Foreign Exchange (FX) Markets
Definition, Functions and Features

- Definition: A market where national currencies are bought and sold

Transfers purchasing power from one currency to another and allows for international transactions.
Facilitates hedging against currency shocks.
Largest market in the world in terms of trade volume (over $5 trillion daily in spot, forward and swaps).
24 hours trading and no trading limit.
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- Foreign Direct Investment (FDI). Example: US definition: Foreign Direct Investment is defined as whenever a US citizen, organization, or affiliated group takes an interest of 10 percent or more in a foreign business entity. It includes setting up a business, buying an office block etc.
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"Foreign" in this context means foreign national or entity established in another country. Ex: Garanti Bank International is a foreign firm.
Types of FX Rate

- Bilateral: Between two countries
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Effective or trade-weighted (Multilateral): Weighted by the proportion of each country’s trade volume in total trade volume. TCMB reports two types of Real Effective FX rate (vs. Developed and vs. Developing Countries)
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- Buying vs. Selling (Bid vs. Ask). Spread = Bid - Ask > 0. Spread increases during weekends, holidays, turbulent times.
Definitions:

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Total excess demand/supply eliminated instantaneously by exchange rate movement
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- Speculators buy or sell TL (sell or buy $)

Total excess demand/supply eliminated instantaneously by exchange rate movement
Equilibrium in FX Market: UK Example

Copeland Ch 1.
Appreciation and Depreciation

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Appreciation and Depreciation

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Exception: Real Effective Exchange Rates reported by TCMB
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Some Exchange Rate Regimes

1. **Pure float (Flexible Float):** exchange rate at any moment determined by net demand for currency.
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Open Economy Macroeconomics

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3. **Managed Float (Dirty Float):** CB intervenes at its discretion.
Exchange Rate Regimes

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- Full Dollarization
Pure Float

Copeland Ch 1.
Balance of Payments (BOP)

Definition

All transactions between Turkey and the rest of the world (ROW) in a given year. It serves as flow of demand and supply for TL.

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- Change in Official Reserves: \( \Delta CB FX \) reserves

- Balancing Item: Current Account + Capital Account = -Balancing Item

visit http://tcmb.gov.tr/odemedenge/odmain.html for Turkish practice.

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Relationship Between BOP and FX rate regime

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  Total net underlying demand for TL = CRA surplus + CPA surplus
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- Under fixed rates:
  Government intervenes to fix exchange rate, in which case. Item for 4 in CPA: \( \Delta CB \text{ FX reserves} = \text{CRA} + \text{CPA} \) to prevent basic balance causing exchange rate to move
Prior to 1939: Gold Standard. Change in money supply = Change in gold reserves. Huge increases in gold reserves after 1890. Period described by high inflation, protectionism and competitive devaluation.
Exchange Rates in 20th Century

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Mechanism of Bretton Woods: Gold Exchange Standard. 1944-68 US $ fixed at 1 oz gold = $35, all other currencies fixed to $ with 1% fluctuation bands, devaluations to correct persistent deficits (Gold Window). Other currencies fixed to dollar. Foundation of IMF to police FX rate system to assure convertibility.

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Increasing importance of Asian exchange rates 2000 onward especially RMB, Won, Rupee (varying degrees of flexibility/convertibility, increasingly linked to $/€/Yen currency basket)
Exchange Rates in Turkey

- 1988 Switch to full convertibility and CB starts managed floating. 5 April 1994. Switch to managed floating with inflation expectations as an anchor.
- Starting from 2000. Target zone with up to 22% bandwidth with inflation target as an anchor.
- Free float with CB intervention compatible with inflation target.
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- Covered Interest Rate Parity
Law of One Price

Definition

The law of one price: Two goods, if they are identical, must sell for the same price.

- Domestic Economy

- Open Economy

\[ P_{I} = P_{P} + S \]

where \( P_{I} \) and \( P_{P} \) are the price of the same good in Istanbul and Paris respectively and \( S \) is the TL/Euro exchange rate.
The law of one price: Two goods, if they are identical, must sell for the same price.

- **Domestic Economy**
  
  The law of one price in the context of domestic economy – the relationship holds if transaction costs are allowed: e.g.,

\[ P_{I} = P_{A} + C \]

where \( P_{I} \) is the price of the same good in Istanbul and \( P_{A} \) is the price of the same good in Ankara respectively and \( C \) is the transaction cost (transportation, local taxes, etc.).

\[ P_{I} = S P_{P} + C \]

where \( P_{I} \) is the price of the same good in Istanbul and \( P_{P} \) is the price of the same good in Paris respectively and \( S \) is the TL/Euro exchange rate.
Definition

The law of one price: Two goods, if they are identical, must sell for the same price.

- Domestic Economy
  - The law of one price in the context of domestic economy – the relationship holds if transaction costs are allowed: e.g.,
  - $P_I = P_A + C$ where $P_I, P_A$ is the price of the same good in Istanbul and Ankara respectively and $C$ is the transaction cost (transportation, local taxes, etc.).
Law of One Price

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- **Open Economy**
  - \( P_I = SP_P + C \) where \( P_I, P_P \) is the price of the same good in Istanbul and Paris respectively and \( S \) is the TL/Euro exchange rate.
PPP and Real Exchange Rate

Definition

The PPP relation is given by $P_i = SP_i^*$ for $i = 1, \ldots, N$ where $P_i$ is the domestic price of good $i$ and $P_i^*$ is the foreign price of good $i$ and $S$ is the exchange rate or $P = SP^*$ where $P$ is domestic price index and $P^*$ is the foreign price index.

Definition

The real exchange rate, $Q$, between two countries is given by $Q = \frac{SP^*}{P}$.

Corollary

*If PPP holds then $Q = 1$.*
PPP and Inflation

**Theorem**

*If PPP holds then the rate of home currency depreciation rate is equal to difference between home and foreign inflation rates.*

**Proof.**

Taking logarithms and derivatives of both sides of \( P = SP^* \)

\[
\log(P) = \log(S) + \log(P^*) \\
dP/P = dS/S + dP^*/P^* \\
\underbrace{dS/S} = \underbrace{dP/P} - \underbrace{dP^*/P^*}
\]

**Depreciation = Inflation - Inflation**

In reality PPP fails most of the time.
PPP and Transaction Costs

Let $K$ be a constant that represents the total costs of conducting international trade including tariffs, etc.

$$P = KS^*$$

$$\log(P) = \log(K) + \log(S) + \log(P^*)$$

**Theorem**

*If trade costs are constant, then they do not affect the currency depreciation rate*

**Proof.**

*Taking the derivative above yields*

$$\frac{dS}{S} = \frac{dP}{P} - \frac{dP^*}{P^*} - \frac{dK}{K}$$

*depreciation = inflation – inflation* – change in trade costs

*but $dK = 0$*
Harrod, Balassa and Samuelson Effect

**Definition**
The observation that consumer price levels in wealthier countries are systematically higher than in poorer ones (the "Penn effect").

**Definition**
An economic model predicting the above, based on the assumption that productivity or productivity growth-rates vary more by country in the traded goods’ sectors than in other sectors (the Balassa–Samuelson hypothesis)

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- Workers in some countries have higher productivity than in others.
- Certain labour-intensive jobs such as those in services are less responsive to productivity innovations than others.
- Some of the fixed-productivity sectors are also the ones producing non-transportable goods (for instance haircuts) - this must be the case or the labour intensive work would have been off-shored.
To equalize local wage levels with the (highly productive) Zurich engineers, McDonalds Zurich employees must be paid more than McDonalds Moscow employees, even though the burger production rate per employee is an international constant.
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The CPI is made up of:

1. Local goods/services (which are expensive relative to tradables in rich countries)
2. Tradables, which have the same price everywhere
3. The (real) exchange rate is pegged (by the law of one price) so that tradable goods follow PPP but not local goods. PPP holds only for tradable goods. Entirely tradable goods cannot vary greatly in price by location (because buyers can source from the lowest cost location). But most services must be delivered locally (e.g. hairdressing) which makes PPP-deviations sustainable.
4. The Penn effect is that PPP-deviations usually occur in the same direction: where incomes are high, average price levels are typically high.
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Goods arbitrage only profitable when price deviation exceeds transactions costs, $C$, so:

$$\text{If price deviation } \frac{P_1 - P_2}{P_2} < C, \text{ no trade.}$$

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But $C$ differs for each trader and each type of good. When price deviation is large (small), arbitrage is (not) profitable for most traders/goods. In general, larger the price deviation, greater volume of arbitrage and more rapid is real exchange rate adjustment.
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Iceberg Model

Does the importer or the exporter pay the shipping cost?

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Combining the above

\[ \frac{P_H}{P_C} = (1 - \tau)^2 \frac{P_H^*}{P_C^*} \]
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Result: Hazelnuts (Brie) are \((1 - \tau)^2\) % expensive relative to Brie (Hazelnuts) in Turkey (France). Price distortions multiply
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Incomplete Pass Through: Exporters and/or importers do not reflect changing costs to prices.
Uncovered Interest Rate Parity (UIRP)

- Assume investors are risk neutral, i.e. they are indifferent between a safe bet and a lottery that offer the same expected return.
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- Let $r^*$ be the foreign interest rate of the same financial instrument with $N$ periods to maturity.

**Definition**

In the absence of hedging opportunities, the relationship between domestic and foreign interest rates are given by

$$(1 + r) = \frac{E_t(S_{t+N})}{S_t}(1 + r^*)$$

where $E_t(S_{t+N})$ is the expected spot exchange rate at $t + N$ as of time $t$. 
Ayşe has 10TL. Let $S_t = 1.6(TL/$), $r = 8\%$, $r^* = 5\%(US)$, $E_t(S_{t+1}) = 1.8$. Should Ayşe invest in Turkey or US?
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Should invest in US
UIRP example (cont’d)

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\frac{E_t(S_{t+N})}{S_t} = \frac{(1+r)}{(1+r^*)}, \text{ subtract 1 from both sides}
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UIRP example (cont’d)

- \( \frac{E_t(S_{t+N})}{S_t} = \frac{(1+r)}{(1+r^*)} \), subtract 1 from both sides
- \( \frac{E_t(S_{t+N}) - S_t}{S_t} = \frac{(1+r)}{(1+r^*)} - 1 = \text{expected depreciation rate} \)
  
  \[ = \Delta S^e \] 
  
  Given \( r^* = 5\% \)
EIRP example (cont’d)

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An increase in \( r \) results in either \( E_t(S_{t+N}) \uparrow \) or \( S_t \downarrow \) or both. If long-run equilibrium is fixed \( E_t(S_{t+N}) \), then only \( S_t \downarrow \).
Find the expected spot rate that leaves Ayse indifferent between investing in US and Turkey.
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- Let \( \frac{E_t(S_{t+N})-S_t}{S_t} = \Delta S^e \)
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- but \( r^* \Delta S^e \approx 0 \) therefore \( r = r^* + \Delta S^e \) \((UIRP\ approximate\ version)\)
In general, agents demand a reward (risk premium) for the risks they take.
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**Definition**

Risk premium is the anticipated excess return agents demand in return for taking the risk. A *risk averter* requires positive risk premium. A *risk neutral* is willing to undertake the risk for zero risk premium. A *risk lover* is willing to pay a premium in order to take the risk.
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- For a *risk neutral* $U(100) = \frac{1}{2} U(150) + \frac{1}{2} U(50)$: linear $U$
- For a *risk averse* $U(100) > \frac{1}{2} U(150) + \frac{1}{2} U(50)$: concave $U$
A forward contract (or a forward) is a non-standardized contract between two parties to buy or sell an asset at a specified future time at a price agreed today. The party agreeing to buy the underlying asset in the future assumes a long position, and the party agreeing to sell the asset in the future assumes a short position. The price agreed upon is called the delivery price, which is equal to the forward price at the time the contract is entered into.
Forward and Futures Contracts

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Definition
A futures contract is a standardized financial contract, in which two parties agree to transact a set of standardized financial instruments or physical commodities for future delivery at a particular price. In futures contracts parties can exchange additional property securing the party at gain (margin call) and the entire unrealized gain or loss builds up while the contract is open.
Futures Example

Ali agrees to sell Ayse $10000 at 1.6TL/$ at T+12

Both Ali and Ayse deposit $1000 (1/10th of the total exchange) with the broker.
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\[ \text{Market Forward Rate and Transactions Timeline} \]

\[ \text{1.65} \]

\[ \text{T} \quad \text{T+1} \quad \text{T+2} \quad \text{T+8} \quad \text{T+12} \]

\[ \text{TL/\$ Spot} \]

\[ \text{1.61} \]

\[ \text{T} \quad \text{T+1} \quad \text{T+2} \quad \text{T+8} \quad \text{T+12} \]

\[ \text{Profit Timeline} \]

Ali’s deposit = $10000 \times (1.65 - 1.60) = $500

Ayse’s deposit = $10000 \times (1.65 - 1.60) = $1500
Futures Example

Ali agrees to sell Ayse $10000 at 1.6TL/$ at T+12

Ali’s deposit = $500 + (1.65 - 1.57) x $10000 = $1300
Ayse’s deposit = $1500 - (1.65 - 1.57) x $10000 = $700
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Ali agrees to sell Ayse $10000 at 1.6TL/$ at T+12

1.67

T T+1 T+2 T+8 T+12

Market Forward Rate and Transactions Timeline

1.66

T T+1 T+2 T+8 T+12

TL/$ Spot

Ali gets the margin call and is required to increase his deposits by $500 to continue

T T+1 T+2 T+8 T+12

Profit Timeline

Ali’s deposit= $1300-(1.67-1.57)x$10000= $300
Ayse’s deposit= $700+(1.67-1.57)$10000= $1700
Futures Example

Ali agrees to sell Ayse $10000 at 1.6TL/$ at T+12

Transaction Closed. Ayse made $400. She can buy at the spot market if she really needs $.

Ali’s deposit= $800 + (1.67 - 1.64) \times 10000 = $1100
Ayse’s deposit= $1700 - (1.67 - 1.64) \times 10000 = $1400
Ali’s profit= $1100 - $1000 - $500 = $400
Ayse’s profit= $1500 - $1000 = $400
Covered Interest Rate Parity

With hedging opportunities, the relationship between domestic and foreign interest rates are given by

\[(1 + r) = \frac{F_t}{S_t}(1 + r^*)\]

where \(F_t\) is the forward rate at \(t + 1\) as of time \(t\). Note that \(F_t = S_t\) at the maturity date.

\[\frac{F_t}{S_t} = \frac{(1+r)}{(1+r^*)}\] , subtract 1 from both sides
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- A forward premium is the proportion by which a country’s forward exchange rate exceeds its spot rate.
- Rewriting \((1 + r) = (1 + r^*)(1 + f)\), \(r^*f \approx 0\)
Covered Interest Rate Parity

With hedging opportunities, the relationship between domestic and foreign interest rates are given by

\[(1 + r) = \frac{F_t}{S_t}(1 + r^*)\]

where \(F_t\) is the forward rate at \(t + 1\) as of time \(t\). Note that \(F_t = S_t\) at the maturity date.

- \(\frac{F_t}{S_t} = \frac{(1+r)}{(1+r^*)}\), subtract 1 from both sides
- \(\frac{F_t - S_t}{S_t} = \frac{(1+r)}{(1+r^*)} - 1 = f = \text{forward premium}\)
- A forward premium is the proportion by which a country’s forward exchange rate exceeds its spot rate.
- Rewriting \((1 + r) = (1 + r^*)(1 + f)\), \(r^* f \approx 0\)
- \(r = r^* + f\) (CIRP approximate version)
Borrowing and Lending

- An investor who has a liability (an asset) denominated is said to have a short (long) position in that currency. The net position is given by the difference between long and short positions. There are two types of arbitrages.

Uncovered

Example: investing in US or Turkey for interest arbitrage without forward contracts

1. January 1:
   - Investing in Turkey:
     - Borrow 1.60TL (short TL) at 8% and place on one year deposit (long TL) with 8% interest.
   - Investing in US:
     - Borrow 1.60TL (short TL) at 8%, buy $ at 1.60, deposit (long $) in US for a year with 5% interest.

2. Net position in Turkey
   \[ \text{Net position in Turkey} = \text{long} (1.60 \times 1.08) - \text{short} (1.60 \times 1.08) = 0. \]

3. Net position in US
   \[ \text{Net position in US} = E_t(S_t + 1) - S_t = 1.60 \times 1.05 - 1.60 = 0. \]

4. December 31:
   - Investing in Turkey:
     - Liquidate deposit (1.60 \times 1.08 = 1.728 TL) pay back loan (1.60 \times 1.08 = 1.728 TL).
     - Net profit = 0 TL
   - Investing in US:
     - Liquidate deposit ($1.10 = $1.05), convert it to TL at the spot price (e.g. 1.70), $1.05 \times 1.70 = 1.785 TL pay back loan (1.60 \times 1.08 = 1.728 TL).
     - Net profit = 1.785 - 1.728 = 0.057 TL.
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Borrowing and Lending (cont’d)

- Covered.
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2. **Net position in Turkey** = \( \text{long}(1.60 \times 1.08) - \text{short}(1.60 \times 1.08) = 0 \). **Net position in US** = \( \frac{F_t}{S_t} \times 1.60 \times 1.05 - 1.60 \times 1.08 \) If CIRP holds then \( F_t = \frac{(1+r)}{(1+r^*)} S_t = \frac{1.08}{1.05} \times S_t \) and the net position in US = 0.

Ozan Hatipoglu (CEE)
Open Economy Macroeconomics
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Borrowing and Lending (cont’d)

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3. December 31. *Investing in Turkey:* Liquidate deposit ($1.60 TL \times 1.08 = 1.728 TL$) pay back loan ($1.60 \times 1.08 = 1.728 TL$). *Net profit* $= 0 TL$. *Investing in US:* Liquidate deposit ($1 \times 1.08 = $1.05), convert it to TL at the forward price ($\frac{1.08}{1.05} \times 1.60 = 1.6457$), $1.05 \times 1.6457 = 1.728$, pay back loan ($1.60 \times 1.08 = 1.728 TL$). *Net profit* $= 1.728 - 1.728 = 0 TL$
In the UIRP example the currency risk associated with investing in Turkey is 0, and in US it is 
\[ A_t \times (1 + r) - A_t \times (1 + r^*) \times E_t(S_{t+1}) / S_t \] where \( A_t \) is the initial asset.
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- the forward rates reflect the risk premium associated with investing in that particular country.
- While the currency risk is zero, the profits are still uncertain. If $S_{t+1} > F_t$ then investing in US without hedging would have resulted in greater profits.
Real Interest Rate

- Future sacrifice required per unit of extra consumption today
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**Definition**

The relationship between real, \( r \), and nominal interest rate, \( R \), is given by
\[
(1 + R) = (1 + r)(1 + \Delta p^e)
\]
or in approximate form by
\[
r = R + \Delta p^e
\]
(Fisher equation) where \( \Delta p^e \) is the expected inflation rate.

**Corollary**

Take two countries
\[
R_R = (r_r + \Delta p^e_e) + (\Delta p^e_e \Delta p^e_e)
\]
by UIRP
\[
R_R = \Delta S_e
\]
therefore
\[
\Delta S_e = (r_r + \Delta p^e_e)
\]
If there is full capital mobility, \( r = r \)
therefore
\[
\Delta S_e = (\Delta p^e_e \Delta p^e_e)
\]
(PPP in expectations).

Note that \( \Delta p^e \) is unobservable therefore at any given time \( R \) is also unobservable.

Methods of estimating \( \Delta p^e \):
- Use surveys
- Econometric forecast methods.
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**Corollary**

*Take two countries* $R - R^* = (r - r^*) + (\Delta p^e - \Delta p^{e*})$ *by UIRP*

$R - R^* = \Delta S^e$ *therefore* $\Delta S^e = (r - r^*) + (\Delta p^e - \Delta p^{e*})$. *If there is full capital mobility, $r = r^*$ therefore* $\Delta S^e = (\Delta p^e - \Delta p^{e*})$ *(PPP in expectations).*
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- Methods of estimating $\Delta p^e$: Use surveys, or econometric forecast methods.
If all investors are fully informed about market conditions all the time, then prices fully reflect all available information and there are no arbitrage opportunities. For example, if the markets are efficient, $f = \Delta S^e$. 
C: Consumption Expenditure on Domestic and Foreign Goods and Services
National Income Accounting in Open Economy

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- \( X \): Exports
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- **S**: Savings
- **T**: Taxes and **TR**: transfers
Three Approaches To Calculate National Income
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1. Expenditure
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1. Expenditure
2. Income
3. Production
Expenditure Approach

- Households, Business, Government and Foreign Sector Expenditures.

National Income Identity in an open economy is given by:

\[ Y = C + I + G + X - M \]

where \( Y \) is gross domestic product. \( M \) are imports, subtracted to prevent double counting.

\[ S_{pri} = Y_d - C \]

\( C \) is private savings where \( Y_d \) is the disposable income.

\[ Y_d = Y - T + TR \]

\( T \) is taxes collected by the government, \( TR \) transfers made by the government to private sector.

\[ S_{pri} + I_{\{z\}} = G_{\{z\}} + TR_{\{z\}} + X_{\{z\}} - M_{\{z\}} \]

Private Surplus = Gov. Deficit + CA Balance

Note GDP is a flow variable and not a stock variable.

GDP is product produced within a country's borders; GNP (Gross National Product) is product produced by enterprises owned by a country's citizens.
Expenditure Approach

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\( GDP \) is product produced within a country’s borders; \( GNP \) (Gross National Product) is product produced by enterprises owned by a country’s citizens.
The income approach divides GDP according to types of income generated. GDP consists of:

- Wages and salaries
- Corporate profits (dividends, corporate income taxes, undistributed profits)
- Proprietors income (the profits of partnerships and sole owned businesses, like a family restaurant)
- Farm income
- Rent
- Interest (interest payments by businesses only)
- Sales taxes (it is an income but later get paid to the government)
- Depreciation (the amount of capital that has worn out during the year)

GDP = compensation of employees + gross operating surplus + gross mixed income + taxes less subsidies on production and imports
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Production Approach

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Example

1. Farmer buys seeds and produces wheat. Value added\#1 = Sale of Wheat - Value of producing and collecting wheat.

2. Whole retailer packages wheat and transports the wheat to factory. Value added\#2 = Sale of Wheat - Cost of Wheat = Value of packaging and shipping wheat.


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\text{GDP} = \sum_{i} \text{Value added}_i
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Example

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2. Whole retailer packages wheat and transports the wheat to factory. Value added\( \#2 = \text{Sale of Wheat} - \text{Cost of Wheat} = \text{Value of packaging and shipping wheat} \)
3. Baker cooks bread. Value added\( \#3 = \text{Sale of Bread} - \text{Cost of Wheat} = \text{Value of baking a bread} \)
4. GDP = \( \sum_{i} \text{Value added}_i \)
Examples of GDP component variables

- If a person spends money to renovate a hotel to increase occupancy, the spending represents private investment, but if he buys shares in a consortium to execute the renovation, it is saving. The former is included when measuring GDP (in I), the latter is not. However, when the consortium conducted its own expenditure on renovation, that expenditure would be included in GDP.

- If a hotel is a private home, spending for renovation would be measured as consumption, but if a government agency converts the hotel into an office for civil servants, the spending would be included in the public sector spending, or G.
Examples of GDP component variables

C, I, G, and NX (net exports): If a person spends money to renovate a hotel to increase occupancy, the spending represents private investment, but if he buys shares in a consortium to execute the renovation, it is saving. The former is included when measuring GDP (in I), the latter is not. However, when the consortium conducted its own expenditure on renovation, that expenditure would be included in GDP.

If a hotel is a private home, spending for renovation would be measured as consumption, but if a government agency converts the hotel into an office for civil servants, the spending would be included in the public sector spending, or G.
Expenditure Approach revisited

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Expenditure Approach revisited

- If the renovation involves the purchase of a chandelier from abroad, that spending would be counted as C, G, or I (depending on whether a private individual, the government, or a business is doing the renovation), but then counted again as an import and subtracted from the GDP so that GDP counts only goods produced within the country.
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- If a domestic producer is paid to make the chandelier for a foreign hotel, the payment would not be counted as C, G, or I, but would be counted as an export.
Expenditure Approach revisited

\[ S_{national} = S^{pri} + S^{gov} = (Y - T) - C + (T - G) = Y - C - G \]
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Is \( CA < 0 \) necessarily a bad thing?
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- \( S^{pri} \) vs. \( S^{gov} \)
- Decisions on \( S^{gov} \) makes taxpayers part of the deal!
Defining Variables of Interest

- Assumptions

\[ B = X(Q) M(Q, y) \]

where \( Q = SP \) and \( \frac{\partial B}{\partial Q} > 0 \), \( \frac{\partial B}{\partial y} < 0 \), \( S(y, r) \), \( \frac{\partial S}{\partial y} > 0 \), \( \frac{\partial S}{\partial r} > 0 \), \( I(r) \), \( \frac{\partial I}{\partial r} < 0 \), \( G + TR \) is exogenously given.
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\( G + TR - T \) is exogenously given
\[ S(y, r) - I(r) = G + TR - T + B(Q, y) \] (IS curve).
*IS Curve*

- \( S(y, r) - I(r) = G + TR - T + B(Q, y) \) (IS curve).

**Definition**

IS curve is the combination of income and interest rate pairs such that the net private savings cover the financing requirements of government and the foreign sector. LEAKAGES \((T + S + M)\) out of the system must equal INJECTIONS \((G + TR + I + X)\) for the circular flow to balance (be in EQUILIBRIUM).
\[ S(y, r) - I(r) = G + B(Q, y) \]
\[ S(y, r) - I(r) < G + B(Q, y) \]
\[ S(y,r) - I(r) = G + B(Q, y) \]
The IS curve is given by the equation:

\[ S(y,r) - I(r) = G + B(Q,y) \]

where
- \( S(y,r) \) is the saving function,
- \( I(r) \) is the investment function,
- \( G \) is government spending,
- \( B(Q,y) \) is the balance term.

The IS curve is plotted in the graph with the axes showing the relationship between the interest rate \( r \) and the output \( y \). The curve is downward sloping, indicating that as the interest rate increases, the output decreases, and vice versa.
An increase in Government Expenditure
An increase in Real Exchange Rate.
LM Curve

- Relationship between the demand for money and national income (ignoring the opportunity cost)

\[ M_d = kY \]

where \( M_d \) is the demand for money and \( Y \) national income, both measured in nominal terms. \( k \) is a positive constant.
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Relationship between the demand for money and national income (ignoring the opportunity cost)

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$\frac{M_d}{P} = ky - lr$

or $\frac{M_d}{P} \equiv \frac{M_d}{P}(y, r)$ Note that $\frac{\partial M_d}{\partial y}(y, r) > 0$, $\frac{\partial M_d}{\partial r}(y, r) < 0$
Let $M_s$ be the nominal money supply and $m_s = \frac{M_s}{P}$ be the real money supply.
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**Definition**

The Equilibrium condition in the money market is given by $m_s = ky - lr$ or $m_s = m(y, r)$.
$\frac{Ms}{P} = ky - lr$
LM Curve

\[ r = \frac{Ms}{P} > ky - lr \]

\[ y^* \]
The LM Curve is represented by the equation:

$$\frac{Ms}{P} = ky - lr$$

where:
- $r$ is the interest rate,
- $y$ is the income level,
- $r^*$ is the foreign interest rate,
- $y^*$ is the potential income level.

The graph shows the relationship between the interest rate ($r$) and income ($y$) with a vertical line at $r^*$ and a horizontal line at $y^*$. The equation represents the condition under which the money market is in equilibrium.
LM Curve

\[ \frac{Ms}{P} = ky - lr \]

LM(Ms/P)
An increase in Money Supply.

\[ Ms/P = ky - lr \]

\[ LM(M^0s/P) \]

Ms/P > ky - lr  
Excess Supply

Ms/P < ky - lr  
Excess Demand

\[ LM(M^1s/P) \]
Monetary System and the Banking Sector

Central bank

**Assets**
- Gold and foreign currency reserves
- Lending to government

**Liabilities**
- Currency issued (‘monetary base’)
- MB

Commercial banks

**Assets**
- Currency plus deposits with central bank
- Loans advanced to personal and corporate sector

**Liabilities**
- Deposits by public
- MB$^b$
- D

Consolidated banking sector

**Assets**
- Gold and foreign currency reserves
- Domestic credit: \( L + LG = \)
- Money supply: \( FX + DC = \)

**Liabilities**
- Currency in circulation: \( MB - MB^b = \)
- Deposits of public
- Money supply: \( MB^p + D = \)
- \( MB^p \)
- \( D \)
- \( M^p \)
For the Central Bank: $FX + LG = MB$
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For Commercial Banks $MB^b + L = D$, Given $D$, $L$ is determined by $MB_b$. 

The reserve requirement, $RR$, is the percentage of Commercial Banks deposits to be held with Central Bank as a precaution or the percent of deposits banks are not allowed to lend.
Monetary System and the Banking Sector

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- Combining both balance sheets: $FX + LG + MB^b + L = MB + D$
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Combining both balance sheets \( FX + LG + MB^b + L = MB + D \)

or \( FX + DC = MB^p + D \) where \( DC = L + LG \) is total domestic credit and \( MB^p = MB - MB^b \) is currency circulation.
Control of Money Supply

- \( FX + DC = MB^p + D = \text{Money Supply} = M^s \)
Control of Money Supply

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- \[ \Delta FX + \Delta DC = \Delta M^s \]
Control of Money Supply

- $FX + DC = MB^p + D = \text{Money Supply} = M^s$
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  1. Reserve/Borrowing Requirements (through reserve requirement ratio $(DC)$ and $MB^p$) or discount interest rate ($MB^p$)
  2. Open Market Operations (selling and buying Reserves $(FX)$, or via buying and selling Treasury Bills $(MB^p)$)
  3. Public Cash Holding (not really a policy tool but CB may pursue policies to increase confidence in the banking system)
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Central Bank Roles

- monetary policy (control inflation, economic growth, employment, financial stability)
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  - There might be conflicts among roles such as controlling inflation and creating employment or growth.
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- managing FX and gold reserves
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- control money supply
- managing FX and gold reserves
- setting official interest rates
- lender of last resort
- issue currency
- regulator and supervisor of commercial banks (now BDDK setting capital requirements for banks)
Under pure float: $\Delta FX = 0$ only $DC$ affects $M^s$, therefore $\Delta DC = \Delta M^s$. $M^s$ is exogenous and $S_t$ is endogenous.
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Under fixed rates: $\Delta FX \neq 0$, CA balance-CAP balance determine $\Delta FX$ therefore $M^s$ is endogenous and $S_t$ is exogenous and $\Delta S_t = 0$. Under fixed rates independent (independent of exchange rate movements) monetary policy is impossible.
Deriving Aggregate Demand

The equilibrium on the demand side is given by \((y, P)\) pairs such that

\[ S(y, r) = I(r) = (G + T) + B(Q, y) \] (IS)

\[ M_sP = m(y, r) \] (LM)

where \(Q = SP\). We want to express the equilibrium in \((y, P)\) plane because prices will

...
The equilibrium on the demand side is given by \((y, P)\) pairs such that

\[
S(y, r) - I(r) = (G - T + TR) + B(Q, y) \quad \text{(IS)}
\]
The equilibrium on the demand side is given by \((y, P)\) pairs such that:

1. \(S(y, r) - I(r) = (G - T + TR) + B(Q, y)\) (IS)
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3. \(\frac{M_s}{P} = (G - T + TR) + B(Q, y)\) where \(Q = \frac{SP^*}{P}\)

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3. \[ \frac{M^s}{P} = (G - T + TR) + B(Q, y) \text{ where } Q = \frac{SP^*}{P} \]

We want to express the equilibrium in \((y, P)\) plane because prices will from the link between aggregate demand and aggregate supply.
Deriving Aggregate Demand (Ex: A reduction in prices)
Deriving Aggregate Demand

\[ r^* \]

\[ P_0 \]

\[ y^0 \]

\[ IS(G,Q_1) \]

\[ IS(G,Q_0) \]

\[ LM(Ms/P_0) \]
Deriving Aggregate Demand

\[ r^* \]
\[ P_0 \]
\[ P_1 \]
\[ IS(G, Q_0) \]
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Policy Analysis: Relaxation of Monetary Policy

- Suppose $M^0_s \uparrow, M^1_s \to M^2_s$ where $M^1_s > M^0_s$
Policy Analysis: Relaxation of Monetary Policy

- Suppose $M_s^0 \uparrow$, $M_s^0 \rightarrow M_s^1$ where $M_s^1 > M_s^0$
- $\frac{M_s^1}{P} > ky - lr$, : Excess money supply, So quantity of money demanded has to increase, money demanded increases when $r \downarrow$ or $y \uparrow$ or both.
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Therefore $y_0 \rightarrow y_1$ where $y_1 > y_0$ and $r_1 \rightarrow r_2$ where $r_2 > r_1$
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This is a movement on $LM$. $\frac{M_1^s}{P} = ky_1 - lr_2 = ky_0 - lr_1$
Suppose $M_s^0 \uparrow, M_s^0 \rightarrow M_s^1$ where $M_s^1 > M_s^0$

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Assumption: $r$ moves faster than $y$. If $y = y_0$ is constant than $r_1 < r_0$ where $r_0$ is the original interest rate and $\frac{M_s^1}{P} = ky_0 - lr_1$

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No shift in $IS$ curve because

$S(y, r) - I(r) = G - T + TR + B(Q, y). \text{ No exogenous change here.}$
Policy Analysis: Relaxation of Monetary Policy

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  - $S(y_0, r_1) - I(r_1) < G - T + TR + B(Q, y_0)$
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- This is a movement on $LM$. $\frac{M_s^1}{P} = ky_1 - lr_2 = ky_0 - lr_1$

- No shift in $IS$ curve because $S(y, r) - I(r) = G - T + TR + B(Q, y)$. No exogenous change here.

- The exact change in $r$ and $y$ is determined by the slopes of $IS$ and $LM$ curves.
Relaxation of Monetary Policy

\[ r_0 \quad y^0 \quad P_0 \]

\[ r_1 \quad y^1 \]

\[ r_2 \]

\[ r \]

\[ LM(Ms^0/P) \]

\[ LM(Ms^1/P) \]

\[ IS(G,Q) \]

\[ AD^0 \]

\[ AD^1 \]
Increase in $G$

- Suppose $G \uparrow$, $G^0 \rightarrow G^1$ where $G^1 > G^0$
Increase in $G$

- Suppose $G \uparrow, G^0 \rightarrow G^1$ where $G^1 > G^0$
- $S(y_0, r_0) - I(r_0) < G^1 - T + TR + B(Q, y_0)$. 

No shift in $LM$ curve there is no exogenous change. The exact change in $r$ and $y$ is determined by the slopes of $IS$ and $LM$ curves.
Increase in G

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Increase in \( G \)

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- IS curve shifts right. To retain eq., \( r \uparrow \) or \( y \uparrow \) or both.
- \textit{Assumption}: \( r \) moves faster than \( y \). If \( y = y_0 \) is constant then \( r_1 > r_0 \) where \( r_0 \) is the original interest rate and
  \[ S(y_0, r_1) - I(r_1) = G^1 - T + TR + B(Q, y_0). \]
  \( I(r_1) < I(r_0) \) crowding out effect.
Increase in G

- Suppose $G \uparrow$, $G^0 \rightarrow G^1$ where $G^1 > G^0$
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- But $y_o, r_1$ can not be an equilibrium in money market because:
Increase in G

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  - $\frac{M_s}{P} > ky_0 - lr_1$ therefore $y_0 \rightarrow y_1$ where $y_1 > y_0$ and $r_1 \rightarrow r_2$ where $r_2 < r_1$
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Increase in G

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- $S(y_0, r_1) - I(r_1) = G^1 - T + TR + B(Q, y_0) =$

\[
S(y_0, r_0) - I(r_0) < G^1 - T + TR + B(Q, y_0).
\]
Increase in $G$

- Suppose $G \uparrow$, $G^0 \rightarrow G^1$ where $G^1 > G^0$
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- $= S(y_1, r_2) - I(r_2) = G^1 - T + TR + B(Q, y_1)$
Increase in G

Suppose $G \uparrow$, $G^0 \rightarrow G^1$ where $G^1 > G^0$

$S(y_0, r_0) - I(r_0) < G^1 - T + TR + B(Q, y_0)$.

IS curve shifts right. To retain eq., $r \uparrow$ or $y \uparrow$ or both.

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$S(y_0, r_1) - I(r_1) = G^1 - T + TR + B(Q, y_0) =

= S(y_1, r_2) - I(r_2) = G^1 - T + TR + B(Q, y_1)$

No shift in LM curve there is no exogenous change.
Increase in G

- Suppose $G \uparrow$, $G^0 \to G^1$ where $G^1 > G^0$
- $S(y_0, r_0) - I(r_0) < G^1 - T + TR + B(Q, y_0)$.
- IS curve shifts right. To retain eq., $r \uparrow$ or $y \uparrow$ or both.
- **Assumption**: $r$ moves faster than $y$. If $y = y_0$ is constant than $r_1 > r_0$ where $r_0$ is the original interest rate and $S(y_0, r_1) - I(r_1) = G^1 - T + TR + B(Q, y_0)$. $I(r_1) < I(r_0)$ crowding out effect.
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  - $S(y_0, r_1) - I(r_1) = G^1 - T + TR + B(Q, y_0) =$
  - $= S(y_1, r_2) - I(r_2) = G^1 - T + TR + B(Q, y_1)$
- No shift in LM curve there is no exogenous change.
- The exact change in $r$ and $y$ is determined by the slopes of IS and LM curves.
Increase in G

\[ \text{LM}(\text{Ms}/P_0) \]

\[ \text{IS}(G_1, Q) \]

\[ \text{IS}(G_0, Q) \]

\[ P \]

\[ y \]

\[ r \]

\[ y^o \]

Open Economy Macroeconomics

Spring 2011

Ozan Hatipoglu (CEE)
Increase in G

[Diagram showing the effects of an increase in government spending (G) on the economy. The diagram illustrates the shifts in the IS and AD curves, leading to higher interest rates and output levels.]
Firms

Assumptions:

- CRS Production Function \( Y_t = f(K_t, N_t) \) where \( K_t \) is capital and \( N_t \) is labor

First order conditions

1. \( p_t \frac{\partial f(K_t, N_t)}{\partial N_t} = w_t \) or \( MPL = w_t \) (Labor Demand Condition)
2. \( p_t \frac{\partial f(K_t, N_t)}{\partial K_t} = r_t \) or \( MPK = r_t \)
Assumptions:

- **CRS Production Function** \( Y_t = f(K_t, N_t) \) where \( K_t \) is capital and \( N_t \) is labor

\[
\begin{align*}
\frac{\partial f(K_t, N_t)}{\partial N_t} & \geq 0, \quad \frac{\partial f(K_t, N_t)}{\partial K_t} \geq 0, \quad \frac{\partial^2 f(K_t, N_t)}{\partial N_t^2} \leq 0, \quad \frac{\partial^2 f(K_t, N_t)}{\partial K_t^2} \leq 0
\end{align*}
\]
Firms

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- \( \frac{\partial f(K_t, N_t)}{\partial N_t} \geq 0, \frac{\partial f(K_t, N_t)}{\partial K_t} \geq 0, \frac{\partial^2 f(K_t, N_t)}{\partial N_t^2} \leq 0, \frac{\partial^2 f(K_t, N_t)}{\partial K_t^2} \leq 0 \)
- Firms operate in a perfectly competitive environment and solve the following problem.
Firms

Assumptions:

- CRS Production Function \( Y_t = f(K_t, N_t) \) where \( K_t \) is capital and \( N_t \) is labor

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\frac{\partial f(K_t, N_t)}{\partial N_t} \geq 0, \quad \frac{\partial f(K_t, N_t)}{\partial K_t} \geq 0, \quad \frac{\partial^2 f(K_t, N_t)}{\partial N_t^2} \leq 0, \quad \frac{\partial^2 f(K_t, N_t)}{\partial K_t^2} \leq 0
\]

- Firms operate in a perfectly competitive environment and solve the following problem.

\[
\max_{\{K_t, N_t\}} p_t Y_t - w_t N_t - r_t K_t \quad \text{subject to} \quad Y_t \leq f(K_t, N_t)
\]
Firms

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- First order conditions
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- First order conditions

\[
p_t \frac{\partial f(K_t, N_t)}{\partial N_t} = w_t \quad \text{or} \quad MPL = \frac{w_t}{p_t} \quad \text{(Labor Demand Condition)}
\]
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\frac{\partial f(K_t, N_t)}{\partial N_t} \geq 0, \quad \frac{\partial f(K_t, N_t)}{\partial K_t} \geq 0, \quad \frac{\partial^2 f(K_t, N_t)}{\partial N_t^2} \leq 0, \quad \frac{\partial^2 f(K_t, N_t)}{\partial K_t^2} \leq 0
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- As \( N \uparrow \), \( MPL \downarrow \) because of diminishing marginal productivity therefore firms are willing to pay less for an additional worker.
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\[
\frac{\partial f(K_t, N_t)}{\partial N_t} \geq 0, \quad \frac{\partial f(K_t, N_t)}{\partial K_t} \geq 0, \quad \frac{\partial^2 f(K_t, N_t)}{\partial N_t^2} \leq 0, \quad \frac{\partial^2 f(K_t, N_t)}{\partial K_t^2} \leq 0
\]

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\max_{\{K_t, N_t\}} p_t Y_t - w_t N_t - r_t K_t \text{ subject to } Y_t \leq f(K_t, N_t)
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- **First order conditions**

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- As \( N \uparrow \), \( MPL \downarrow \) because of diminishing marginal productivity therefore firms are willing to pay less for an additional worker.

- Define Labor Demand as \( w \equiv Pf(N) \)
Assumptions:

- Concave Utility function $U(c_t, l_t)$ where $c_t$ is consumption and $l_t$ is leisure
Assumptions:

- Concave Utility function $U(c_t, l_t)$ where $c_t$ is consumption and $l_t$ is leisure
- $\frac{\partial U(c_t, l_t)}{\partial c_t} \geq 0$, $\frac{\partial U(c_t, l_t)}{\partial l_t} \geq 0$, $\frac{\partial^2 U(c_t, l_t)}{\partial c_t^2} \leq 0$, $\frac{\partial^2 U(c_t, l_t)}{\partial l_t^2} \leq 0$
Workers

Assumptions:

- Concave Utility function $U(c_t, l_t)$ where $c_t$ is consumption and $l_t$ is leisure
  
  $\frac{\partial U(c_t, l_t)}{\partial c_t} \geq 0, \frac{\partial U(c_t, l_t)}{\partial l_t} \geq 0, \frac{\partial^2 U(c_t, l_t)}{\partial c_t^2} \leq 0, \frac{\partial^2 f(c_t, l_t)}{\partial l_t^2} \leq 0$

- $\max U(c_t, l_t)$ subject to $P_t^e c_t \leq w_t (1 - l_t)$ and $0 \leq l_t \leq 1$
Assumptions:

- Concave Utility function $U(c_t, l_t)$ where $c_t$ is consumption and $l_t$ is leisure
  $$\frac{\partial U(c_t, l_t)}{\partial c_t} \geq 0, \frac{\partial U(c_t, l_t)}{\partial l_t} \geq 0, \frac{\partial^2 U(c_t, l_t)}{\partial c_t^2} \leq 0, \frac{\partial^2 U(c_t, l_t)}{\partial l_t^2} \leq 0$$
- $\max_{\{c_t, l_t\}} U(c_t, l_t)$ subject to $P^e_t c_t \leq w_t (1 - l_t)$ and $0 \leq l_t \leq 1$
- $P^e_t = P(P)$ $0 \leq P' \leq 1$
Workers

Assumptions:

- Concave Utility function $U(c_t, l_t)$ where $c_t$ is consumption and $l_t$ is leisure
  $$\frac{\partial U(c_t, l_t)}{\partial c_t} \geq 0, \quad \frac{\partial U(c_t, l_t)}{\partial l_t} \geq 0, \quad \frac{\partial^2 U(c_t, l_t)}{\partial c_t^2} \leq 0, \quad \frac{\partial^2 U(c_t, l_t)}{\partial l_t^2} \leq 0$$

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- $P^e_t = P(P)$ $0 \leq P' \leq 1$

- $P' = 0$ no adjustment (extreme Keynesian)
Assumptions:

- Concave Utility function $U(c_t, l_t)$ where $c_t$ is consumption and $l_t$ is leisure
  \[
  \frac{\partial U(c_t, l_t)}{\partial c_t} \geq 0, \quad \frac{\partial U(c_t, l_t)}{\partial l_t} \geq 0, \quad \frac{\partial^2 U(c_t, l_t)}{\partial c_t^2} \leq 0, \quad \frac{\partial^2 f(c_t, l_t)}{\partial l_t^2} \leq 0
  \]
- Maximize $U(c_t, l_t)$ subject to $P^e_t c_t \leq w_t (1 - l_t)$ and $0 \leq l_t \leq 1$
- $P^e_t = P(P)$ $0 \leq P' \leq 1$
- $P' = 0$ no adjustment (extreme Keynesian)
- $P' = 1$ full adjustment (perfect fullsight, neoclassical)
Assumptions:

- Concave Utility function $U(c_t, l_t)$ where $c_t$ is consumption and $l_t$ is leisure
  \[ \frac{\partial U(c_t, l_t)}{\partial c_t} \geq 0, \quad \frac{\partial U(c_t, l_t)}{\partial l_t} \geq 0, \quad \frac{\partial^2 U(c_t, l_t)}{\partial c_t^2} \leq 0, \quad \frac{\partial^2 f(c_t, l_t)}{\partial l_t^2} \leq 0 \]

- $\max_{\{c_t, l_t\}} U(c_t, l_t)$ subject to $P^e_t c_t \leq w_t (1 - l_t)$ and $0 \leq l_t \leq 1$

- $P^e_t = P(P)$ $0 \leq P' \leq 1$

- $P' = 0$ no adjustment (extreme Keynesian)

- $P' = 1$ full adjustment (perfect fullsight, neoclassical)

- Lagrangian:
Assumptions:

- Concave Utility function $U(c_t, l_t)$ where $c_t$ is consumption and $l_t$ is leisure
  \[ \frac{\partial U(c_t, l_t)}{\partial c_t} \geq 0, \quad \frac{\partial U(c_t, l_t)}{\partial l_t} \geq 0, \quad \frac{\partial^2 U(c_t, l_t)}{\partial c_t^2} \leq 0, \quad \frac{\partial^2 U(c_t, l_t)}{\partial l_t^2} \leq 0 \]
- \[ \max_{\{c_t, l_t\}} U(c_t, l_t) \text{ subject to } P^e_t c_t \leq w_t (1 - l_t) \] and $0 \leq l_t \leq 1$
- \[ P^e_t = P(P) \quad 0 \leq P' \leq 1 \]
- \[ P' = 0 \] no adjustment (extreme Keynesian)
- \[ P' = 1 \] full adjustment (perfect fullsight, neoclassical)
- Lagrangian:
  \[ L = U(c_t, l_t) + \lambda (w_t (1 - l_t) - P^e_t c_t) \]
Assumptions:

- Concave Utility function $U(c_t, l_t)$ where $c_t$ is consumption and $l_t$ is leisure
  \[
  \frac{\partial U(c_t, l_t)}{\partial c_t} \geq 0, \quad \frac{\partial U(c_t, l_t)}{\partial l_t} \geq 0, \quad \frac{\partial^2 U(c_t, l_t)}{\partial c_t^2} \leq 0, \quad \frac{\partial^2 f(c_t, l_t)}{\partial l_t^2} \leq 0
  \]
- \[
  \max_{\{c_t, l_t\}} U(c_t, l_t) \text{ subject to } P^e_t c_t \leq w_t (1 - l_t) \text{ and } 0 \leq l_t \leq 1
  \]
- $P^e_t = P(P)$ $0 \leq P' \leq 1$
- $P' = 0$ no adjustment (extreme Keynesian)
- $P' = 1$ full adjustment (perfect fullsight, neoclassical)
- Lagrangian:
  \[
  L = U(c_t, l_t) + \lambda (w_t (1 - l_t) - P^e_t c_t)
  \]
  \[
  U_c(c_t, l_t) = \lambda P^e_t
  \]
Workers

Assumptions:

- Concave Utility function $U(c_t, l_t)$ where $c_t$ is consumption and $l_t$ is leisure
  \[ \frac{\partial U(c_t, l_t)}{\partial c_t} \geq 0, \quad \frac{\partial U(c_t, l_t)}{\partial l_t} \geq 0, \quad \frac{\partial^2 U(c_t, l_t)}{\partial c_t^2} \leq 0, \quad \frac{\partial^2 f(c_t, l_t)}{\partial l_t^2} \leq 0 \]
- \[
\max_{\{c_t, l_t\}} U(c_t, l_t) \text{ subject to } P^e_t c_t \leq w_t (1 - l_t) \text{ and } 0 \leq l_t \leq 1
\]
- $P^e_t = P(P) \quad 0 \leq P' \leq 1$
- $P' = 0$ no adjustment (extreme Keynesian)
- $P' = 1$ full adjustment (perfect fullsight, neoclassical)
- **Lagrangian:**
  \[ L = U(c_t, l_t) + \lambda (w_t (1 - l_t) - P^e_t c_t) \]
  1. $U_c(c_t, l_t) = \lambda P^e_t$
  2. $U_l(c_t, l_t) = \lambda w$
  combining
Assumptions:

- Concave Utility function $U(c_t, l_t)$ where $c_t$ is consumption and $l_t$ is leisure
  
  \[
  \frac{\partial U(c_t, l_t)}{\partial c_t} \geq 0, \quad \frac{\partial U(c_t, l_t)}{\partial l_t} \geq 0, \quad \frac{\partial^2 U(c_t, l_t)}{\partial c_t^2} \leq 0, \quad \frac{\partial^2 f(c_t, l_t)}{\partial l_t^2} \leq 0
  \]

- \[
  \max_{\{c_t, l_t\}} U(c_t, l_t) \text{ subject to } P_t c_t \leq w_t (1 - l_t) \text{ and } 0 \leq l_t \leq 1
  \]

- $P_t^e = P(P)$ \[0 \leq P' \leq 1\]
- $P' = 0$ no adjustment (extreme Keynesian)
- $P' = 1$ full adjustment (perfect fullsight, neoclassical)

Lagrangian:

\[
L = U(c_t, l_t) + \lambda (w_t (1 - l_t) - P_t^e c_t)
\]

1. $U_c(c_t, l_t) = \lambda P_t^e$
2. $U_l(c_t, l_t) = \lambda w$
3. combining

\[
\frac{U_c(c_t, l_t)}{U_l(c_t, l_t)} = \frac{P_t^e}{w}
\]
Assumptions:

- Concave Utility function $U(c_t, l_t)$ where $c_t$ is consumption and $l_t$ is leisure
  $$\frac{\partial U(c_t, l_t)}{\partial c_t} \geq 0, \quad \frac{\partial U(c_t, l_t)}{\partial l_t} \geq 0, \quad \frac{\partial^2 U(c_t, l_t)}{\partial c_t^2} \leq 0, \quad \frac{\partial^2 f(c_t, l_t)}{\partial l_t^2} \leq 0$$
- $\max U(c_t, l_t)$ subject to $P_t^e c_t \leq w_t (1 - l_t)$ and $0 \leq l_t \leq 1$
- $P_t^e = P(P)$, $0 \leq P' \leq 1$
- $P' = 0$ no adjustment (extreme Keynesian)
- $P' = 1$ full adjustment (perfect fullsight, neoclassical)
- Lagrangian:
  $$L = U(c_t, l_t) + \lambda (w_t (1 - l_t) - P_t^e c_t)$$
  1. $U_c(c_t, l_t) = \lambda P_t^e$
  2. $U_l(c_t, l_t) = \lambda w$
  combining
  3. $\frac{U_c(c_t, l_t)}{U_l(c_t, l_t)} = \frac{P_t^e}{w}$
- Define Labor Supply as $w = P_t^e \frac{U_c(c_t, l_t)}{U_l(c_t, l_t)} \equiv P_t^e g(N_t)$ where $N_t = 1 - l_t$
Labor Supply: An increase in prices

\[ N_0^s \]

\[ N_1^s \]

\[ N^* \]

\[ W \]

\[ N \]