Productivity, Output, and Employment

ECON202 Macroeconomics – UG-I, 2025: Semester III

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Sections Covered

§	Topic
3-1	The Production Function
3-2	The Demand for Labor
3-3	The Supply of Labor
3-4	Labor Market Equilibrium
3-5	Unemployment
3-6	Okun's Law

Learning Objectives

1. Discuss production function properties and changes
2. Discuss factors that affect the demand for labor
3. Discuss the factors that affect the supply of labor
4. Identify factors that affect labor market equilibrium
5. Explain how the unemployment rate is measured and describe changes in employment status
6. Explain the significance of Okun's law

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The Production Function - Introduction

- **Factors of production**
  - Capital (K)
  - Labor (N)
  - Others (raw materials, land, energy)
  - Productivity of factors depends on technology and management
- **General form**

$$Y = AF(K, N) \quad (3.1)$$

- Parameter A is **total factor productivity** – the effectiveness with which capital and labor are used

The Production Function - Cobb–Douglas Form

- **Cobb–Douglas specification**

$$Y = AK^{\alpha}N^{\beta} \quad (3.2)$$

  - α, β: output elasticities of capital and labor
- TFP cannot be measured directly, but it can be measured indirectly, as a residual. Also known as the **Solow residual**

Constant Returns to Scale & Production Elasticities

- **Constant Returns to Scale:** When $\alpha + \beta = 1$
  - If you double all inputs, output exactly doubles
  - Foundation of neoclassical growth theory
- **Production Elasticities:**
  - α = elasticity of output with respect to capital
  - β = elasticity of output with respect to labor

Income Shares: The Dual Interpretation

- In competitive markets, factors are paid their marginal products
  - Wage rate = Marginal product of labor (MPN)
  - Rental rate = Marginal product of capital (MPK)
- **Income Shares:**
  - Labor's share of total income = β
  - Capital's share of total income = α
  - Total shares: $\alpha + \beta = 1$
- **Amazing Result:** Production elasticities = Income shares!

The Production Function - EU Economy Application

Cobb-Douglas production function works well for EU economy:

$$Y = A \cdot K^{0.33} \cdot N^{0.67}$$

TABLE 3.1

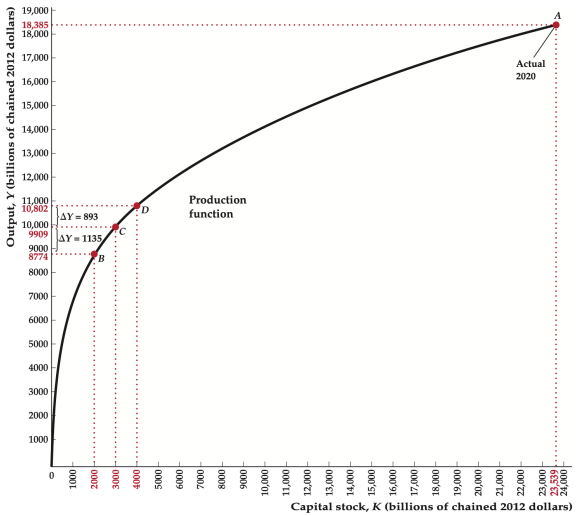
The Production Function of the EU-28, 2005–2014

Year	(1) Real GDP (Y) in 2010 prices Million EUR	(2) Real Capital Stock (K) in 2010 prices Million EUR	(3) Labor, N (millions of workers)	(4) $A = Y/(K^{0.33}N^{0.67})$	(5) Growth in A (% change in A)
2005	12,230	2660	208	25.35	—
2006	12,647	2848	212	25.32	0.12%
2007	13,037	3031	216	25.55	0.91%
2008	13,103	2980	218	25.36	−0.74%
2009	12,527	2478	214	26.1	2.92%
2010	12,789	2613	212	26.33	0.88%
2011	13,011	2696	212	26.51	0.68%
2012	12,943	2539	211	26.99	1.8%
2013	12,956	2513	210	27.19	0.74%
2014	13,127	2576	213	27.08	−0.40%

Source: Real GDP, capital stock, and labor force figures are from the Eurostat Database website, *http://ec.europa.eu/eurostat/data/database.*

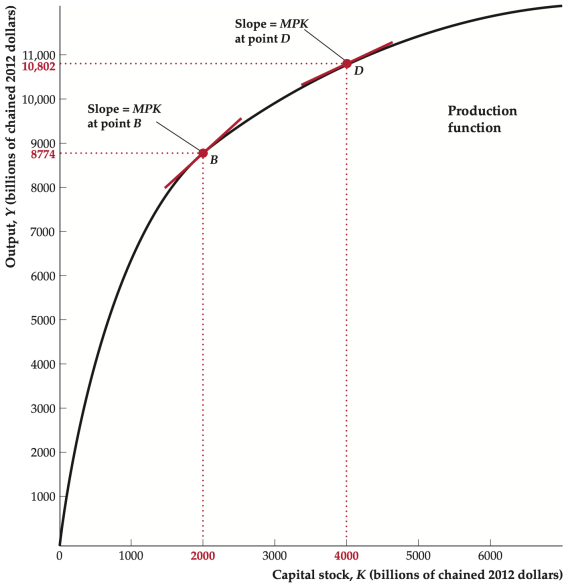
Figure 1: The Production Function of the EU, 2005–2014

The Properties of the Production Function



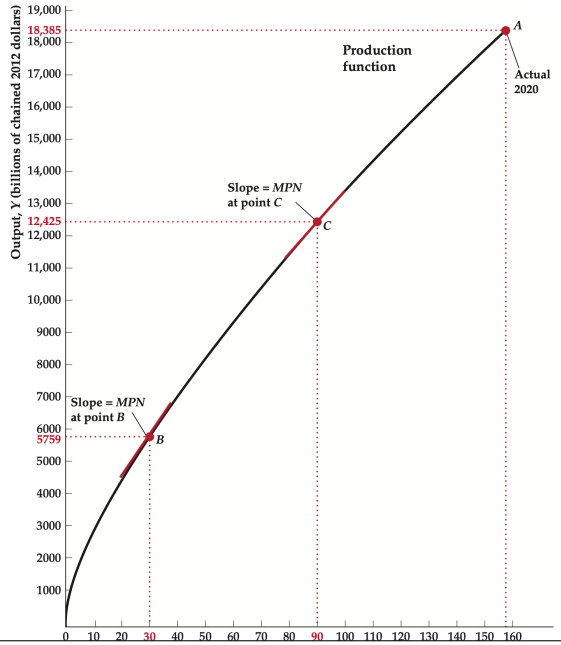
- Slopes upward: more of any input produces more output
- Slope becomes flatter as input rises: diminishing marginal product as input increases

Marginal Product of Capital: $MPK = \Delta Y / \Delta K$



- Equal to slope of production function graph (Y vs K)
- MPK always positive
- Diminishing marginal productivity of capital

Marginal Product of Labor: $MPN = \Delta Y / \Delta N$



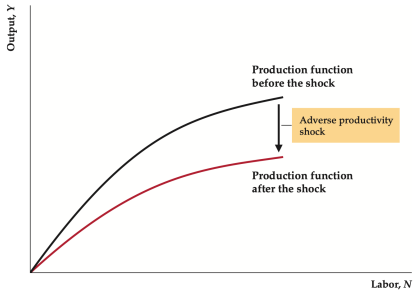
- Equal to slope of production function graph (Y vs N)
- MPN always positive
- Diminishing marginal productivity of labor

Supply Shocks

Productivity shock = a change in an economy's production function

- Supply shocks affect the amount of output that can be produced for a given amount of inputs
- Shocks may be positive (increasing output) or negative (decreasing output)
- Examples: weather, inventions and innovations, government regulations, oil prices

An Adverse Supply Shock that Lowers the MPN



- Negative (adverse) shock: Usually slope of production function decreases at each level of input
- Positive shock: Usually slope of production function increases at each level of input (e.g., if parameter **A** increases)

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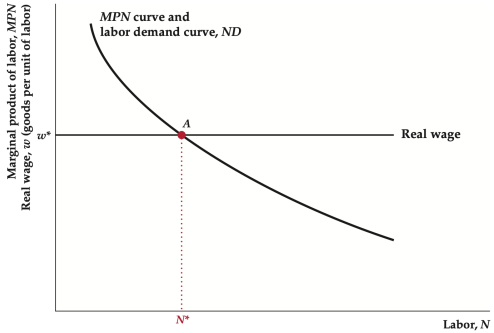
The Demand for Labor - Assumptions

- How much labor do firms want to use?
  - Hold capital stock fixed–short-run analysis
  - Workers are all alike
  - Labor market is competitive
  - Firms maximize profits

Marginal Analysis for Labor Demand

Analysis at the margin: costs and benefits of hiring one extra worker



The Clip Joint Example

- Setting the nominal wage (W) equal to the marginal revenue product of labor

$$W = MRPN = P \times MPN \quad (3.3)$$

- $W = MRPN$ is the same condition as $w = MPN$, since
  - $W = P \times w$ and
  - $MRPN = P \times MPN$

The Clip Joint's Production Function, W = $240/Day.

Workers, N	Dogs groomed, Y	Marginal product, MPN	$MRPN = MPN \times P$ ($P = \$30$)
0	0	–	–
1	11	11	$330
2	20	9	$270
3	27	7	$210
4	32	5	$150
5	35	3	$90
6	36	1	$30

The MP of Labor and Labor Demand: Example

A change in the wage

- Begin at equilibrium where W = MRPN
- A rise in the wage rate means W > MRPN, unless N is reduced so the MRPN rises
- A decline in the wage rate means W < MRPN, unless N rises so the MRPN falls

Labor Demand Curve Properties

The marginal product of labor and the labor demand curve

- Labor demand curve shows relationship between the real wage rate and the quantity of labor demanded
- It is the same as the MPN curve, since $w = MPN$ at equilibrium
- So the labor demand curve is downward sloping; firms want to hire less labor, the higher the real wage

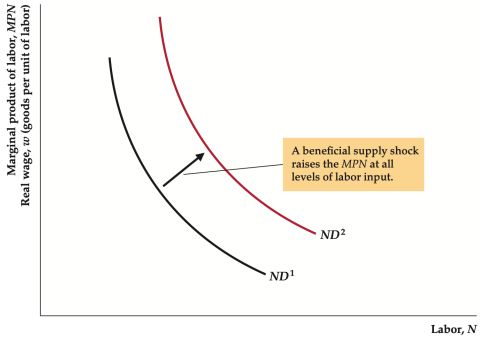
Factors That Shift Labor Demand -1

- A change in the wage causes a movement along the labor demand curve, not a shift of the curve
- Supply shocks: a beneficial shock raises MPN ⍰ labor demand shifts right (adverse shifts left)
- Capital stock: more capital raises MPN ⍰ labor demand shifts right (less capital shifts left)

Production Function after a +ve Productivity Shock

Workers, N	Dogs groomed, Y	Marginal product, MPN	$MRPN = MPN \times P$ ($P = \$30$)
0	0	–	–
1	22	22	\$660
2	40	18	\$540
3	54	14	\$420
4	64	10	\$300
5	70	6	\$180
6	72	2	\$60

The Effect of a +ve Supply Shock on Labor Demand



Aggregate Labor Demand

- Aggregate labor demand is the sum of all firms' labor demand
- Same factors (supply shocks, size of capital stock) that shift firms' labor demand cause shifts in aggregate labor demand

Factors That Shift Labor Demand -2

An increase in	Causes the labor demand curve to shift	Reason
Productivity	Right	Beneficial supply shock increases MPN and shifts MPN curve up and to the right.
Capital stock	Right	Higher capital stock increases MPN and shifts MPN curve up and to the right.

Labor Supply Overview

- Supply of labor is determined by individuals
- Aggregate supply of labor is the sum of individuals' labor supply
- Labor supply of individuals depends on labor-leisure choice

Lunch atop a Skyscraper in New York: 20, 1932

The Income-Leisure Trade-off

- Utility depends on consumption and leisure
- Need to compare costs and benefits of working another day
  - Costs: Loss of leisure time
  - Benefits: More consumption, since income is higher
- If benefits of working another day > costs, work another day
- Keep working additional days until benefits = costs

Income and Substitution Effects

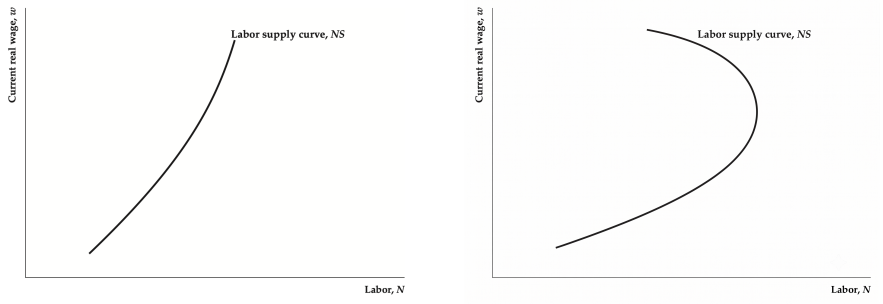
An increase in the real wage has offsetting income and substitution effects

- Substitution effect: a higher wage raises the reward for working ⇒ work more
- Income effect: a higher wage makes you richer at the same hours ⇒ afford more leisure, work less

Pure Effects

- A pure substitution effect: a one-day rise in the real wage
  - A temporary real wage increase has just a pure substitution effect, since the effect on wealth is negligible
- A pure income effect: winning the lottery
  - Winning the lottery doesn't have a substitution effect, because it doesn't affect the reward for working
  - But winning the lottery makes a person wealthier, so a person will both consume more goods and take more leisure; this is a pure income effect

The Labor Supply Curve of an Individual Worker



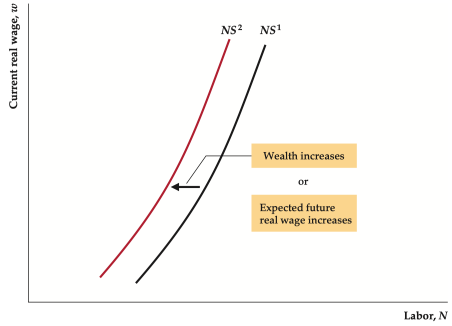
Empirical Evidence: On Real Wages and Labor Supply

- Overall result: Labor supply increases with a temporary rise in the real wage
- Labor supply falls with a permanent increase in the real wage

Factors That Shift Labor Supply

- Wealth: more wealth reduces labor supply ⍰ curve shifts left
- Expected future real wage: a higher expected wage acts like more wealth ⍰ curve shifts left

The Effect on Labor Supply of an Increase in Wealth



Why Does the Aggregate Labor Supply Curve Slope Upward?

Aggregate labor supply rises when current real wage rises

- Some people work more hours. Intensive Margin
- Other people enter labor force Extensive Margin

How elastic is the LS? Imp. Macro Question: (Keane & Rogerson, 2012)

Factors Increasing Labor Supply

- Decrease in wealth
- Decrease in expected future real wage
- Increase in working-age population (higher birth rate, immigration)
- Increase in labor force participation (increased female labor participation, elimination of mandatory retirement)

Why LS Matters for Macroeconomics

(Rogerson, 2024) suggest an important role for labor supply in affecting macroeconomic outcomes

- Large differences in hours of work across OECD[1] economies imply large differences in GDP per capita
- Large differences in the size of tax and transfer programs across countries (proxied by government revenues relative to GDP)
- These two outcomes are strongly negatively correlated

[1] Organisation for Economic Co-operation and Development

Recent Labor Supply Trends

- Participation has fallen since 2010 as baby boomers retire
- Prime-age (25–54) participation is down too, even for women
- The 2020 pandemic recession pushed participation lower still
- Causes: post-recession discouragement, more disability, the opioid crisis, weak family benefits

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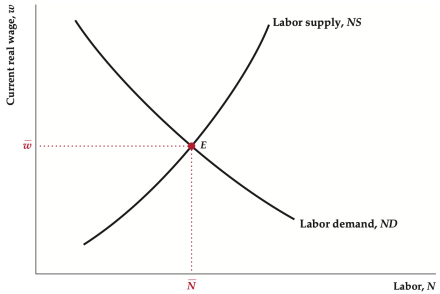
Labor Market Equilibrium

- Classical model of the labor market–real wage adjusts quickly
- Pins down full-employment employment and the market-clearing real wage
- Problem with classical model: can't study unemployment



Full-Employment Output

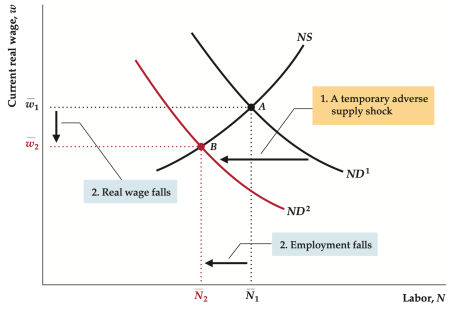
- Full-employment output = potential output = level of output when labor market is in equilibrium

$$\bar{Y} = AF(K, \bar{N}) \quad (3.4)$$

- Affected by changes in full employment level or production function (example: supply shock)

LM Effects of a Temporary Adverse Supply Shock

Temporary Adverse Supply Shock?



Relative Price of Energy, 1960–2021