number?

\_\_\_\_\_ Before \_\_\_\_\_ After

On the line below, please make your best estimate of the actual year in which the Taj Mahal was completed: \_\_\_\_\_

**Problem 10** Which of the following instances appears most likely? Which appears second most likely?

- a) Drawing a red marble from a bag containing 50 percent red marbles and 50 percent white marbles.
- b) Drawing a red marble seven times in succession, with replacement (i.e., a selected marble is put back into the bag before the next marble is selected), from a bag containing 90 percent red marbles and 10 percent white marbles.
- c) Drawing at least one red marble in seven tries, with replacement, from a bag containing 10 percent red marbles and 90 percent white marbles.

**Problem 11** Ten uncertain quantities are listed below. Do not look up any information about these items. For each, write down your best estimate of the quantity. Next, put a lower and upper bound around your estimate, so that you are confident that your 98 percent range surrounds the actual quantity.

Estimate    Lower    Upper

- |       |       |       |  |
|-------|-------|-------|--|
| _____ | _____ | _____ | a. Wal-Mart's 2006 revenue   |
| _____ | _____ | _____ | b. Microsoft's 2006 revenue  |
| _____ | _____ | _____ | c. World population as of July 2007  |
| _____ | _____ | _____ | d. Market capitalization (price per share times number of shares outstanding) of Best Buy as of July 6, 2007 |
| _____ | _____ | _____ | e. Market capitalization of Heinz as of July 6, 2007   |
| _____ | _____ | _____ | f. Rank of McDonald's in the 2006 Fortune 500  |
| _____ | _____ | _____ | g. Rank of Nike in the 2006 Fortune 500  |
| _____ | _____ | _____ | h. Number of fatalities due to motor vehicle accidents in the United States in 2005                          |
| _____ | _____ | _____ | i. The national debt of the U.S. federal government as of July 2007  |
| _____ | _____ | _____ | j. The U.S. federal government budget for the 2008 fiscal year   |

**Problem 12** If you had to describe the relationship between baseball players' batting averages in one season and their batting averages in the subsequent season, which of the following four descriptions would you pick?

1. **Zero correlation:** Performance is entirely unpredictable, in the sense that knowing how well a player hits one year does not help you predict how well he is going to hit the next year.
2. **Weak correlation of about .4:** Performance from one season to the next is moderately predictable, but there are also a lot of random, unpredictable influences on how well a particular player hits in a particular season.
3. **Strong correlation of about .7:** Performance is quite predictable from one season to the next, but there is a small random component in how well a player hits.
4. **Perfect correlation of 1.0:** Performance is stable from one year to the next. The player with the highest batting average in one season always has the highest batting average the next season.

Read *Bazerman and Moore (2009, p. 6-41)* for answers to the question/assignment above. In class, we will discuss the problems in decision making when using heuristics in further detail.

**Problem 1** According to (*Mokdad et al., 2004, p. 1240*) the answer is the following order:

- Tobacco
- Poor diet and physical inactivity
- Motor vehicle accidents
- Firearms (guns)
- Illicit drug use

**Problem 2 and 3** Most people estimate that there are more words beginning with ‘a’ than words in which ‘a’ is the third letter. In fact, the latter are more numerous than the former. Words beginning with ‘a’ constitute roughly 6 percent of English words , whereas words with ‘a’ as the third letter make up more than 9 percent of English words.

**Problem 4** Most people think that Lisa has a substantial chance of having a baby with Down syndrome. The test gets it right 86 percent of the time, right? That sounds rather reliable, doesn’t it? Well it does, but we should not rely on our feelings here and better do the math because the correct result would be that there is just a 1.7 percent chance of the baby having a Down syndrome. Here is the proof for that small number:

Let  $A$  be the event of the Baby has a Down syndrome and  $B$  the test is positive. Then,

$$\begin{aligned} P(A) &= 0.001 \\ P(B | A) &= 0.86 \\ P(B | \neg A) &= 0.05 \\ P(B) &= \frac{999 \cdot 0.05}{1000} + \frac{1 \cdot 0.86}{1000} = \frac{50.81}{1000} = 0.05081 \\ P(A | B) &= \frac{P(B | A)P(A)}{P(B)} = \frac{0.86 \cdot 0.001}{0.05081} = 0.016925802 \end{aligned}$$

**Problem 5** Most individuals choose  $C$ , expecting the two hospitals to record a similar number of days on which 60 percent or more of the babies born are boys. People seem to have some basic idea of how unusual it is to have 60 percent of a random event occurring in a specific direction. However, statistics tells us that we are much more likely to observe 60 percent of male babies in a smaller sample than in a larger sample. This effect is easy to understand. Think about which is more likely: getting more than 60 percent heads in three flips of a coin or getting more than 60 percent heads in 3,000 flips of a coin. Half of the time, three flips will produce more than 60 percent heads. However, ten flips will only produce more than 60 percent heads about 17 percent of the time. Three thousand flips will produce more than 60 percent heads only .000001 percent of the time (odds of one in a million). However, most people judge the probability to be the same in each hospital, effectively ignoring sample size. Although the importance of sample size is fundamental in statistics, Tversky and Kahneman (1974) argue that sample size is rarely a part of our intuition.

**Problem 6** Most individuals have a strong intuitive sense that the probability of having four girls in a row is unlikely; thus, they assume that the probability of having another girl in this instance ought to be lower than 50 percent. The problem with this reasoning is that the gender determination of each new baby is a chance event; the sperm that determines the baby’s gender does not know how many other girls the couple has.

**Problem 7** Most people who respond to Problem 7 predict that a player’s 2006 performance will be almost identical to his 2005 performance. In fact, statistics show that the correlation between Major League Baseball players’ batting averages from one year to the next is only .4. The correlation from 2005 to 2006 among these nine players is roughly the same as in the league overall (.39). You will note that exceptional performances tend to regress to the mean—the worst performances improve and the best performances decline from one year to the next.

**Problem 8** Examine your rank orderings of descriptions C, F, and H. Most people rank order C as more likely than Hand Has more likely than F. Their rationale for this ordering is that C-H-F reflects the degree to which the descriptions are representative of the short profile of Linda. Linda's profile was constructed by Tversky and Kahneman to be representative of an active feminist and unrepresentative of a bank teller. One of the simplest and most fundamental laws of probability is that a subset (for example, being a bank teller and a feminist) cannot be more likely than a larger set that completely includes the subset (for example, being a bank teller). In other words, a conjunction (a combination of two or more descriptors) cannot be more probable than any one of its descriptors; all feminist bank tellers are also bank tellers.

**Problem 9** Most people who answer this question are influenced by this obviously irrelevant information. Reconsider how you would have responded if your phone number resulted in the year 1978 or the year 1040. On average, individuals whose final three digits are high give more recent estimates for the Taj Mahal's completion than do individuals with lower phone numbers. In fact, the Taj Mahal was completed in 1648 in Agra, India, after fifteen years of construction.

**Problem 10** The most common ordering of preferences is B-A-C. Interestingly, the correct order of likelihood is C (52 percent), A (50 percent), and B (48 percent)—the exact opposite of the most common intuitive pattern! This result illustrates a general bias to overestimate the probability of conjunctive events, or events that must occur in conjunction with one another (Bar-Hillel, 1973), and to underestimate the probability of disjunctive events, or events that occur independently (Tversky & Kahneman, 1974). Thus, when multiple events all need to occur (choice B), we overestimate the true likelihood of this happening, while if only one of many events needs to occur (choice C) we underestimate the true likelihood of this event.

**Problem 11** Let's look at the correct answers : (a) \$351, 3 ,000,000 (\$351 billion); (b) \$44,282,000,000 (\$44 billion); (c) 6,602,224,175 people (6.6 billion); (d) \$23,150,000,000 (\$23 billion); (e) \$15,230,000,000 (\$15 billion); (f) 108; (g) 158; (h) 43,443; (i) \$8,800,000,000,000 (\$8.8 trillion) (j) \$2 900 000 000 000 (\$2.9 trillion).

Most people surround only between three (30 percent) and seven (70 percent), despite claiming a 98 percent confidence that each range will surround the true value. Why? Most of us are overconfident in the precision of our beliefs and do not acknowledge our true uncertainty.

**Problem 12** True is a correlation of about .4.

#### 18.4.4 The rational model of decision making

The most popular model of decision making is the rational model. It basically consists of a logical sequence of steps. One example is the following one (see Fitzgerald, 2002, p. 13):

1. **Clearly identify the problem.** A *problem* may be defined as a perceived gap between the current and desired reality, hence *gap analysis* as a standard approach to problem identification.
2. **Generate potential solutions.** For routine decisions, various alternatives may be fairly easily identified through pre-specified decision rules, but non-routine decisions require a creative process to come up with novel alternatives.
3. Using appropriate analytic approaches, choose a solution from among the available alternatives, preferably the one with the greatest expected value. In decision theory this is called **maximizing the expected utility of the results**.
4. **Implement the solution.** Managers frequently undermine implementation by not ensuring that those responsible for the implementation fully understand and accept what they need to do, and that they have the motivation and resources needed to do it successfully.
5. **Evaluate the effectiveness of the implemented decision.**

While these rational models may be helpful, they can be criticized in various ways. In particular, it is believed that managers actually optimize their decision-making behaviors based on rationality because

they deliberately choosing and implementing the best alternatives. It is an belief because any rational optimization is based on a host of dubious assumptions. For example (see Fitzgerald, 2002, p. 13):

- it is possible to know in advance all of the possible alternative solutions and the specific results that will flow from each of them;
- there is in fact an optimal solution, and that solution is included among the alternatives that have been identified;
- it is possible to accurately, numerically weight the various alternatives, the probabilities of their outcomes, and the relative desirability of those alternatives and outcomes;
- decision-makers always act rationally, and therefore decision making is free of emotion, prejudice, and politics; and
- business decisions are entirely driven by the desire to maximize profits.

The **rational model can be considered as normative** because it strictly sets forth a logical sequence of steps to be followed in every decision situation. The rational models are based on the **believe** that under a given set of circumstances **human behavior is logical** and therefore predictable. This in not necessarily what is actually happening in the real world. Think, for example, on the insights within the field of behavioral economics that clearly show that the *homo economicus* is let's say a concept that is weak in several aspects.

In 1978, decision theorist Herbert A. Simon (1916-2001) won the Nobel Prize in economics for his theories on *bounded rationality*. The theory proposes that decision making is constrained by managers' ability to process information, i.e., the rationally is *bounded*. Managers use shortcuts and rules of thumb which are based on their prior experience with similar problems and scenarios. Given the constraints of managers in their position, they do not actually *optimize* their choice given the available information. It is more like finding a *satisfactory* solution, not necessarily the *best* of *optimal* solution.

#### 18.4.5 System 1 and System 2 thinking

I recommend to watch

► <https://youtu.be/PirFrDVRBo4> — Daniel Kahneman: Thinking Fast vs. Thinking Slow | Inc. Magazine

Do people actually reason in the logical manner? Well, in some cases maybe. David Kahnemann<sup>2</sup> popularized the modes of System 1 and System 2 thinking.

**System 1** thinking refers to our intuitive system, which is typically fast, automatic, effortless, implicit, and emotional. We make most decisions in life using this mode of thinking. For instance, we usually decide how to interpret verbal language or visual information automatically and unconsciously.

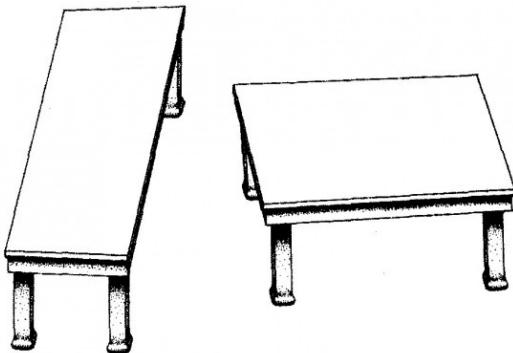
By contrast, **System 2** refers to reasoning that is slower, conscious, effortful, explicit, and logical. In most situations, our System 1 thinking is quite sufficient; it would be impractical, for example, to logically reason through every choice we make while shopping for product of our daily life. But System 2 logic should preferably influence our most important decisions. The busier and more rushed people are, the more they have on their minds, and the more likely they are to rely on System 1 thinking. In fact, the pace of managerial life suggests that executives often rely on System 1 thinking. Although a complete System 2 process is not required for every managerial decision, a key goal for managers should be to identify situations in which they should move from the intuitively compelling System 1 thinking to the more logical System 2.

#### Exercise 18.6 — Shepard tabletop illusion

(Solution → p. ??)

Which table is larger and which one looks more than a squared table. Proof your decision and watch this: [https://youtu.be/\\_EqGqEp0V3o](https://youtu.be/_EqGqEp0V3o)

<sup>2</sup>Well known for his book *Thinking, Fast and Slow* in which he summarizes his work for a broader audience.



### Exercise 18.7 — Kahnemann's examples

(Solution → p. ??)

Kahneman describes the two different ways the brain forms thoughts in the first section of his book as follows: **System 1:** Fast, automatic, frequent, emotional, stereotypic, unconscious. **System 2:** Slow, effortful, infrequent, logical, calculating, conscious. In the following, you find a list of things system 1 and system 2 can do. How do you do these things. Do you use more of system 1 thinking or system 2 thinking. Mark each number with a 1 and a 2 correspondingly.

1. determine that an object is at a greater distance than another
2. localize the source of a specific sound
3. complete the phrase "war and ..."
4. display disgust when seeing a gruesome image
5. solve  $2+2=?$
6. read text on a billboard
7. drive a car on an empty road
8. come up with a good chess move (if you're a chess master)
9. understand simple sentences
10. connect the description 'quiet and structured person with an eye for details' to a specific job
11. brace yourself before the start of a sprint
12. direct your attention towards the clowns at the circus
13. direct your attention towards someone at a loud party
14. look out for the woman with the gray hair
15. dig into your memory to recognize a sound
16. sustain a higher than normal walking rate
17. determine the appropriateness of a particular behavior in a social setting
18. count the number of A's in a certain text
19. give someone your phone number
20. park into a tight parking space
21. determine the price/quality ratio of two washing machines
22. determine the validity of a complex logical reasoning
23. solve  $17 \times 24$

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