

14.02 Recitation

By

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The Short Run

- I. Course Introduction
- II. Mathematical Background
- III. Real vs. Nominal & Growth Rate
- IV. National Account
- V. Government Budget
- VI. Basic Macroeconomic Model– Kenyes Model
- VII. The Investment Saving Equilibrium
- VIII. The IS Curve
- IX. LM Curve
- X. IS-LM Model

I. Course Introduction

- a) Course Strategy
- b) Course Outlines
- c) Macro vs. Micro
- d) Why Are You Taking Macroeconomics?

I(a) Course Strategy

- Define the important **concepts, magnitudes** and **questions** in the real world.
- Learn alternative **theories** suggesting answers and explaining behavior.
- Evaluate **data** to test and then choose among theories.
- Put you in position to have a **serious opinion on important topics**.

I(b) Macro vs. Micro

- **Microeconomics** examines the economic behavior of individual households and firms-- their responses to prices, income, tastes, opportunities and other fundamental variables.
- **Macroeconomics** examines the sum of microeconomic actions, their dynamics & interactions.
- **Therefore** Macro must be fully **compatible** with Micro in its explanations of behavior: to trust any Macro answer, you must be sure of each of its Micro roots. Usually, this requires common sense and introspection.
- The **power** and elegance of Macro is its ability to confront important questions, resolve paradoxes, explain past and predict future dynamics.
- Why is there so much **controversy** about macro theory and policy and so little about micro?
- Macro hits us in the **pocketbook** through its policy prescriptions so we may want certain answers to be true even if not.
- Macro gets intimately involved in **politically** sensitive issues, and only religious arguments are more emotional than political debates.
- The **media** cares about these issues and wants to find/exaggerate controversy to sell itself.

I(c) Why Are You Taking Macroeconomics?

- **Possible reasons:**

- It's required for economics majors.
- You've heard it's as good a way as any to meet distribution requirements in the social sciences since this will at least involve mathematics.
- Economist jokes are better than lawyer or computer nerd jokes.
- You want to call in to talk- show radio hosts and sound important.

- **Better reasons:**

- You know that, today or tomorrow, you will really need the macroeconomic analysis skills as:
 - An investor
 - a politician
 - a manager or employee
 - an intellectually curious person

- **Your interest might be as following:**

- **An investor:**

- ✓ *Where are interest rates headed?*
- ✓ *Which sectors of the economy will do best and worst during the next quarter, year, and decade?*
- ✓ *What will be the distinguishing differences across countries.*

- **A politician**

- ✓ *What determines interest rates and what are appropriate monetary targets?*
- ✓ *What are the appropriate taxes to raise?*
- ✓ *How will the level and composition of the budget affect family incomes?*
- ✓ *How will international trade impact jobs, inflation and credit?*
- ✓ *What is the cost of low inflation or low unemployment?*

➤ **a manager or employee**

- ✓ *What growth will my current markets provide if I maintain my share?*
- ✓ *Can I raise my prices as rapidly as my costs?*
- ✓ *What opportunities are emerging in the developing nations?*

➤ **a manager or employee**

- ✓ *Why do cycles exist/ persist in all economies?*
- ✓ *Are macro relationships stable?*
- ✓ *Can nonlinear mathematics and chaos physics help to understand economics?*
- ✓ *How can growth and environmental concerns be reconciled?*

I(d) Course Outlines

- Output- level, growth, trend, fluctuations (recessions and expansions).
- Great Depression
- Stagflation in the 1970s
- Current long expansion and low unemployment
- High stock markets and bubbles
- From budget deficit to budget surplus
- Who is Greenspan? Why is he worry? Why we care?
- Asian 1980's miracle and 1990's crisis and the political consequences
- Russia and Latin America financial crises
- European Community (EC)
- Foreign trade
- Financial markets
- Globalization

II. Mathematical background

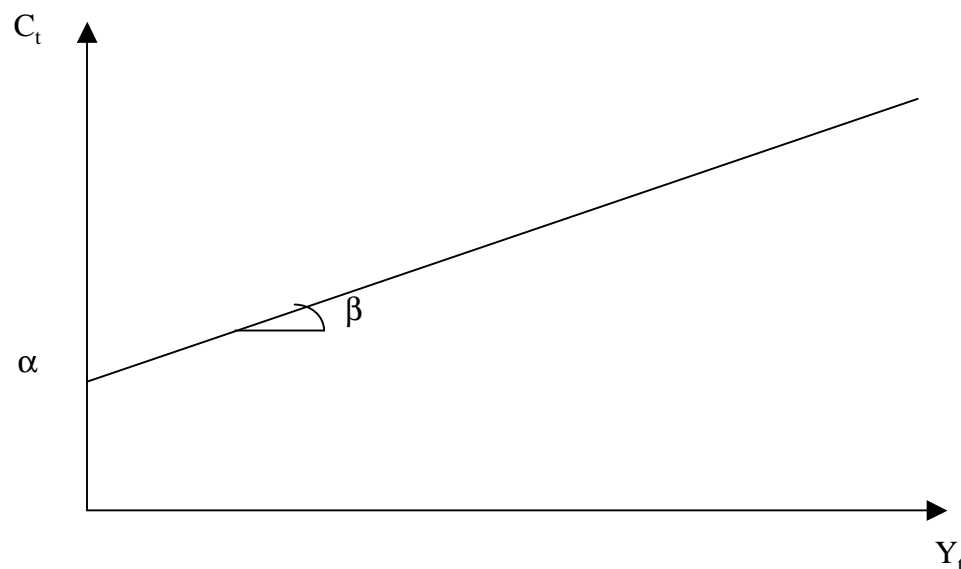
- a) Linearity
- b) Curve shifting
- c) Adjacent or Stacked Graphs
- d) Changes and Logarithm
- e) Elasticity

II(a) Linearity

For simplicity, we usually assume linearity only to get the notion and intuition (specially the sign and factors that affect the endogenous variables).

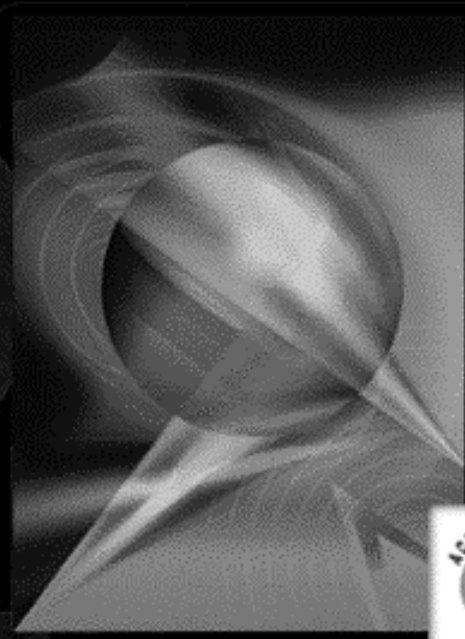
- *Example:*

$$C = \alpha + \beta Y \quad \Rightarrow \quad \beta = \partial C / \partial Y$$



II(b) Curves, which way do they shift?


Active Graphs to accompany
Macroeconomics



ACTIVE GRAPH

**ENTER
HERE**

Real wage, W/P



Price setting relation

Wage setting relation

u_n

Unemployment rate, u

Java!

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II(c) Adjacent or Stacked Graphs

Active Graphs to accompany
Macroeconomics

Real wage, W/P

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u_n

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ACTIVE GRAPH

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II(d) Changes and Logarithm

- $dY \equiv (Y_t - Y_{t-1}) = \Delta Y$
- $RY \equiv \frac{(Y_t - Y_{t-1})}{Y_{t-1}} \equiv \frac{\partial Y_t}{\partial t} \equiv \dot{Y}$
- if $W_t = X_t Y_t / Z_t \Rightarrow \dot{W}_t = \dot{X}_t + \dot{Y}_t - \dot{Z}_t$
- if $C_t = A Y_t^\beta i_t^{-\gamma} e^{\varepsilon_t} \Rightarrow \ln(C_t) = \ln(A) + \beta \ln(Y_t) - \gamma \ln(i_t) + \varepsilon_t$

II(e) Elasticity

- **Definition**

$\eta_{C,Y}$ = The percentage change of C due to one percentage change in Y

$$= \% \Delta C / \% \Delta Y$$

$$= [\Delta C/C] / [\Delta Y/Y]$$

$\eta_{C,Y} = [\Delta C/\Delta Y] * [Y/C] = \text{MPC} * Y/C$ -How is it represented in the graph?

- If the economic theory assumes an exponential model (instead of previous linear model), then:

- $C_t = A Y_t^\beta i_t^{-\gamma} e^{\varepsilon_t}$

- Therefore, in order to estimate our theoretical model we can run log_log model:

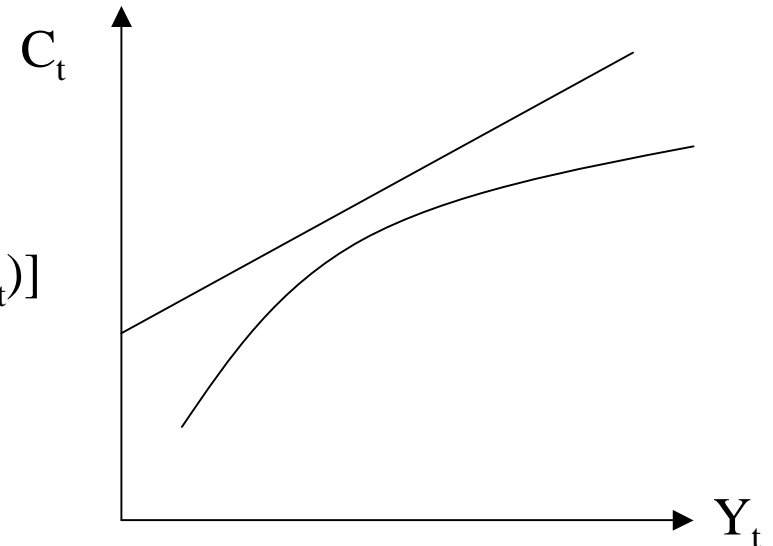
$$\checkmark \ln(C_t) = \ln(A) + \beta \ln(Y_t) - \gamma \ln(i_t) + \varepsilon_t$$

$$- \text{ where: } \beta = \partial \ln(C_t) / \partial \ln(Y_t)$$

- Which means that, instead of assuming a constant propensity to consume (and increasing elasticity of consumption with respect to the disposal income) as in the linear model, the exponential model assumes a constant elasticity of consumption with respect to the disposal income (and decreasing propensity to consume).

- *Proof: Apply the chain rule:*

$$\begin{aligned} \checkmark \beta &= [\partial \ln(C_t) / \partial C] * [\partial C / \partial Y] * [\partial Y / \partial \ln(Y_t)] \\ &= [1/C] * [\partial C / \partial Y] * [Y / 1] \\ &= [\partial C / \partial Y] * [Y / C] \\ &= \eta_{C,Y} \end{aligned}$$


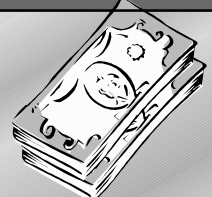

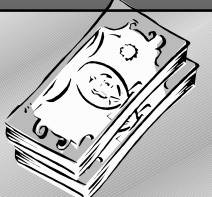


III. Real vs. Nominal & Growth Rate

- a) An Exercise
- b) Nominal vs. Real

III(a). An exercise



	Q₁₉₈₁	P₁₉₈₁	Q₁₉₉₃	P₁₉₉₃
				
Banana	15	0.1	20	0.3
Orange	50	0.15	60	0.25

You are required to calculate:

1. Paasche:
 - a) Index
 - b) Average Annual Inflation Rate

2. Laspeyres:
 - a) Index
 - b) Average Annual Inflation Rate

3. GDP Average Annual Growth Rate:
 - a) Nominal
 - b) Real


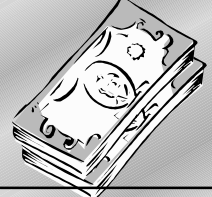

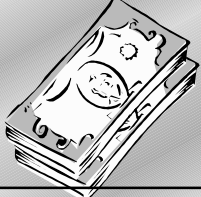
You have 5 minutes

Can we start???







	Q₁₉₈₁	P₁₉₈₁	Q₁₉₉₃	P₁₉₉₃
				
Banana	15	0.1	20	0.3
Orange	50	0.15	60	0.25

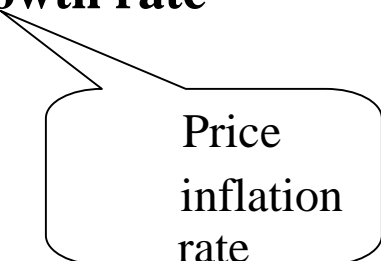
III(b). Nominal vs. Real

- **Real quantity** is measured in terms of number of physical units, no matter how its money value was changed.
- **Nominal value** is measured in terms of its money value, no matter how its number of physical units was changed.

	Year 1	Year 2		
		<u>Case I</u>	<u>Case II</u>	<u>Case III</u>
Cars	1,000	1,020	1000	?
<u>Price</u>	<u>100</u>	<u>100</u>	<u>102</u>	<u>?</u>
Total nominal value	100,000	102,000	102,000	102,000
Real change		2%	0%	?
Nominal change		2%	2%	2%
Price inflation		0%	2%	?

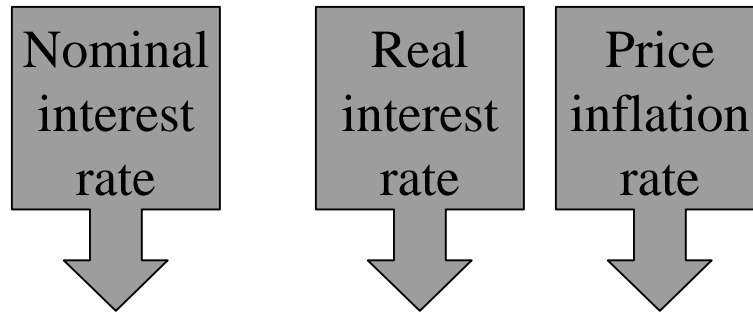
Notice:

- Inflation $\equiv \pi \equiv \dot{P} \equiv dP/P \equiv (P_t - P_{t-1}) / P_{t-1}$
- There is more than one representative price index: GDP deflator, CPI, and WPI.
- GDP deflator = Nominal GDP / Real GDP
- $CPI = (P_t * C_0) / (P_0 * C_0)$
- GDP deflator is a **Paasche Index** (uses current price)
- CPI is a **Laspeyres Index** (uses basis quantity)
- **NGDP growth rate = GDP growth rate + P growth rate**



Price
inflation
rate

Also notice that:

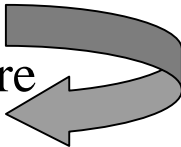


- $(1+i) = (1+r)(1+\pi)$

- $1 + i = 1 + r + \pi + r\pi$


- $i = r + \pi + r\pi$

- $i \cong r + \pi$

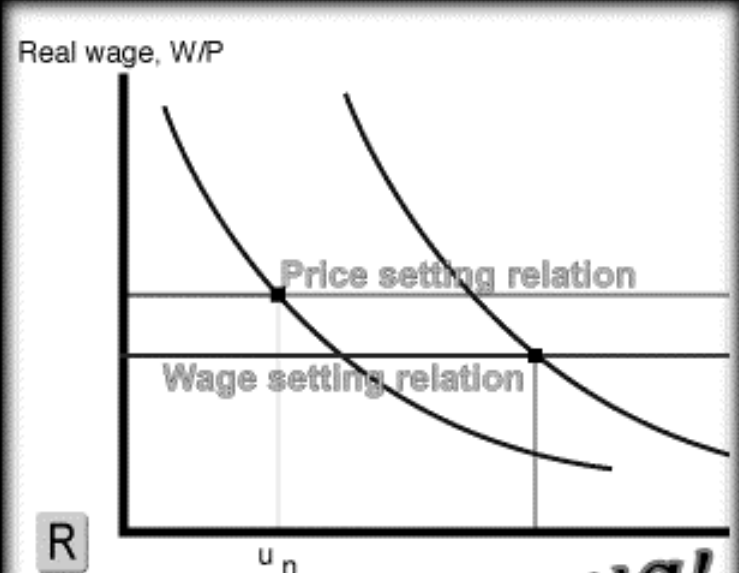
When r and π are  small enough

III(c). Another Real versus Nominal Exercise

Active Graphs to accompany
Macroeconomics



**ENTER
HERE**



Real wage, W/P

Price setting relation

Wage setting relation

u_n

Unemployment rate, u

Java!

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1(a). Paasche Index

$$\begin{aligned} \text{Paasche Index} &= \frac{\sum_{i=1}^n p_t^i \times q_t^i}{\sum_{i=1}^n p_0^i \times q_t^i} \\ &= \frac{(0.3\$/Ba * 20Ba) + (0.25\$/Or * 60Or)}{(0.1\$/Ba * 20Ba) + (0.15\$/Or * 60Or)} \\ &= \frac{\$6 + \$15}{\$2 + \$9} \\ &= 1.909 \end{aligned}$$

← This is a neutral index

Which means 91% price increase over 12 years.

1(b). Paasche Average Annual Inflation Rate

$$= (1.909)^{1/12} - 1 \cong 5.54\%$$





2(a). Laspeyres Index

$$\begin{aligned} \text{Laspeyres Index} &= \frac{\sum_{i=1}^n p_t^i \times q_0^i}{\sum_{i=1}^n p_0^i \times q_0^i} \\ &= \frac{(0.3\$/Ba * 15Ba) + (0.25\$/Or * 50Or)}{(0.1\$/Ba * 15Ba) + (0.15\$/Or * 50Or)} \\ &= \frac{\$4.5 + \$12.5}{\$1.5 + \$7.5} \\ &= 1.889 \end{aligned}$$

← This is a neutral index


Which means 89% price increase over 12 years.

2(b). Laspeyres Average Annual Inflation Rate

$$= (1.889)^{1/12} - 1 \cong 5.44\%$$



3(a). Nominal GDP Annual Growth Rate

$$\dot{Y} = \left(\frac{\sum_{i=1}^n p_t^i \times q_t^i}{\sum_{i=1}^n p_0^i \times q_0^i} \right)^{1/12} - 1$$

$$= \left(\frac{(0.3\$ / Ba * 20Ba) + (0.25\$ / Or * 60Or)}{(0.1\$ / Ba * 15Ba) + (0.15\$ / Or * 50Or)} \right)^{1/12} - 1$$
$$= \left(\frac{\$6 + \$15}{\$1.5 + \$7.5} \right)^{1/12} - 1$$
$$= 7.32\%$$

3(b). Real GDP Annual Growth Rate

$$\dot{Y} = \left(\frac{\sum_{i=1}^n p_0^i \times q_t^i}{\sum_{i=1}^n p_0^i \times q_0^i} \right)^{1/12} - 1$$



$$= \left(\frac{(0.1\$ / Ba * 20Ba) + (0.15\$ / Or * 60Or)}{(0.1\$ / Ba * 15Ba) + (0.15\$ / Or * 50Or)} \right)^{1/12} - 1$$

$$= \left(\frac{\$2 + \$9}{\$1.5 + \$7.5} \right)^{1/12} - 1$$

$$= 1.69\%$$

IV. The National Accounting

- a) Key players
- b) Counting the GDP
- c) Counting the GDP- an example
- d) Other definitions
- e) A Summary: The Relationships among the basic spending and income categories

IV(a) Key players

- The key actors in the macro economy:
 - ❖ **Firms:** (domestically) producing (**Y**) and investing (**I**) entities.
 $\Rightarrow Y = \text{GDP}$
 - ❖ **Households:** consuming (**C**) and saving (**S**) entities.
 $\Rightarrow Y^D = Y - T, \quad Y^D = C + S_p, \quad S_p = Y^D - C$
 - ❖ **Government Agencies:** raise net taxes ($T = T_0 + t \cdot Y - Tr$), spend on public goods (**G**) and pay interest on their debt.
 $\Rightarrow S_g = T - G, \quad BD = G - T$
 - ❖ **Central Bank:** controls the interest rates (**i**) through the money supply (**M**).
 - ❖ **Foreign counterparts:** we export products to them (**EX**) and import products from them (**IM**) and exchange financial assets with them.
 $\Rightarrow NX = EX - IM$

$$Y = C + G + I + EX - IM .$$

IV(b) Counting the GDP

- Three alternative ways for counting the GDP (see example):
 - I. **Final values:** the sum of only *final purchases* (not intermediate purchases) by *final users* (C, I, G or X) from domestic firms (Don't double count. It is as if merging all domestic firms). Adjust for foreign trade: deduct purchases from foreign suppliers and add purchases by foreign buyers.
 - II. **Value added:** the sum of only the difference between value of the output and input of all domestic firms.
 - III. **Households' income:** earnings of all types entitled to the households from domestic firms plus the excise taxes (sales taxes, tariffs, etc.).
- Since we are adding up oranges and apples, we have to multiply quantities with their prices:
 - ● **Nominal GDP**- times their *current price*.
 - ● **Real GDP**- times their *base year price (constant prices)*.
- **GDP** does not include some **none-market activities** (your mother's homework), and it does impute some other none-market activities, especially the services of owner-occupied housing.
- Note, also, some **data collection problems**.

IV(c) Counting the GDP- an example

		Mining firm	Car firm	GNP
Revenue		100	210	
Expenses				
Payments to households	{ Wages	60	50	
	Rents	15	10	
	Interests	5	10	
Payments to firms	{ Purchases	0	100	
	Rents	0	0	
	Interests	<u>0</u>	<u>0</u>	
	Total	<u>(80)</u>	<u>(170)</u>	
Profit		<u>20</u>	<u>40</u>	
Dividends to HH		(10)	(25)	
Retained earnings		10	15	
	Final value	0	210	210
	Value added	100	110	210
	Households' income	100	110	210

IV(d) Other definitions

- **GDP** = Output produced by factors located domestically (in our borders).
- **GNP** = Output produced by factors owned by US citizens (US-nation holders).
- **NNP** = GNP – D. (a.k.a., **CCA**= Capital Consumption Allowance)
- **NNP** = Net National Income + indirect taxes (sales-like “excise” taxes collected before any private sector unit calculates its income).
- **Indirect taxes** = sales-like “excise” taxes collected before any private sector unit calculates its income.
- **Income** = Earnings of all types: wages, rent, interest, dividends, retained earnings, and depreciation allowances.
- **Consumption** is composed of durable (C_D), non-durable (C_N) and services (C_S).
- **New residential houses** are recorded as an investment of a firm, in the one hand, and rent income, in the other hand (as if they were all owned by firms who rent these houses, some of which they rent to their shareholders).
- **Investment** can be broken down to: non-residential investment (I_{NR}), residential investment (I_R) and inventory investment (I_{Inv}).
- **$Y = C + G + I + NX$**

(V) The Government Budget

- a) Definitions
- b) The Federal Budget
- c) State & Local Budgets

V(a) Definitions

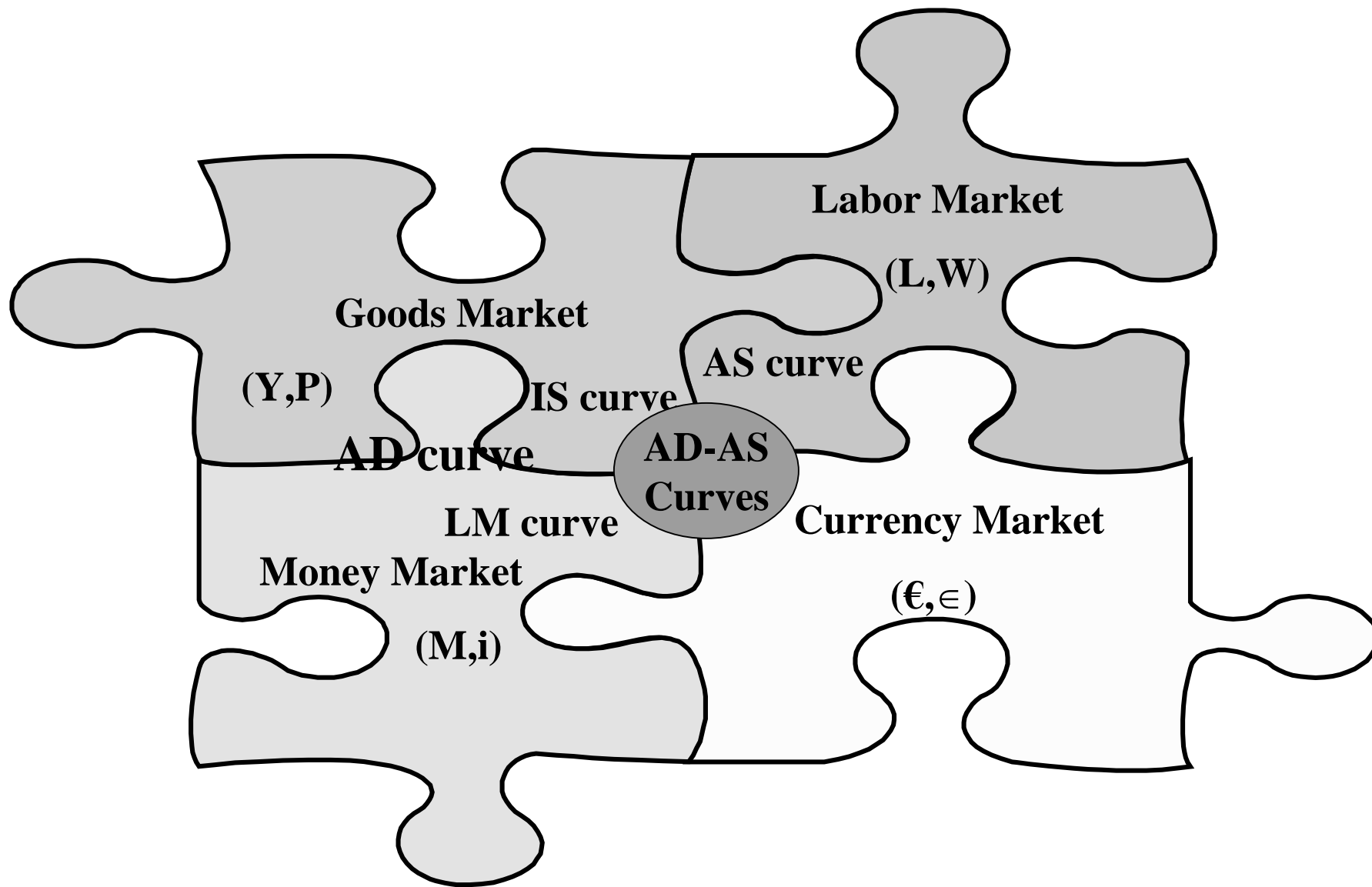
- **G:** is all the purchases of goods and services made by the government
- It does NOT including government transfers or interest rate payments (otherwise, you will get double counting).
- **Government outlays** include them all: purchases of goods and services, transfers and or interest rate payments made by the government.
- **Net Taxes** are total taxes after deducting government transfers.
- **Government** includes the Federal, State and local government agencies.
- Note their decomposition of budget.

V(b) The Federal Budget

<u>1995 US FEDERAL GOVERNMENT (Approximate)</u>				
\$BILLION	RECEIPTS		SPENDING	\$BILLION
94	INDIRECT TAXES		TRANSFERS	632
579	PAYROLL			
177	CORP. PROFIT		GRANTS-IN-AID	184
579	PERSONAL		PURCHASES	524
			OF GOOD & SERVICES	
			<i>Military-Pay \$135</i>	
			<i>Military-Goods \$161</i>	
			<i>Other-Pay \$71</i>	
			<i>Other-Goods \$73</i>	
			NET SUBSIDIES	32
	DEFICIT		NET INTEREST	262
	=\$205 BILLION		PAID	
1429	TOTAL		TOTAL	1634

VI. Basic Macroeconomic Model– Keynes Model

- a) Key players
- b) Behavioral (simultaneous) equations for the endogenous variables
- c) Exogenous variables
- d) Identity (definition) equations
- e) Equilibrium condition in the goods market
- f) A graphical presentation
- g) A fiscal expansion: $\uparrow G$
- h) A monetary contraction: $\uparrow i$
- i) Reduced form of the endogenous variables 42



VI(a) Key players

- The key actors in the macro economy:
 - ❖ **Firms:** (domestically) producing (**Y**) and investing (**I**) entities.
 $\Rightarrow Y = \text{GDP}$
 - ❖ **Households:** consuming (**C**) and saving (**S**) entities.
 $\Rightarrow Y^D = Y - T, Y^D = C + S_p, S_p = Y^D - C,$
 - ❖ **Government Agencies:** raise net taxes ($T = T_0 + t \cdot Y - Tr$), spend on public goods (**G**) and pay interest on their debt.
 $\Rightarrow S_g = T - G, BD_g = T - G$
 - ❖ **Central Bank:** controls the interest rates (**i**) through the money supply (**M**).
 - ❖ **Foreign counterparts:** we export products to them (**EX**) and import products from them (**IM**) and exchange financial assets with them.
 $\Rightarrow NX = EX - IM$

$$Y = C + G + I + EX - IM .$$

VI(b) Behavioral (simultaneous) equations for the endogenous variables

Consumer Spending:	$C = f(Y^D, i, P, \text{wealth})$	$= c_0 + c_1 Y^D - c_2 i$
Firms' Investment:	$I = f(Y, i)$	$= b_0 + b_1 Y - b_2 i$
Exports:	$X = f(Y^W, e)$	$= x_0 (Y^W, e)$
Imports:	$IM = f(Y, e)$	$= m_0 + m_1 Y$

⊕ *Real / Nominal terms?*

VI(c) Exogenous variables

Government Spending	G	A fiscal instrument
Net Taxes	t, T_0, Tr	A fiscal instrument
Interest Rate	i	A monetary instrument
GNP of the world	Y^W	
Price level	P	

⊕ *Real / Nominal terms?*

VI(d) Identity (definition) equations

GNP:	$Y \equiv C + I + G + EX - IM$
NNP:	$Y_N \equiv Y - D$
GDP:	GNP + recipients of factor income from the rest of the world – payment of factor income to the rest of the world
National Income:	NNP – Indirect taxes.
Net Taxes:	$T \equiv T_0 + t * Y - Tr$
Disposal Income:	$Y^D \equiv Y - T$
Private Savings:	$S_p \equiv Y^D - C$
Government Saving:	$S_g \equiv T - G, BD_g \equiv T - G$
Total Savings of the economy:	$S \equiv S_p + S_g$
Total Investment of the economy:	$\equiv I + NX$
Trade Surplus: (Net Export)	$NX \equiv EX - IM$
Net Investment:	$I_N \equiv I - D = \Delta K$
Capital:	$K_t \equiv K_{t-1} + I_t - D_t \equiv K_{t-n-1} + \sum_{t-n}^t I_j - \sum_{t-n}^t D_j$
Productivity	$A \equiv \# \text{ of units produced by one unit of labor}$

VI(e) Equilibrium condition in goods market

Agg. supply = $Y = C + I + G + EX - IM = \text{Agg. Demand (ZZ)}$

$$Y^* = \frac{1}{\{1 - [(1-t)c_1 + b_1 - m_1]\}} * \{[c_0 + b_0 + G - c_1 T] + [x_1 - m_0] - [c_2 + b_2] i\}$$

$$Y^* = \frac{1}{(1-\beta)} * A$$

Multiplier * Autonomous Spending

$Y^* = a_1 - a_2 i$, which is the **IS curve**

Where:

$$a_1 = \frac{1}{\{1 - [(1-t)c_1 + b_1 - m_1]\}} * [c_0 + b_0 + G - c_1 T] + [x_1 - m_0]$$

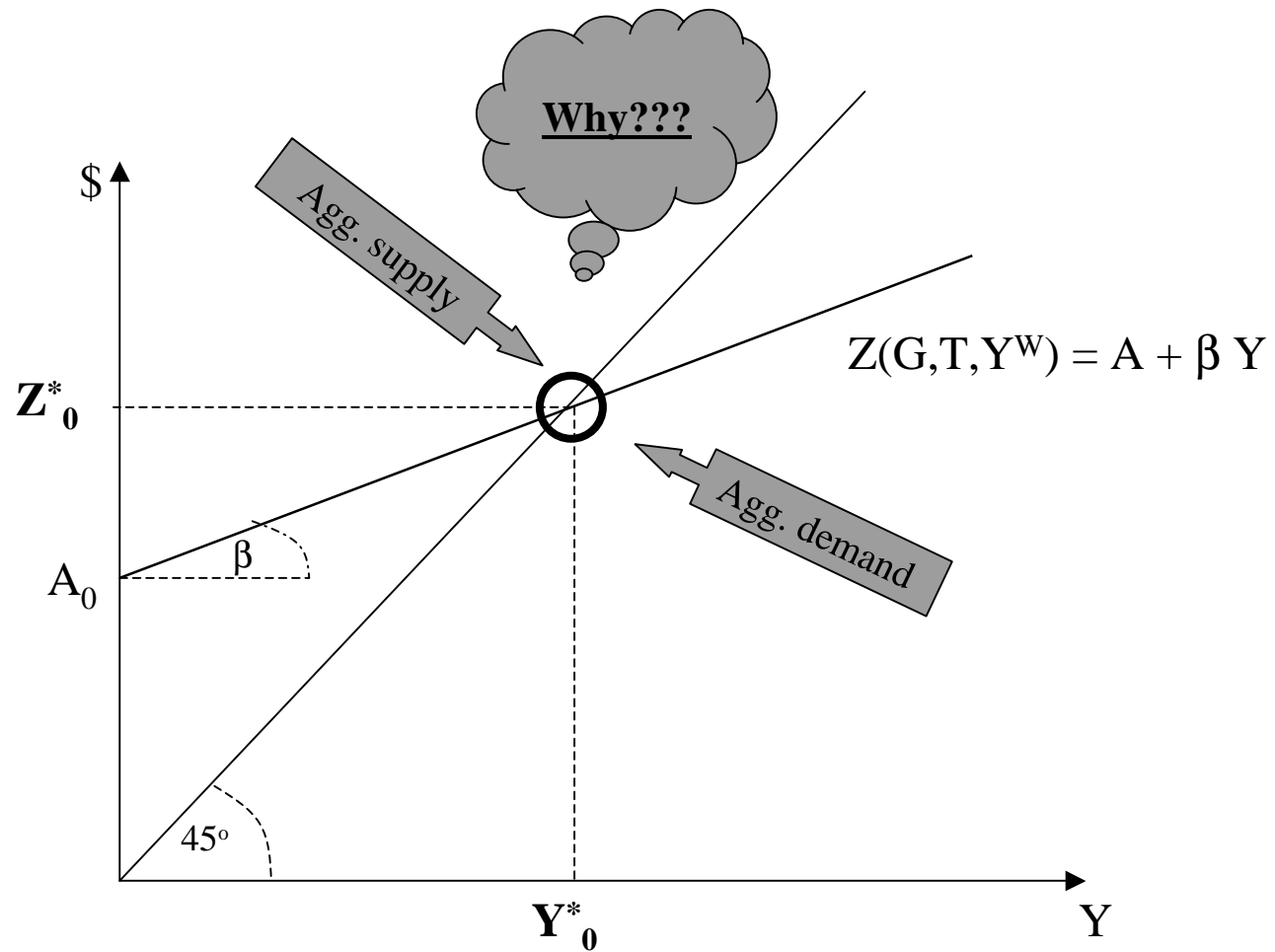
$$a_2 = \frac{1}{\{1 - [(1-t)c_1 + b_1 - m_1]\}} * [c_2 + b_2]$$

VI(i) The Reduced form of the endogenous variables &

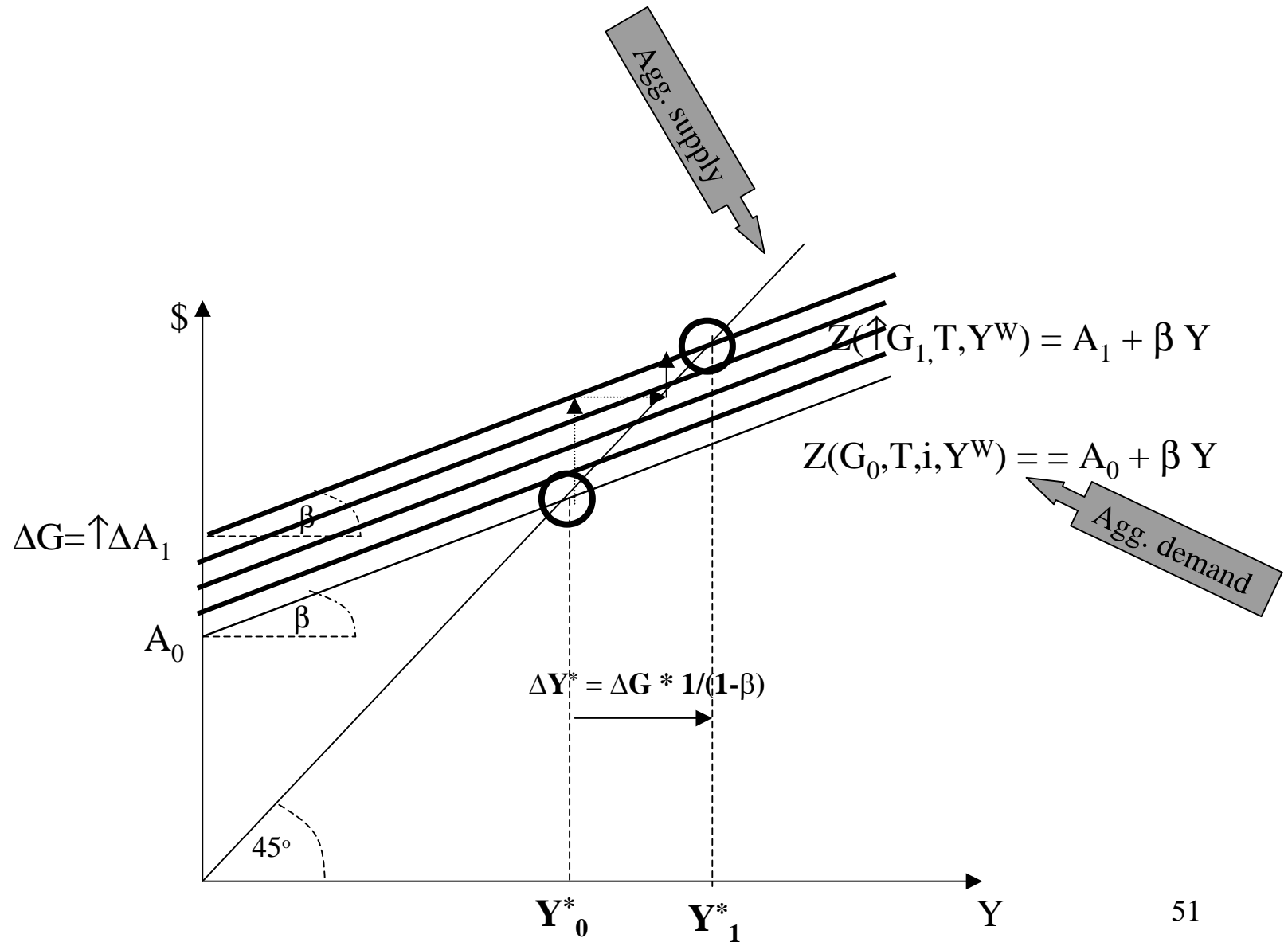
$C =$	$f(G, T, i, Y^W)$
$I =$	$f(G, T, i, Y^W)$
$X =$	$f(G, T, i, Y^W)$
$M =$	$f(G, T, i, Y^W)$
$\Rightarrow Y =$	$f(G, T, i, Y^W)$

& Obtained by substituting Y^* and the identities
in the above simultaneous behavioral equations

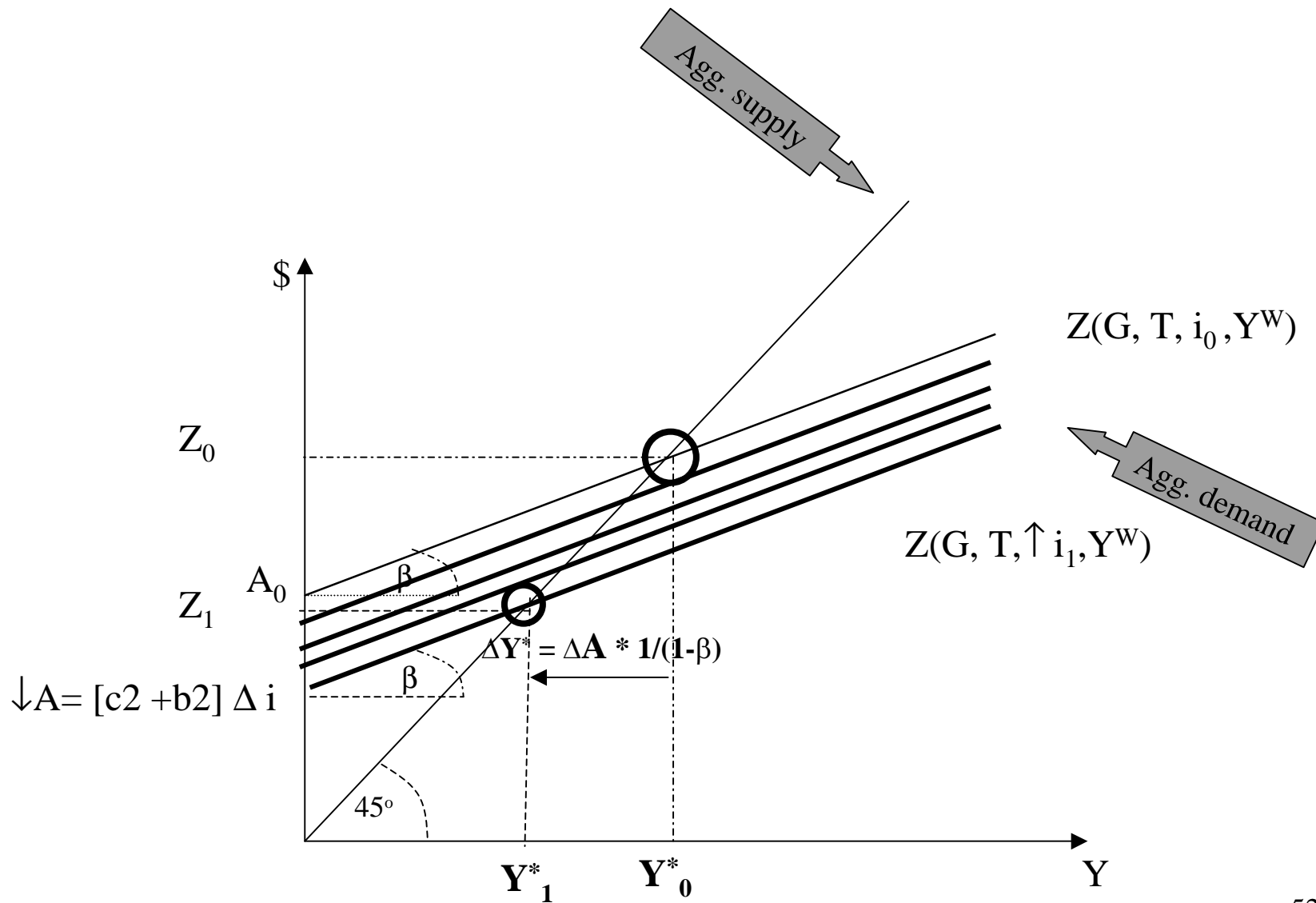
VI(f) A graphical presentation



VI(g) A fiscal expansion: $\uparrow G$



VI(h) A monetary contraction: $\uparrow i$



Exercise:

1. Suppose $T = t Y$. Find equilibrium output for this case. How does the multiplier here compare to the multiplier in the case where taxes do not depend on income?
2. If taxes depend on income, show the effect on equilibrium output of an increase in the tax rate. First show the result graphically and then find the precise mathematical expression for the change in equilibrium output.
3. In the early 1980s, President Ronald Reagan proposed a cut in the tax rate. He argued that such a cut would stimulate the economy so much that the government's budget deficit would be reduced. Is this possible in our model (again, supposing that taxes depend on income). Prove your answer mathematically.
4. Suppose that imports depend on domestic income: $IM = m_0 + m_1 Y$. Also suppose that taxes depend on income. Find the mathematical expression for equilibrium output. How does the multiplier here compare to the multiplier in the case where imports does not depend on income?

Answers

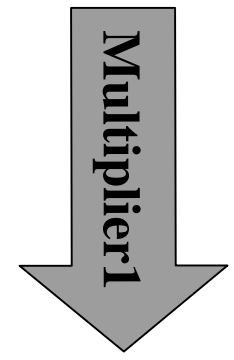
$$Y^* = \frac{1}{1-\beta} * A$$

$$Y^* = \frac{1}{\{1-[(1-t)c_1 + b_1 - m_1]\}} * \{[c_0 + b_0 + G - c_1 T] + [x_1 - m_0] - [c_2 + b_2] i\}$$

$$Y^* = \frac{1}{\gamma + t c_1} * A \quad \text{where} \quad \gamma = 1 + c_1 + b_1 - m_1$$

$$BD = G - T = G - \{t*Y + T - Tr\} = G - T + Tr - \frac{A t}{\gamma + c_1 t}$$

$$\Rightarrow \partial BD / \partial t = - \frac{\gamma A}{[\gamma + c_1 t]^2} < 0$$



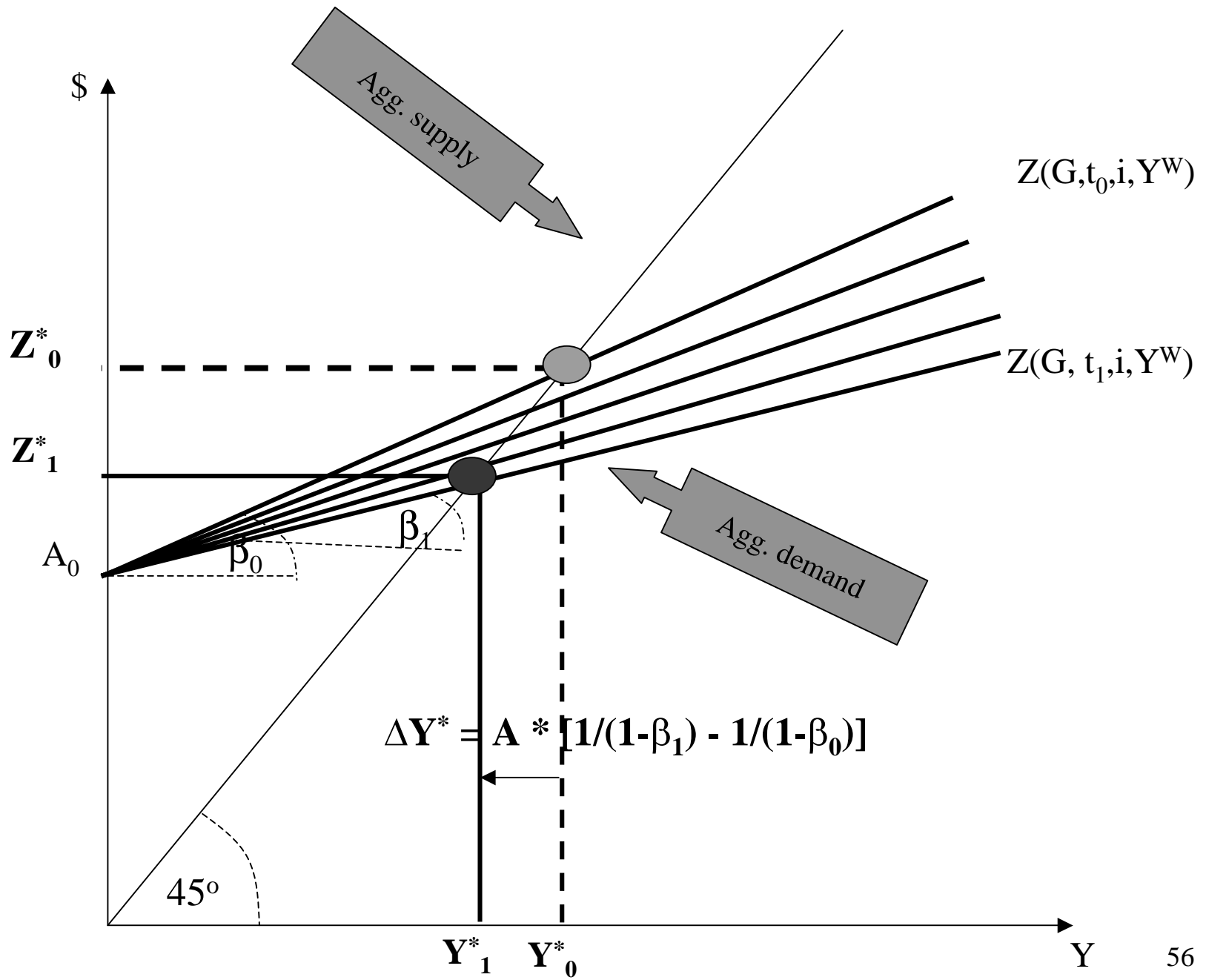
Therefore:

$$t \uparrow \longrightarrow (1-t) \downarrow \longrightarrow [(1-t)c_1 + b_1 - m_1] \downarrow \longrightarrow \beta \downarrow \longrightarrow (1-\beta) \uparrow \longrightarrow \frac{1}{1-\beta} \downarrow$$

$$m \uparrow \longrightarrow [(1-t)c_1 + b_1 - m_1] \downarrow \longrightarrow \beta \downarrow \longrightarrow (1-\beta) \downarrow \longrightarrow \frac{1}{1-\beta} \downarrow$$

Therefore::

$$\Delta Y^* = \Delta \frac{1}{1-\beta} * A \longrightarrow \Delta Y^* = \left\{ \frac{1}{1-\beta_1} - \frac{1}{1-\beta_0} \right\} * A \longrightarrow Y^* \downarrow$$



Notes:

- **Y:** is the total gross national production (GNP). It also the **aggregate supply provided by the equilibrium in the labor market.**
- **C:** is the total purchases of goods and services made by the consumers/households. Sometime we exempt new houses.
- **I:** is all domestic gross accumulated durable productive goods (tangible and non- tangible) and knowledge by the producers/firms. Sometime it includes private new houses (residential investment), as well.
- **G:** is all the purchases of goods and services made by the government, NOT including government transfers or interest rate payments. **Government outlays** include them all.
- **T:** is the total taxes levied minus social transfers.
- **D:** is the depreciation- the using up of capital accumulated created in earlier periods through wear, tear, loss, obsolescence and displacement– a.k.a. “Capital Consumption Allowance” (CCA).

- c_1 : (the Marginal Propensity to Consume = **MPC**) gives the effect of additional one unit of disposal income on consumption. It is negatively correlated with the price level and positively correlated with the private wealth. For convenience, we won't explicitly carry this over all the time. Note, $0 < \mathbf{MPC} < 1$. It could change with level of income and be different from one consumer to another. In this model we assume a unique constant MPC for all consumers. Note also, that $(1 - c_1)$ is the Marginal Propensity to Save = **MPS**, which gives the effect of additional one unit of disposal income on saving.
- m_1 : (the Marginal Propensity to Import = MPI) is negatively correlated with the exchange rate level (the price of one unit of foreign currency in terms of domestic currency- e), which is also negatively correlated with the domestic interest rate. Again, for convenience, we won't explicitly carry this over all the time. For some analyses, it might be useful to partition the import – for consumption and for investment.
- x_0 : is positively correlated with the exchange rate level. Again, for convenience, we won't explicitly carry this over all the time.
- β : is the marginal propensity to purchase from domestic production.

VII. The Investment Saving Equilibrium

In equilibrium in the goods market :

$$\text{Agg. supply} \rightarrow Y = C + G + I + NX \leftarrow \text{Agg. demand}$$

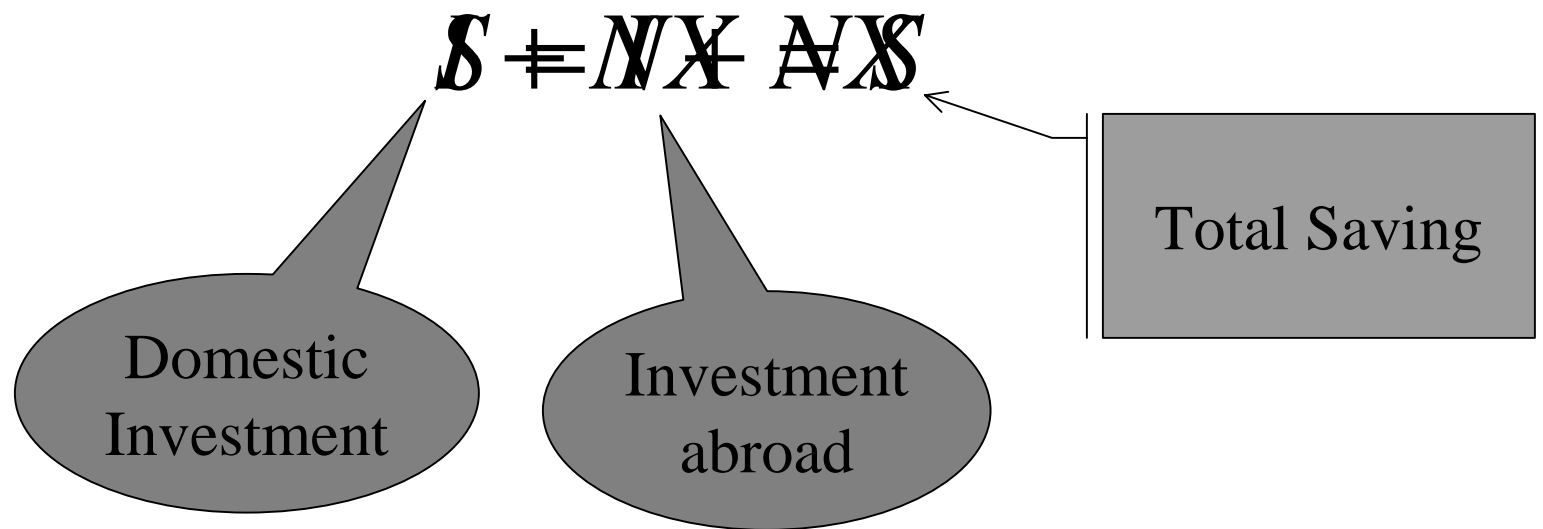
$$Y - C - G = I + NX$$

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

$$Y^D - C + T - G = I + NX$$

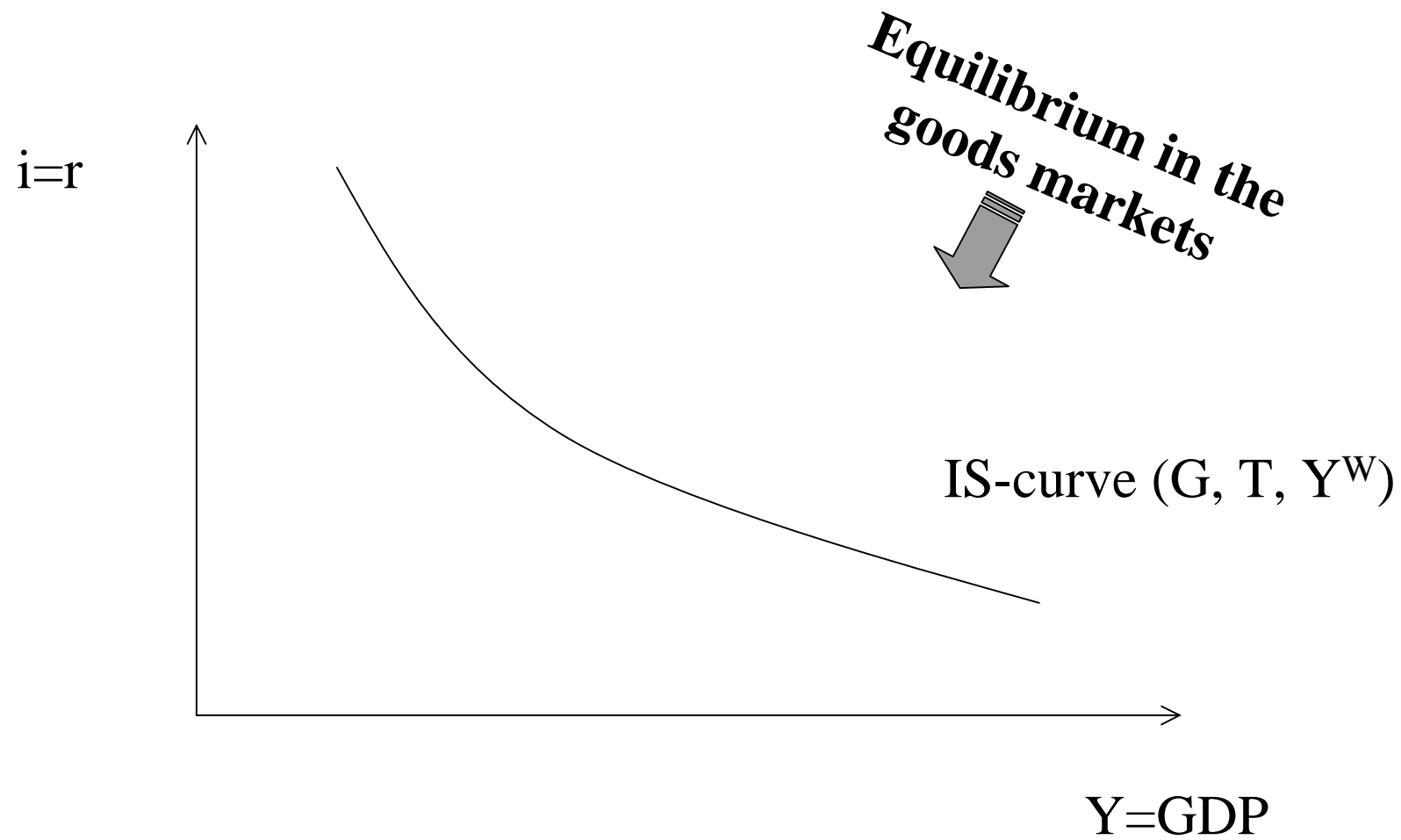
$$S_p + S_g = I + NX$$

$$S = I + NX$$



⇒ **Total Investment = Total Saving**

Notice that the above equations depend, inter alia, on two variables: i and Y .



VIII. IS Curve

- a) Definition
- b) The derivation of the IS curve
- c) Shifts of the IS curve

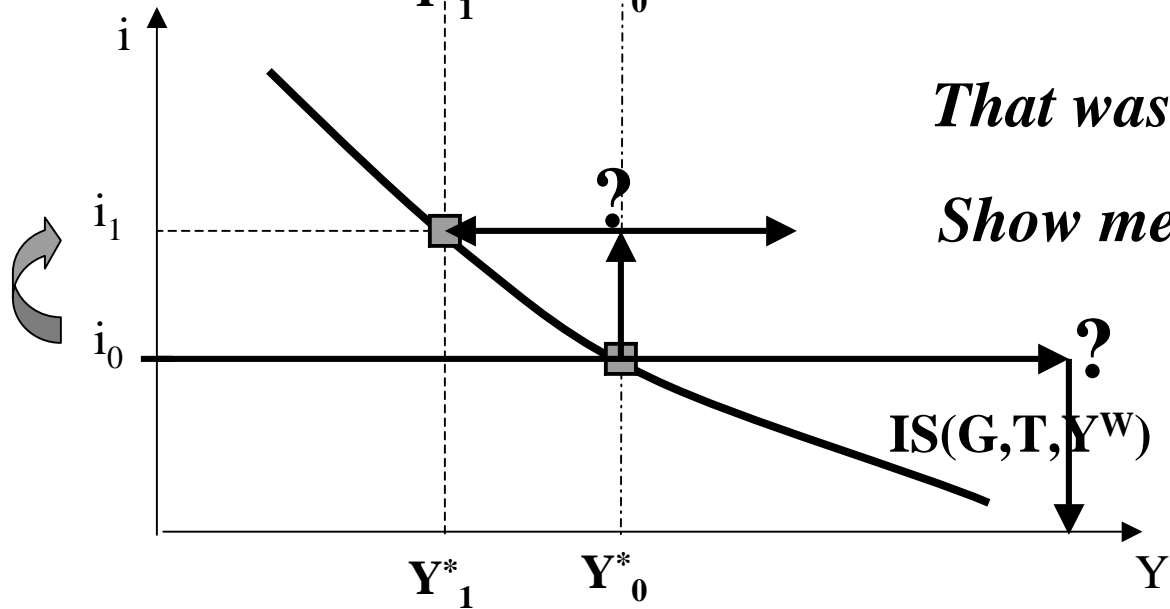
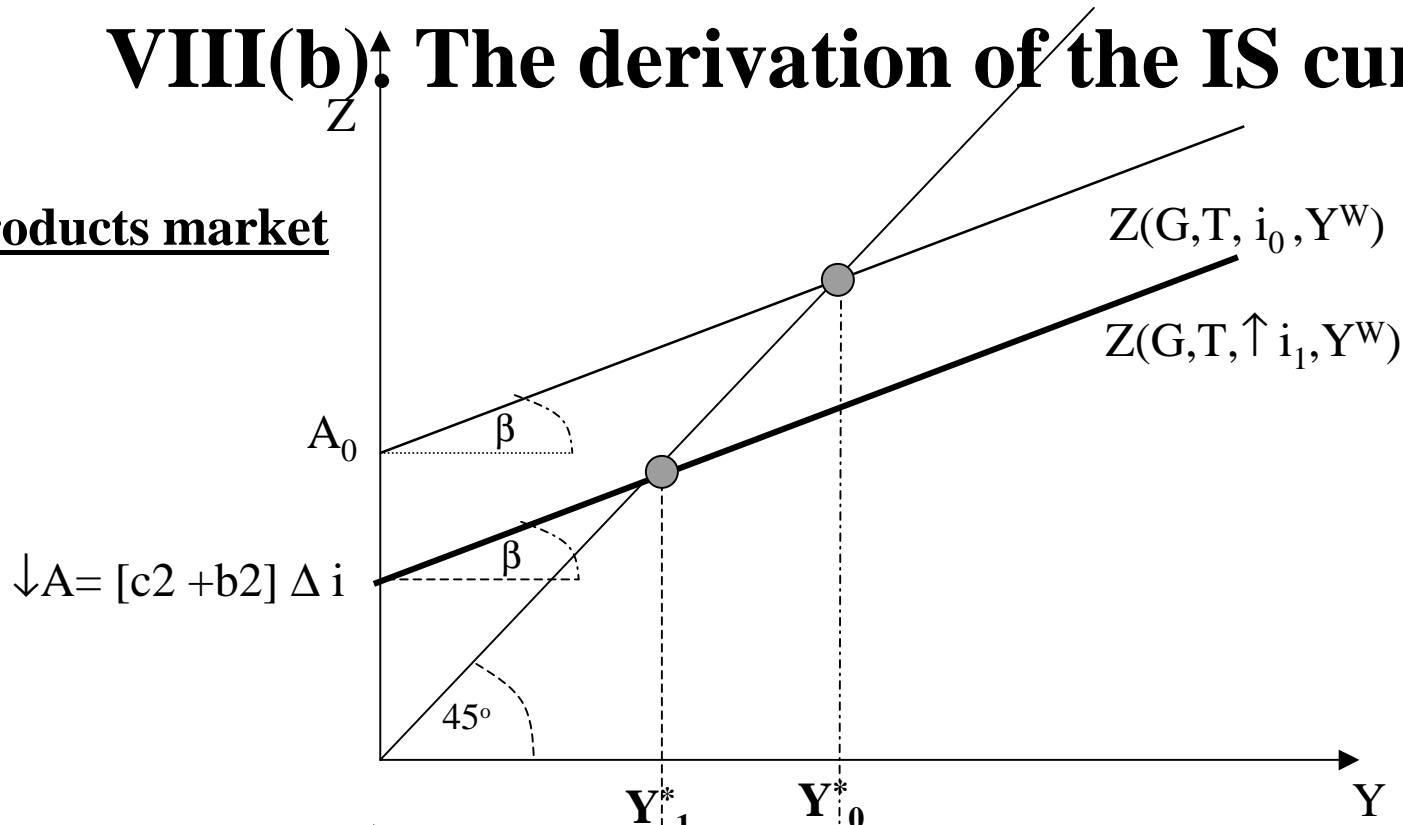
VIII(a). IS Curve- Definition

- The IS curve gives the pairs (Y,i) that support the equilibrium in the products market, given a fiscal policy.

\Rightarrow *Endogenousing i .*

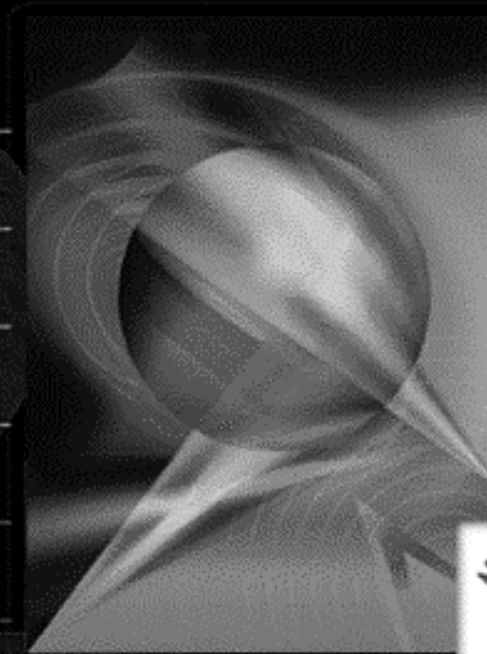
VIII(b) The derivation of the IS curve

Products market



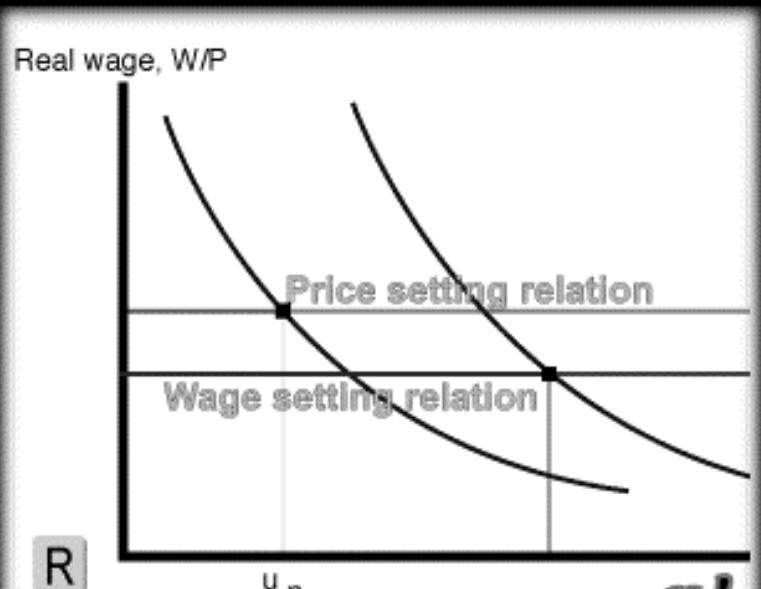
The derivation of the IS curve

Active Graphs to accompany
Macroeconomics



ACTIVE GRAPH

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Real wage, W/P

Price setting relation

Wage setting relation

u_n

Unemployment rate, u

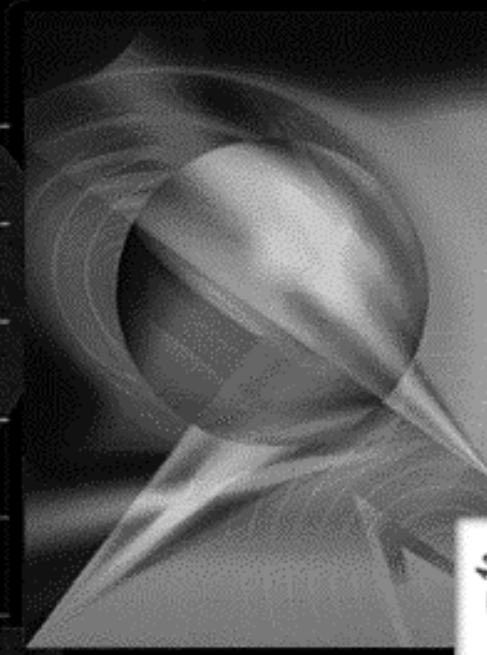
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VIII(c). Shifts of the IS curve

Active Graphs to accompany
Macroeconomics



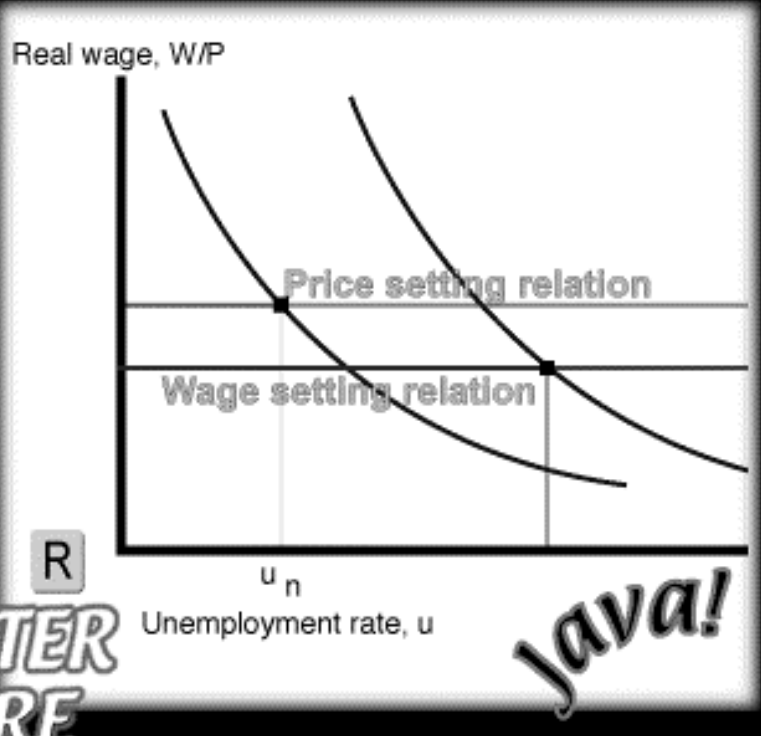
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Real wage, W/P

Price setting relation

Wage setting relation

u_n

Unemployment rate, u

R

Note:

- **The IS curve is flatter:**
 - (a) the greater is the investment and consumption sensitivity to interest rates,
 - (b) the greater is the investment and consumption sensitivity to income.

IX. LM Curve

- a) Definition
- b) Money Demand Curve Shifts of the IS curve
- c) The Quantity Theory
- d) Money Supply Curve
- e) The Equilibrium in the Money Market
- f) The Interest rate determination in the money market
- g) The derivation of the LM curve
- h) Shifts of the LM curve

IX(a). LM Curve- Definition

- The LM curve gives the pairs (Y,i) that support the equilibrium in the financial market, given a monetary policy.

\Rightarrow *Endogenous* i .

IX(b). Money Demand Curve

- In holding your wealth accumulated from your savings, you need to decide how to allocate among different financial assets.
- Basically, two types of financial assets are available:
 1. **Perfectly liquid- money** (currency and checkable deposits): can be used for private spending (nominal product-transactions [barter is rare]), precautionary (possible unexpected future transactions), speculative motive (maximizing return on all assets in uncertain world), but it bears zero nominal yields.
 2. **Imperfectly liquid- bonds, stocks, options**: not enough liquid for transaction, precautionary and speculative needs, but bear risky positive expected nominal yields.

Notes:

- We focus on “money = currency and checkable deposits \equiv M1” rather than other assets (+savings +brokerage account)?
 - ⊕I. Traditionally, it was distinctive because it paid no tangible yield and was the only perfectly liquid asset.
 - ⊕II. The central bank was thought to have greater control over its supply.
- How do innovations in the financial market (introduction of credit card) affect demand for money?
- Be careful about defining the spending measure for private money holding: it's not all of GDP. Why? Because remember that this is only the transaction demand component. (What about demand for investment?)

- Therefore, it's clear that the proportions (of perfect and imperfect liquid assets) that you choose depend on two variables:

I. Level of nominal transactions (+): this is highly correlated (proportional) with the private nominal income and spending.

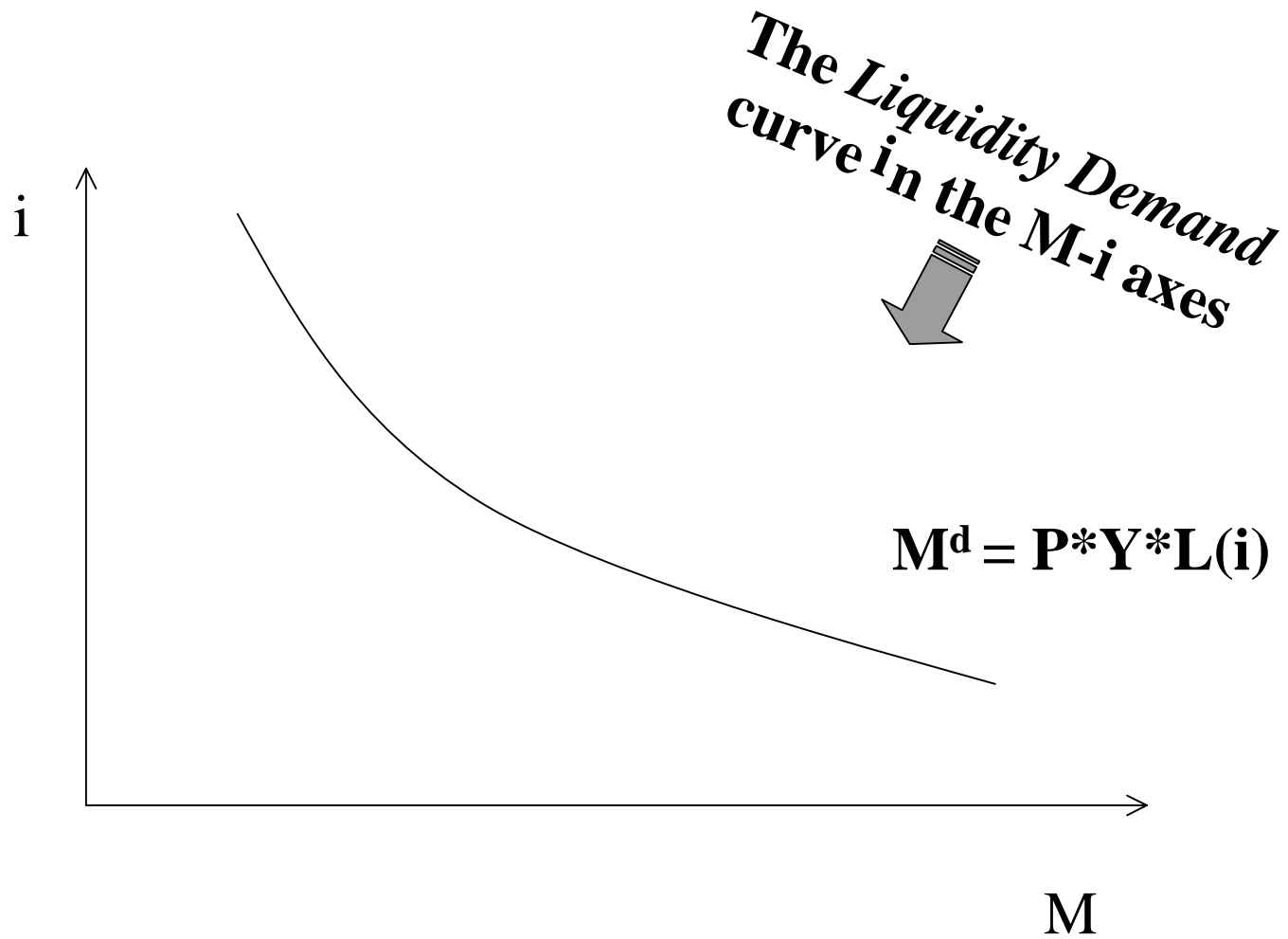
II. Interest rate on bonds (-).

- Therefore, the behavioral demand function for nominal money- M^d :

$$M^d = P * Y * L(i)$$

- **Or, equivalently:**

$$(M/P)^d = Y * L(i)$$

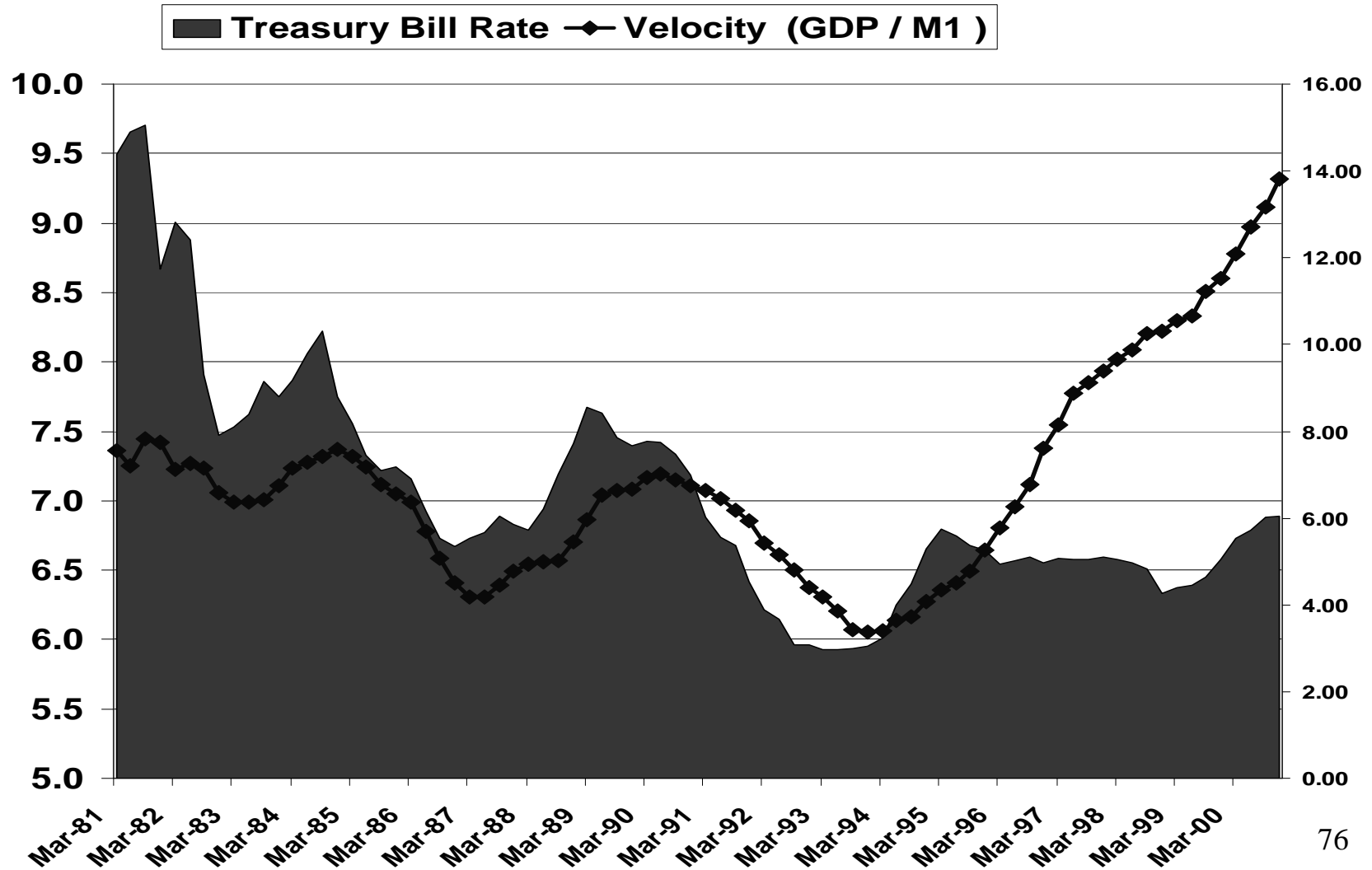


⊕ *How does the demand function for real money look like??*

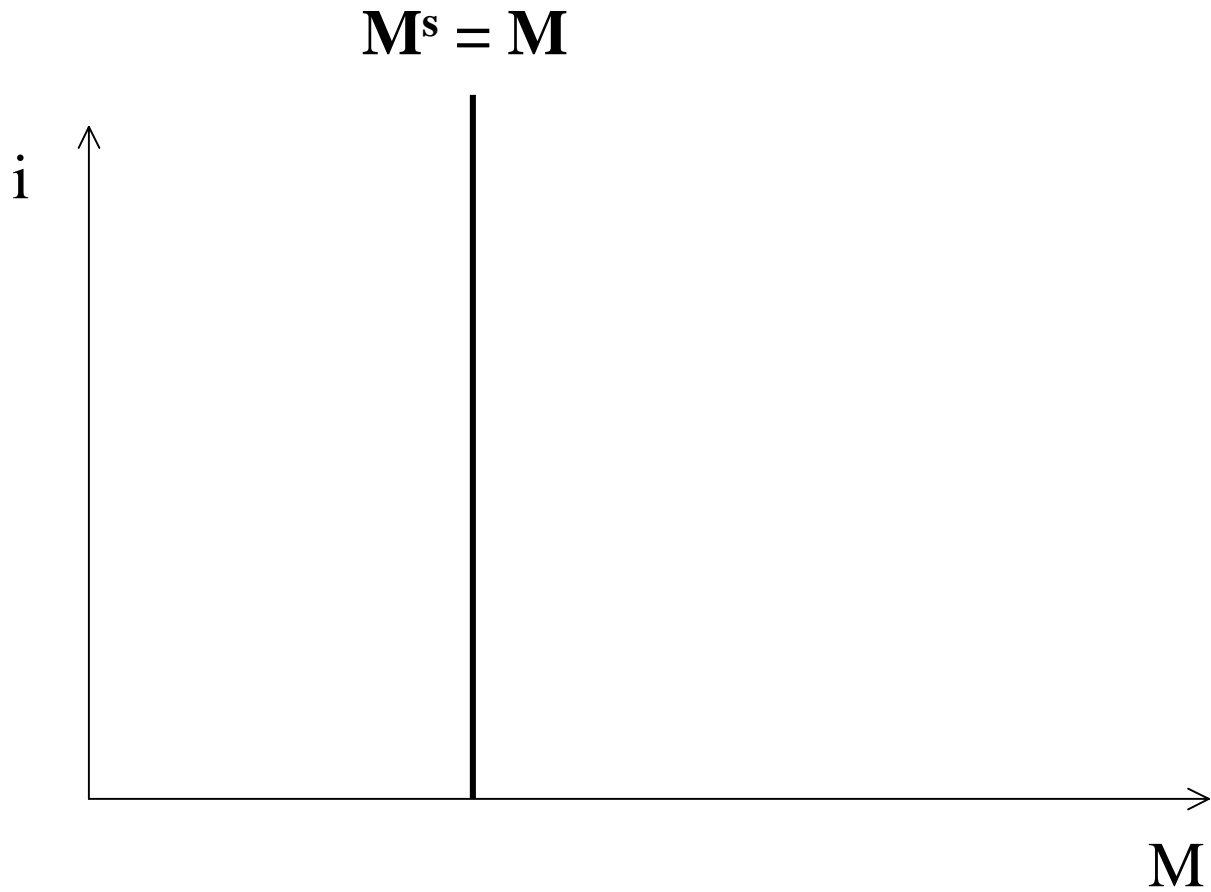
IX(c). The Quantity Theory

- Define: velocity of money $\equiv v \equiv P*Y/M$. -This is called the quantity equation.
- In words- the ratio of nominal income to money is higher, the number of transactions for a given quantity of money is higher, and it must be the case that money is changing hands faster. Put another way, the velocity is higher.
- **Strict monetarism** asserts, in the long run, $Y (=Y_n)$ and v are fixed in equilibrium. Therefore, $P*Y = M * v$, which means that the Fed can have a strict control over inflation via its control of the money (usually, was thought M1).
- Empirically, velocity is not fixed; rather it is sensitive to interest rates.
- See graph below.
- Still, the Fed can control the inflation via its grip on the money, but (1) not as easy as it was thought, and (2) not by only controlling M1.

The Velocity of Money (M1) vs. the Treasury Bill Rate

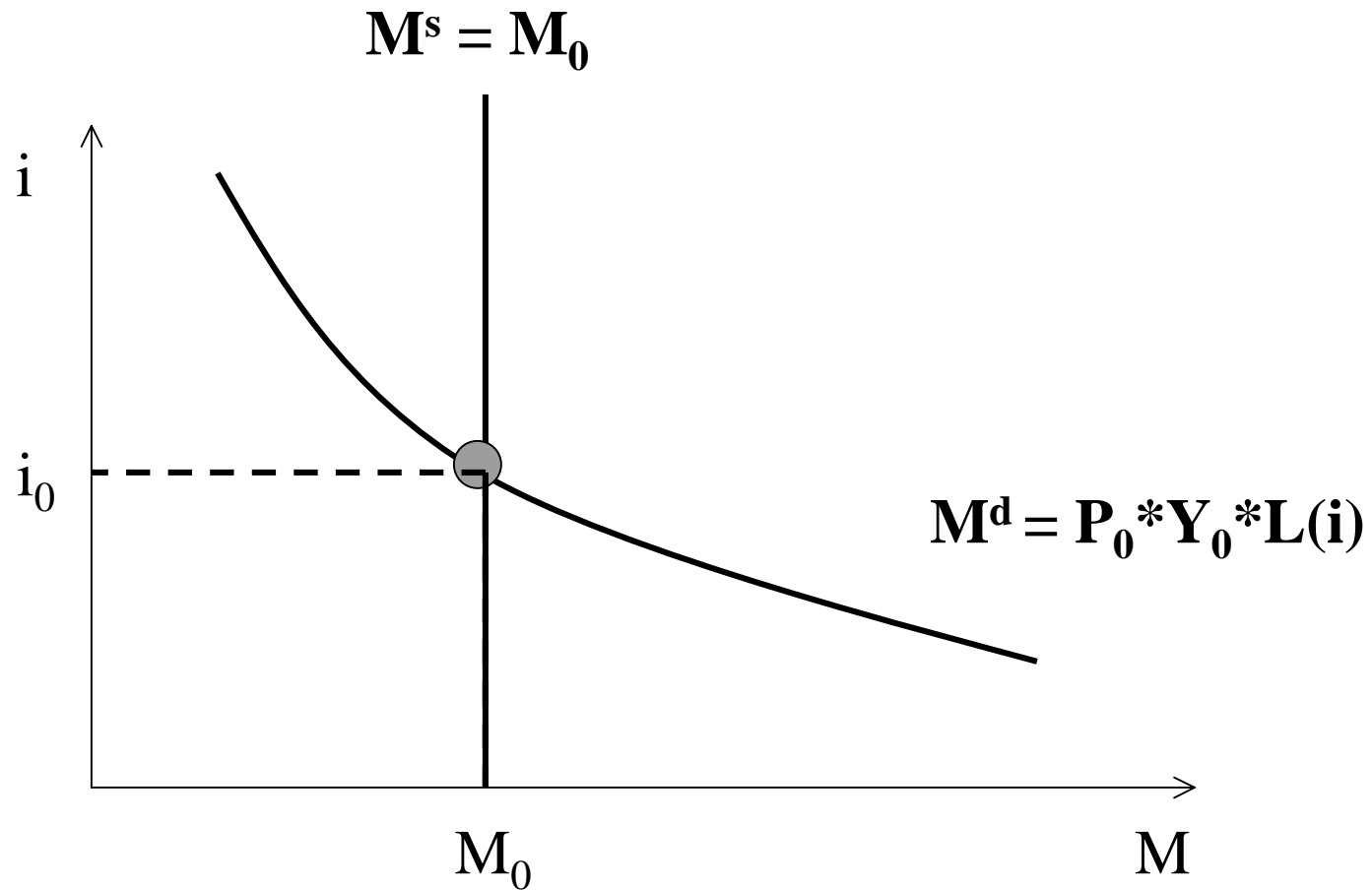


IX(d). Money Supply Curve



⊕ *How does the supply function for real money look like??*

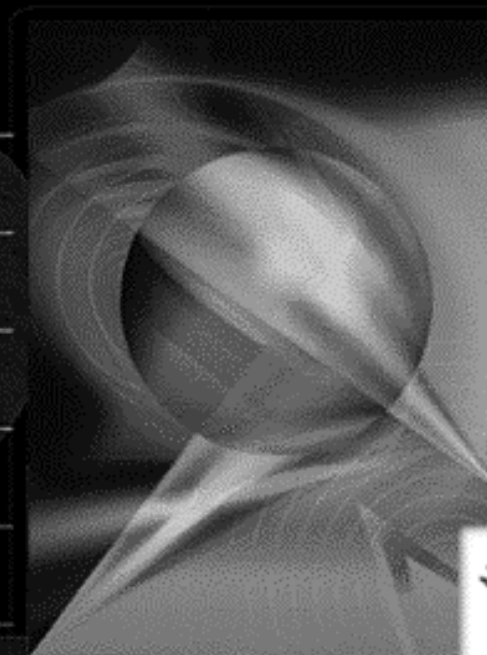
IX(e). The Equilibrium in the Money Market



⊕ *How does the equilibrium in real money terms look like??*

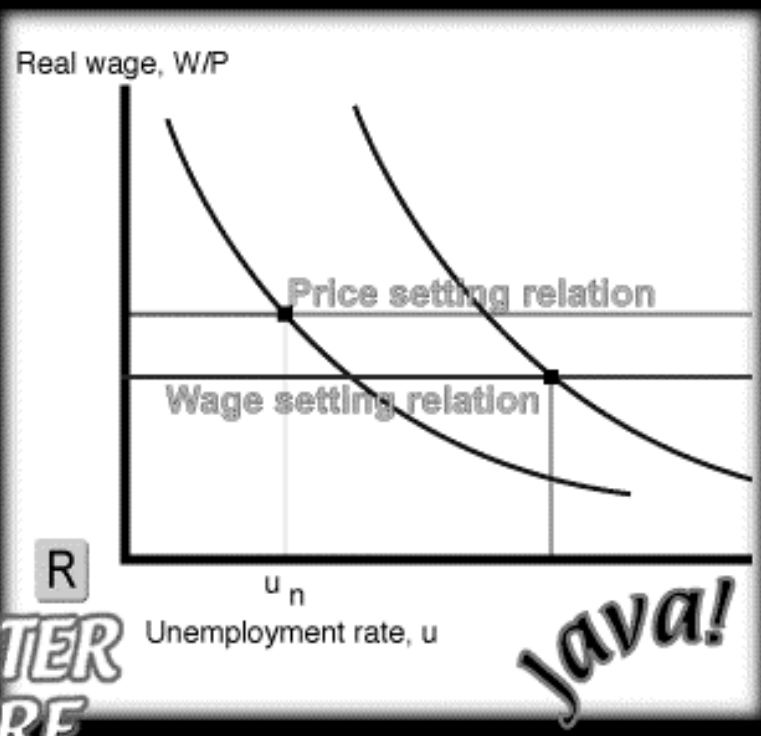
IX(f). The Interest rate determination in the money market

Active Graphs to accompany
Macroeconomics



ACTIVE GRAPH

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Real wage, W/P

Price setting relation

Wage setting relation

u_n

Unemployment rate, u

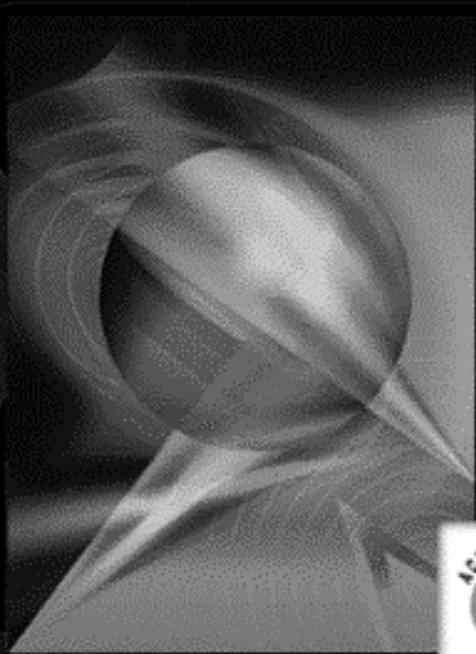
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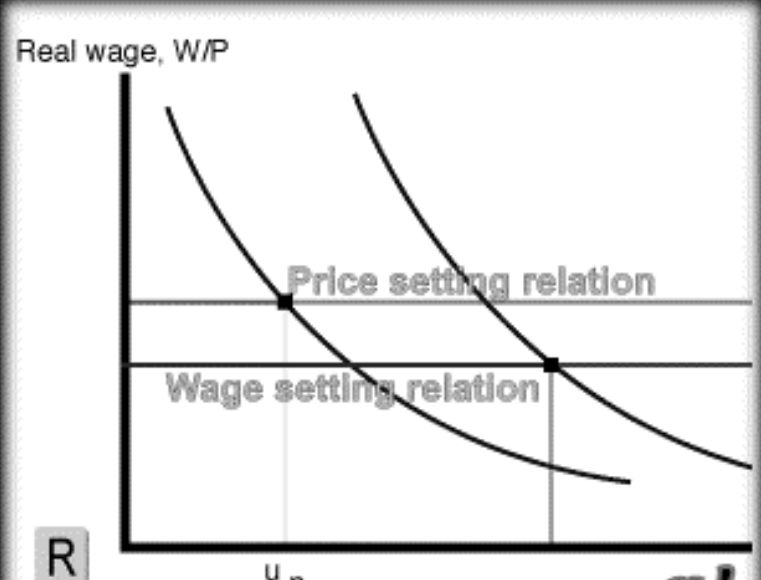
IX(g) The derivation of the LM curve

Active Graphs to accompany
Macroeconomics



ACTIVE GRAPH

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Real wage, W/P

Price setting relation

Wage setting relation

R

u_n

Unemployment rate, u

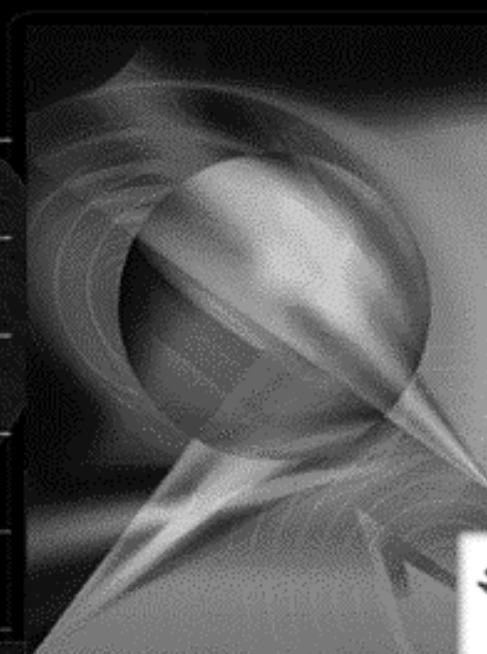
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IX(h). Shifts of the LM curve

Active Graphs to accompany
Macroeconomics



Real wage, W/P



Price setting relation

Wage setting relation

u_n

Unemployment rate, u

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Java!

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X. IS-LM


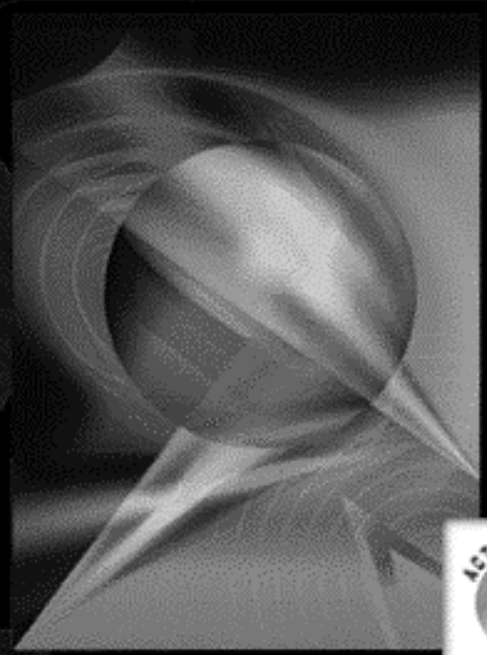
- a) IS/LM: Effects of a tax increase
- b) IS/LM: Effects of a monetary expansion
- c) IS/LM: Clinton-Greenspan mix and policy coordination
- d) IS/LM: Dynamic effects of monetary contraction
- e) Fiscal and monetary efficacy

In each of the following exercises, show the effect on the national accounts as follows:

	A	B	C	D
C				
G				
I				
Ex				
Im				
Y				
i				
P				

X(a). IS/LM: Effects of a tax increase

Active Graphs to accompany
Macroeconomics



Real wage, W/P

Price setting relation

Wage setting relation

u_n

Unemployment rate, u

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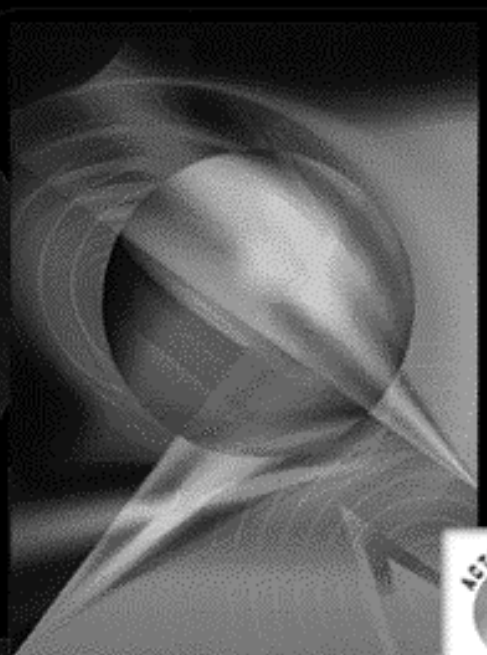
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X(b). IS/LM: Effects of a monetary expansion

Active Graphs to accompany
Macroeconomics



Real wage, W/P

Price setting relation

Wage setting relation

R

u_n

Unemployment rate, u

ENTER HERE

Java!

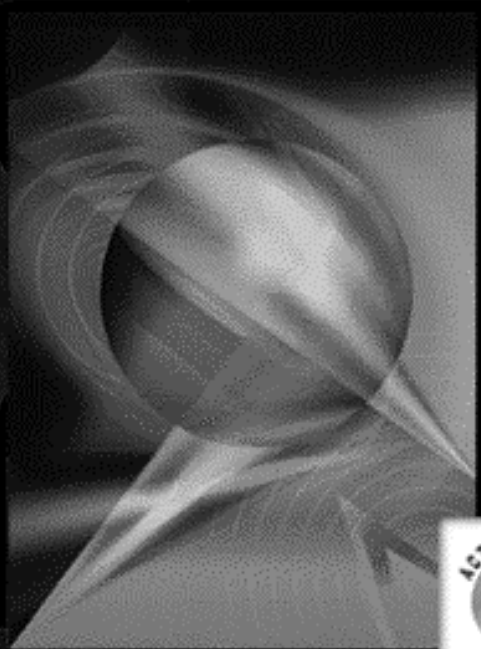
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The figure is a graph with 'Real wage, W/P ' on the vertical axis and 'Unemployment rate, u ' on the horizontal axis. Two downward-sloping curves are shown: the upper one is labeled 'Price setting relation' and the lower one is labeled 'Wage setting relation'. A horizontal line intersects the 'Price setting relation' curve at a point corresponding to an unemployment rate of u_n on the horizontal axis. Another horizontal line, lower than the first, intersects the 'Wage setting relation' curve at a higher unemployment rate. A small box containing the letter 'R' is located near the bottom left of the graph area.


X(c). IS/LM: Clinton-Greenspan mix and policy coordination

Active Graphs to accompany
Macroeconomics



ACTIVE GRAPH

**ENTER
HERE**



Real wage, W/P

Price setting relation

Wage setting relation

u_n

Unemployment rate, u

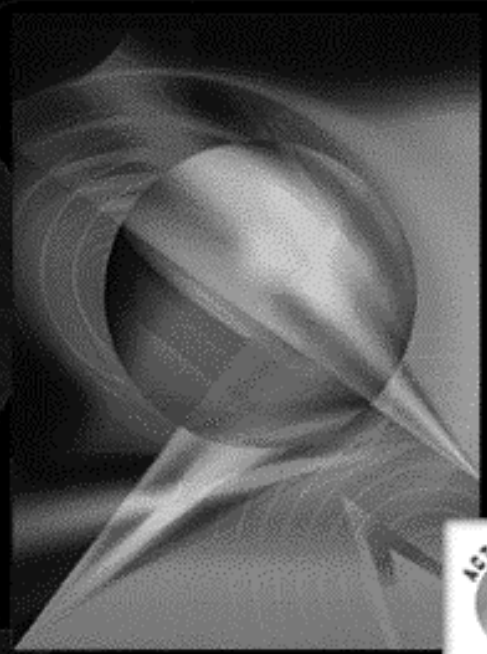
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X(d). IS/LM: Dynamic effects of monetary contraction

Active Graphs to accompany
Macroeconomics



Real wage, W/P

Price setting relation

Wage setting relation

R

u_n

Unemployment rate, u

**ENTER
HERE**

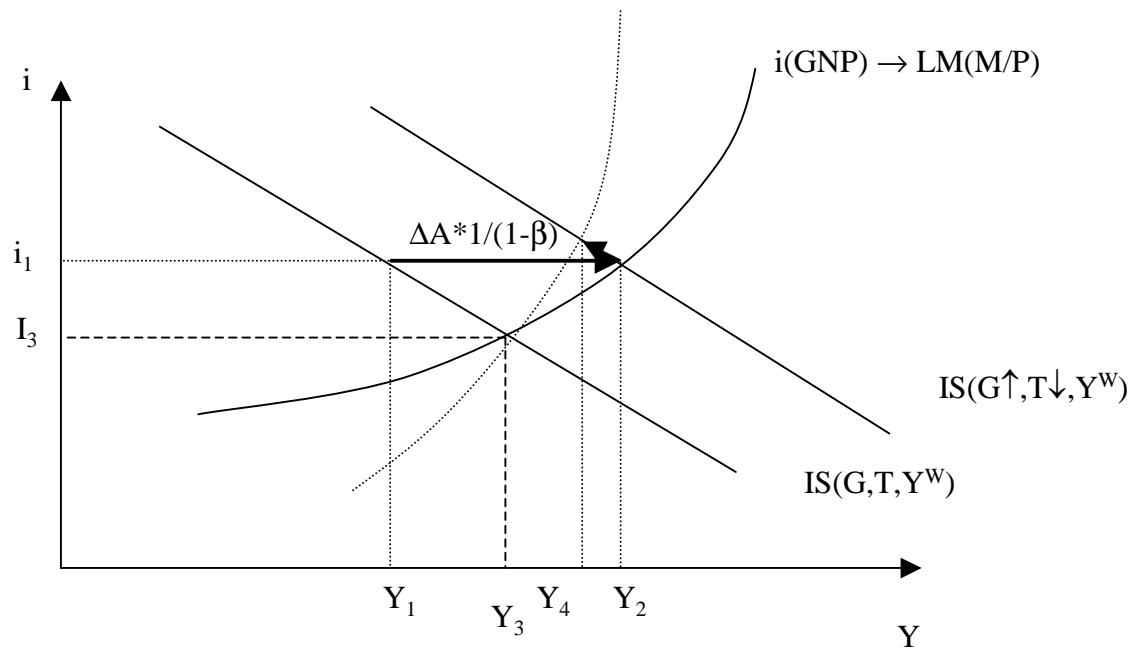
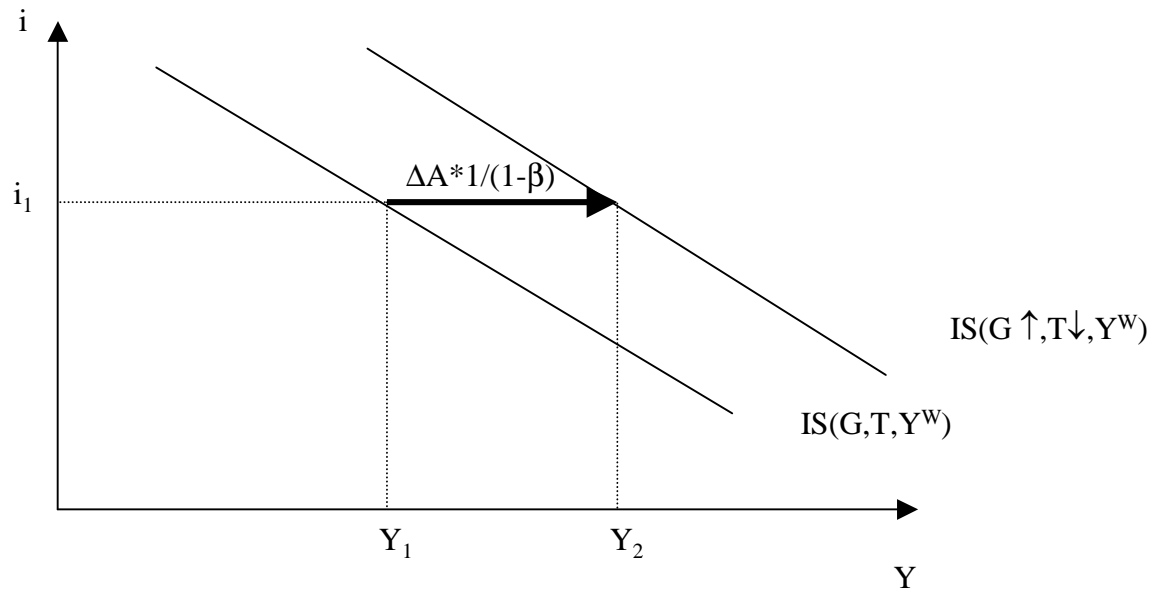
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X(e). Fiscal and monetary efficacy

- Fiscal instruments: G & T
 - Expansionary fiscal policy = $\uparrow G$ or/and $\downarrow T$.
- Monetary instruments: i .
 - Contractionary monetary policy = $\uparrow i$.
- What is the effect of expansionary fiscal policy on Y , C & I : $\uparrow G = \Delta G$ from G_1 to G_2 ($G_2 > G_1$)?
- By how much does the GNP change, while holding interest rate fixed?
- By how much does the GNP change, if instead $\downarrow T$ by the same amount of ΔG , while holding interest rate fixed?
- By how much does the GNP change, if we maintain a budget balance ($\uparrow G = \downarrow T$), while holding interest rate fixed?
- By how much does the GNP change as a result of $\uparrow G = \Delta G$, while the Fed responds to changes in the GDP?
- What if the Fed has a tighter response (strict inflation and GNP target)?



Conclusions:

- Deficit Reduction will change the economy, but it might not boost the unemployment enough due to strict Fed inflationary target.
- Fiscal expansionary policy might be offset by contractionary monetary policy.
- Contrary to what is often stated by politicians, a reduction in the budget does not necessarily lead to an increase in investment.
- The flatter IS (high sensitivity of output to interest rate) the more effective the monetary policy (need small changes in interest rate to achieve the same change in output).
- The steeper LM (strict inflation target by the Fed) the less effective the monetary policy (changes in G or T have less affect on changing the output).

XI. Labor Market

- a) Overview
- b) Some world wide facts
- c) Definitions
- d) Wage setting equation
- e) Price setting equation
- f) Equilibrium in the labor market and the natural rate of unemployment
- g) Equilibrium unemployment and Output

XI(a) Overview

- A good measurement for growth of the standard of living is: the real output per capita: RGNP/pop.

(USA2000=\$40,000 per year).

- In order to have growth, we need to invest in capital.
- Investing in capital = accumulating durable productive goods (like machines, hardware and software) and knowledge (R&D and human capital). It does not include financial investment.
- Which also means forfeiting current consumption (saving) for higher future consumption. Therefore, investments must be equal to savings. Investing in education may also mean lower current production for higher future production.

XI(b) Some World Wide Key Facts

	1500	1700	1820	1950	1970	2000
	→	→	→	→	→	→
	0%	0.1%	0.8%	1.5%	5%	2%
Agriculture	America	Ind. of USA	Ind. Rev.	Post WWII	Post oil crisis	

- There is a convergence of the Output per Capita among the OECD countries, but not among the African countries.
- Sometimes we even got a leapfrogging: the economic leadership slips from one country to another.
- OECD= The Organization for Economic Cooperation and Development. This organization includes most of the world's rich countries.
- Four Tigers = Singapore, Taiwan, Hong-Kong and South Korea.

XI(c) Definitions

- Population * (1 - dependency rate) = *working age population*
- working age population * labor force participation rate = *labor force*
- labor force * (1 - unemployment rate) = *employees*
- employees * Avg. hours per employee = *hours worked*
- hours worked * Avg. output per hour (“labor productivity”) = *Output*.
- *Productivity* is the # of units produced by one unit of production factor (usually, labor).
- *GNP growth* is the increase in production (could be stimulated by migration, population growth, net investment or productivity growth).
- *Productivity growth* is the increase of # of units produced by one unit of production factor (usually, labor), usually stimulated by investing in infrastructure, education, information, language, social insurance, R&D, etc.

- Two kinds of unemployed:
 - **Voluntary unemployed:** as in searching for a job at a wage higher than they or their peers are being offered: not a sign of dis-equilibrium (U^{VOL})
 - **Involuntary unemployed:** actively searching for a job and would accept the prevailing wage, but no offer forthcoming \Rightarrow labor supply greater than demand at the prevailing wage \Rightarrow Involuntary unemployment creates pressure for (real) wages to fall. ($U - U^{VOL}$)
- **Labor force (L^d)** = Employees (N) + Involuntary unemployed ($U - U^{VOL}$).
- **Labor supply (L^s)** = the total labor units (monthly, weekly or yearly working hours or jobs) offered for a given real wage, other things equal.
- **Unemployment rate (u)** = $(U - U^{VOL}) / L$
- **Non-employment rate** = U/L
- **Participation rate** = $L / \text{Population of working age}$
- $\uparrow U \rightarrow$ often comes hand in hand with **low participation rate**.
U.S. ($u = 4\%$, $pr = 80\%$) France ($u=13\%$, $pr = 65\%$)
- **Separation** negatively depends on age: experience, education level, skill, seniority, social security and family responsibility.

The US CPS

XI(d) Wage setting equation

- Employees care about their wages' purchasing power of products. Therefore, what is important for them is their **real wage** - $W/P \equiv \omega$.
- When unemployment is low, then (a) Workers have more **bargaining power**, and (b) employers are more anxious to pay higher “**efficiency wages**” (*Ford in 1914*). Therefore, real and nominal wages are negatively correlated with unemployment rate.
- $\uparrow U \rightarrow$ Workers are worse-off because (a) probability of losing a job \uparrow (it's easier now for the firms to find a replacement), and (b) probability of finding a job \downarrow (more workers are now competing). Therefore, real and nominal wages are negatively correlated with unemployment rate.
- Most wages are having **rigidities** for some length of time (a year or more) due contracts (wages are *pre-set in advance*). Therefore, nominal wages depend on expected prices (forward looking).
- There is a **reservation real wage**, under which workers won't consider any offer to work. Therefore, real wages are always above this floor.
- **Other factors** that affect real wages include: productivity, unemployment benefits, experience, education level, skill, seniority, social security.

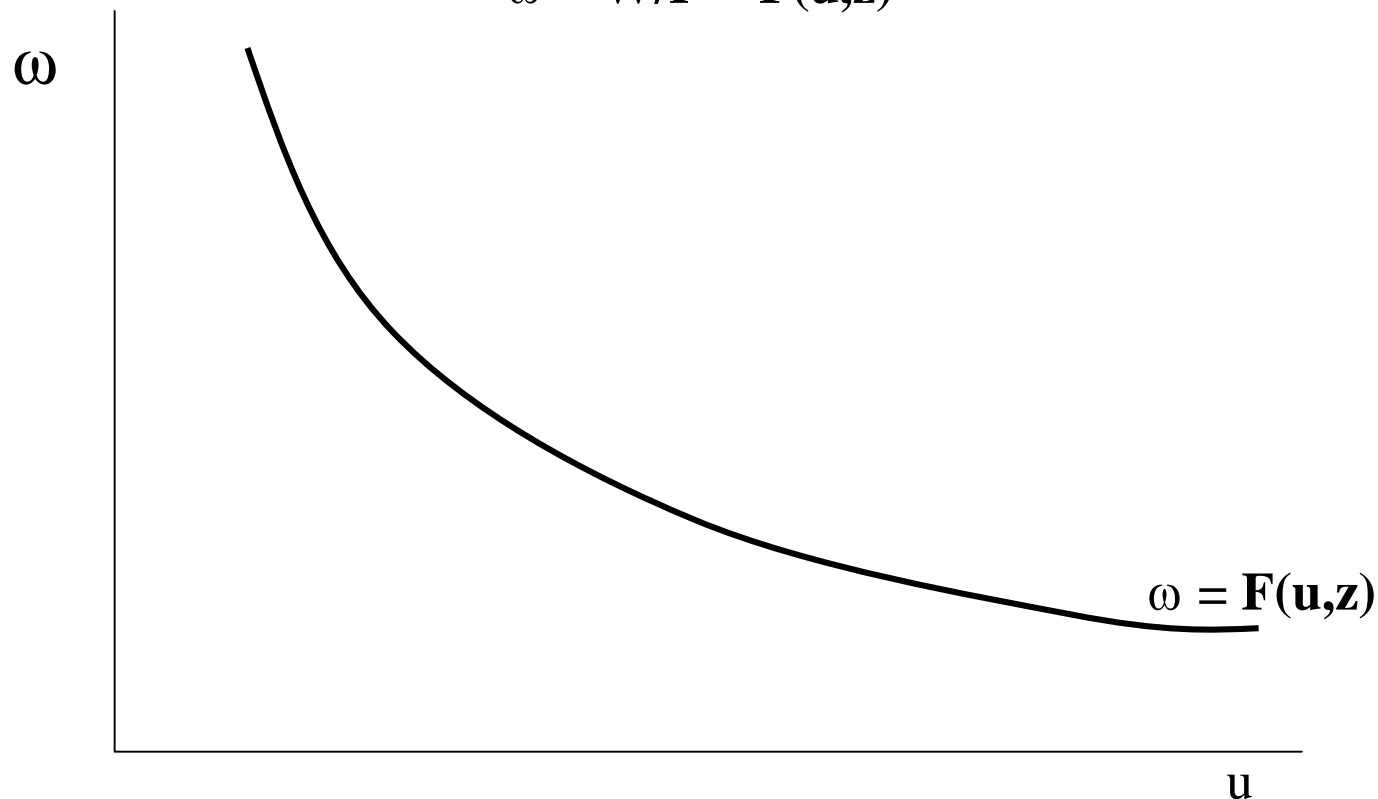
- Therefore, we can write the **wage setting relation** (*the determination of wages given expected prices*):

$$W = P^e F(u, z)$$

$$\omega^e = W/P^e = F(u, z)$$

- If we assume that **expected price equal to actual prices**, then:

$$\omega = W/P = F(u, z)$$



XI(e). Price setting equation

- Now, we turn to talk about the determination of prices given wages.
- As we know from microeconomics, prices (**P**) are equal to the marginal cost of production (**MC**), which is equal to **W/A**, where **A** \equiv productivity.
- Since there are many goods that are not in a full competition, some firms charge a **mark-up** (μ) of price over their marginal cost (“*cost plus pricing*”).
- Therefore, the **price setting relation** is (*determination of prices given wages*):

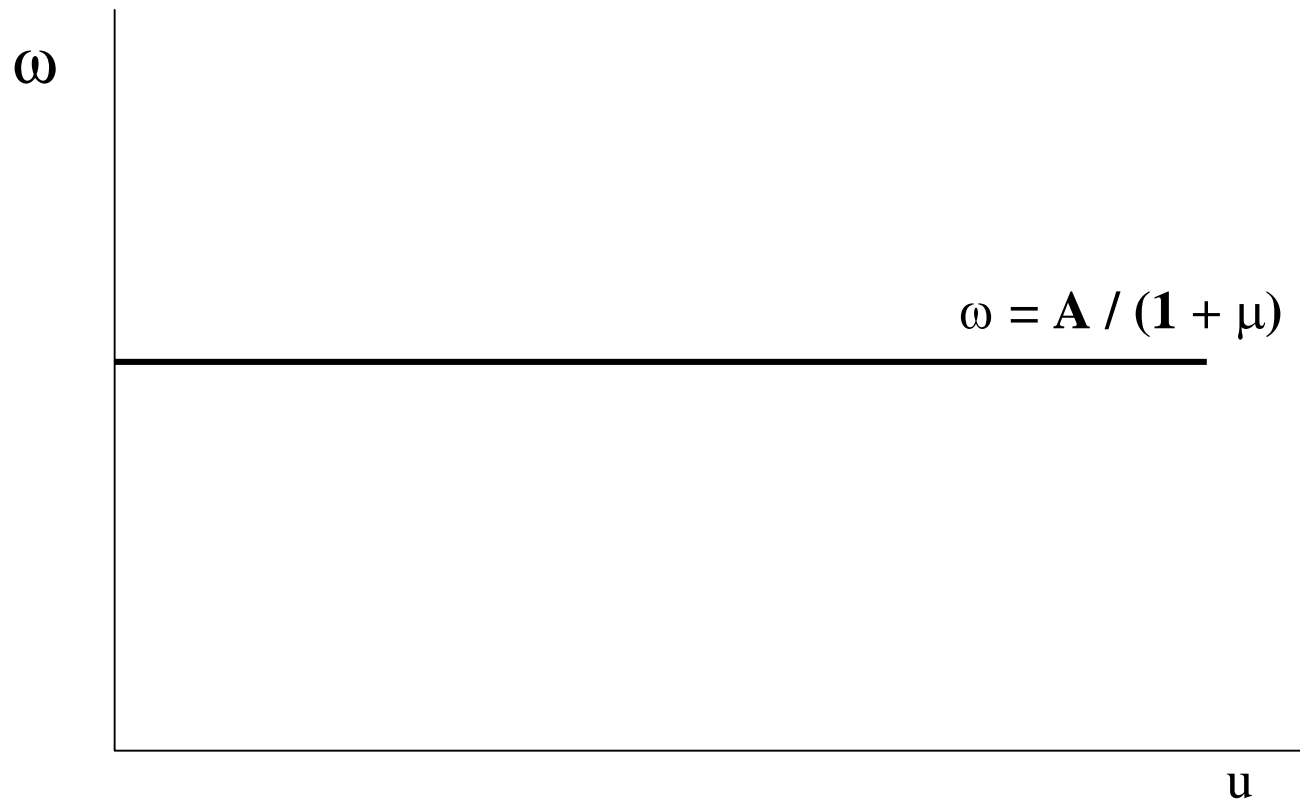
$$P = (1 + \mu) W/A$$

- Which is equivalent to:

$$\omega \equiv W/P = A / (1 + \mu)$$

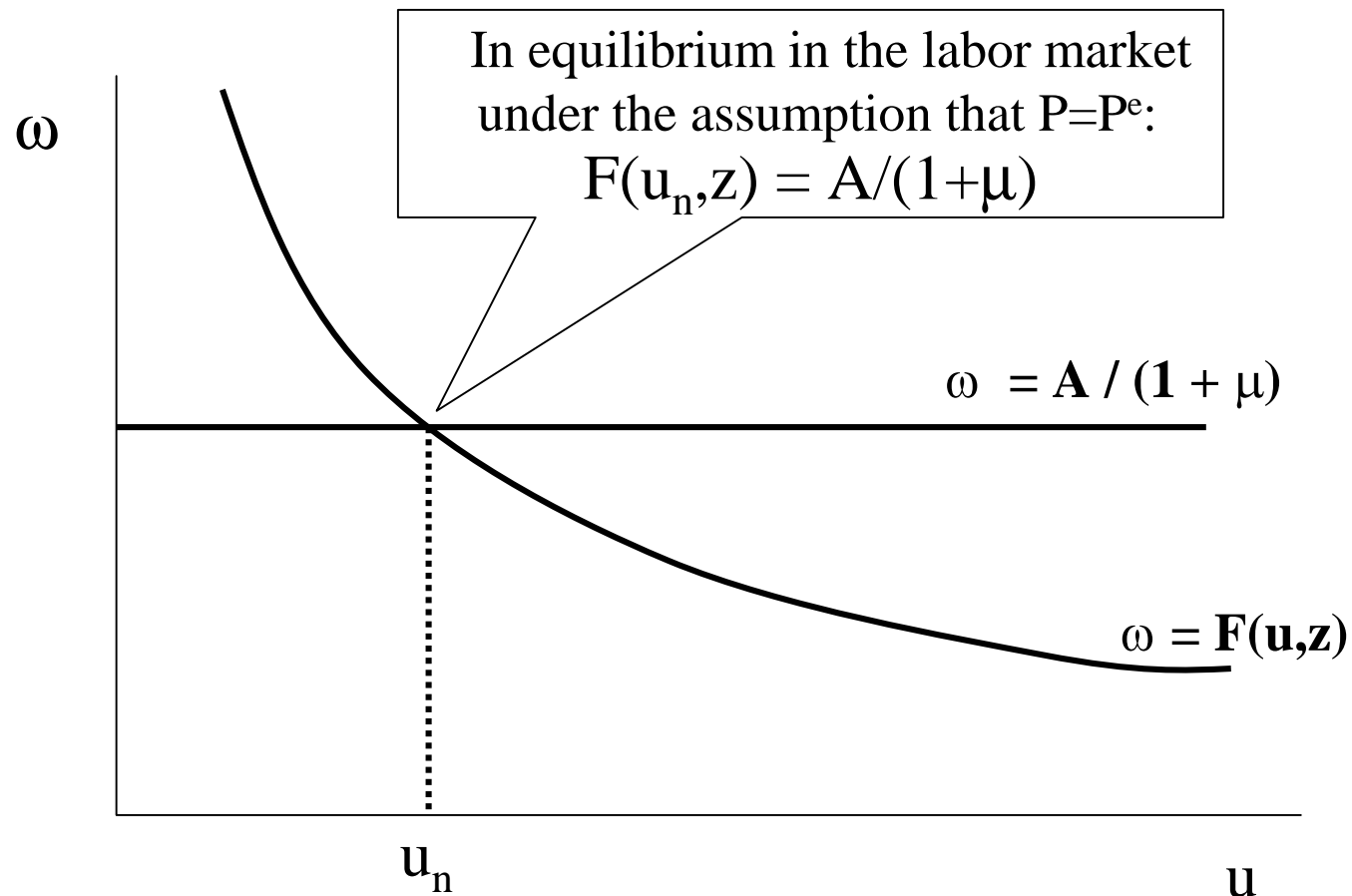
- Let’s assume, for simplicity, **constant returns to factors**, which implies that **A** is constant, and **Y = N A**.

- Therefore, the **price setting relation** curve looks:



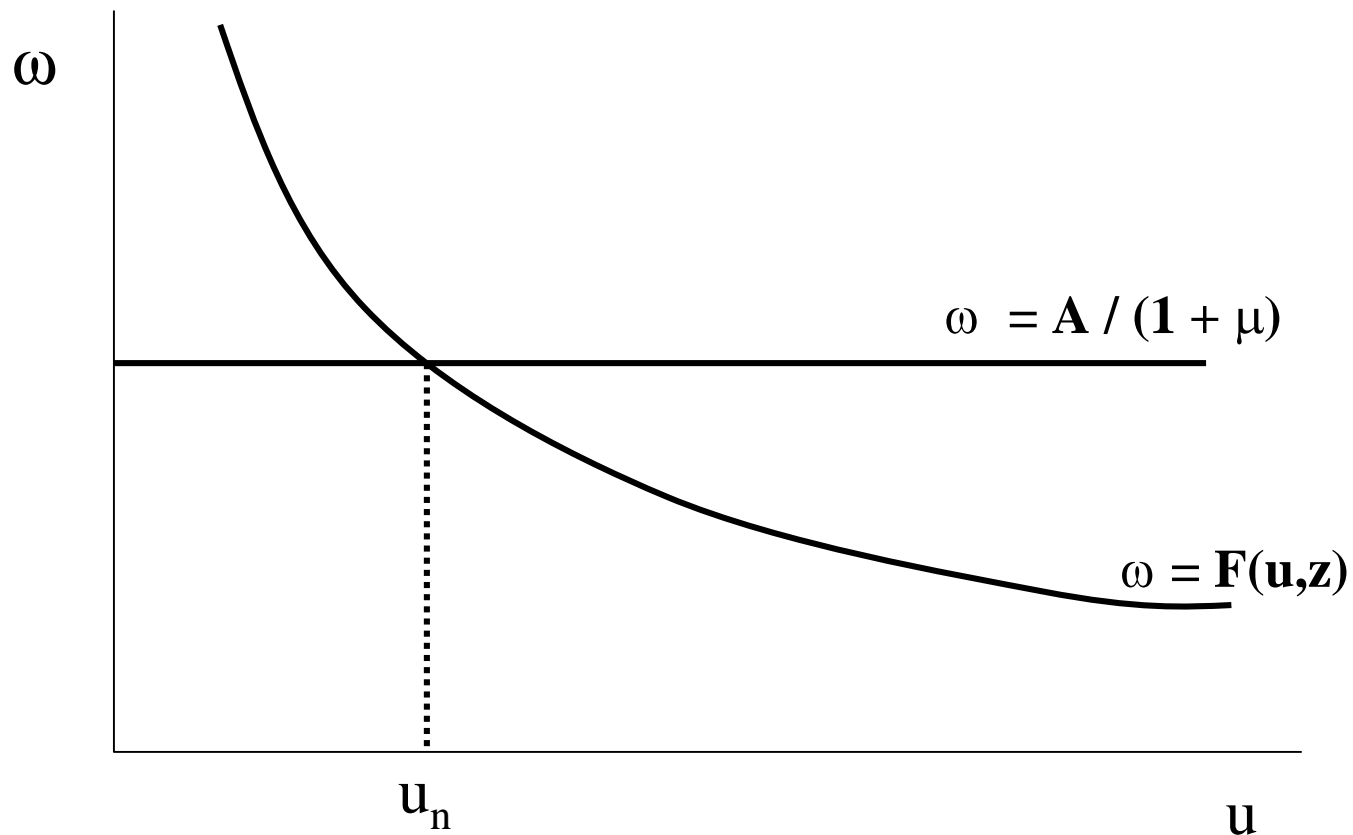
- The intuition behind this equation: firms increase markup \rightarrow prices increase \rightarrow for a given W , real wage decrease. Therefore, by choosing their markup, firms in effect determine the real wage.

XI(f). Equilibrium in the labor market and the natural rate of unemployment



- **Natural rate of unemployment is the unemployment rate that prevails if the expected price level and the actual price level are equal.**

- What's the effect on natural rate of unemployment:
 - (a) An increase in unemployment benefits?
 - (b) An increase of the markup?



XI(g) Equilibrium unemployment and Output

- In general (by definition):

$$u = U/L = (L - N) / L \Rightarrow N = (1-u) L$$

- Since $Y = N A$, therefore:

$$Y = (1-u) L A \Rightarrow u = 1-Y/LA$$

- Therefore:

$$u_n = U/L = (L - N_n) / L \Rightarrow N_n = (1-u_n) L$$

$$Y_n = (1-u_n) L A \Rightarrow u_n = 1-Y_n/LA$$

- Since in equilibrium $F(u_n, z) = A/(1+\mu)$, therefore in equilibrium:

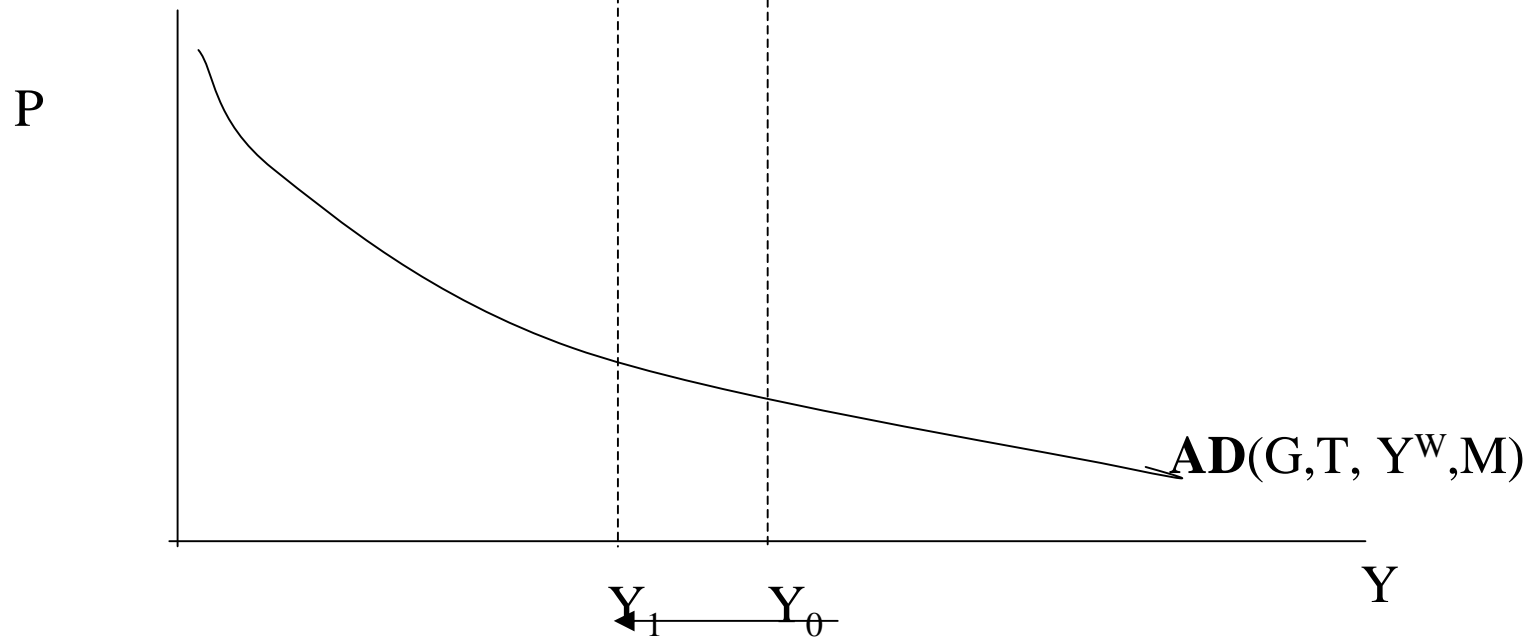
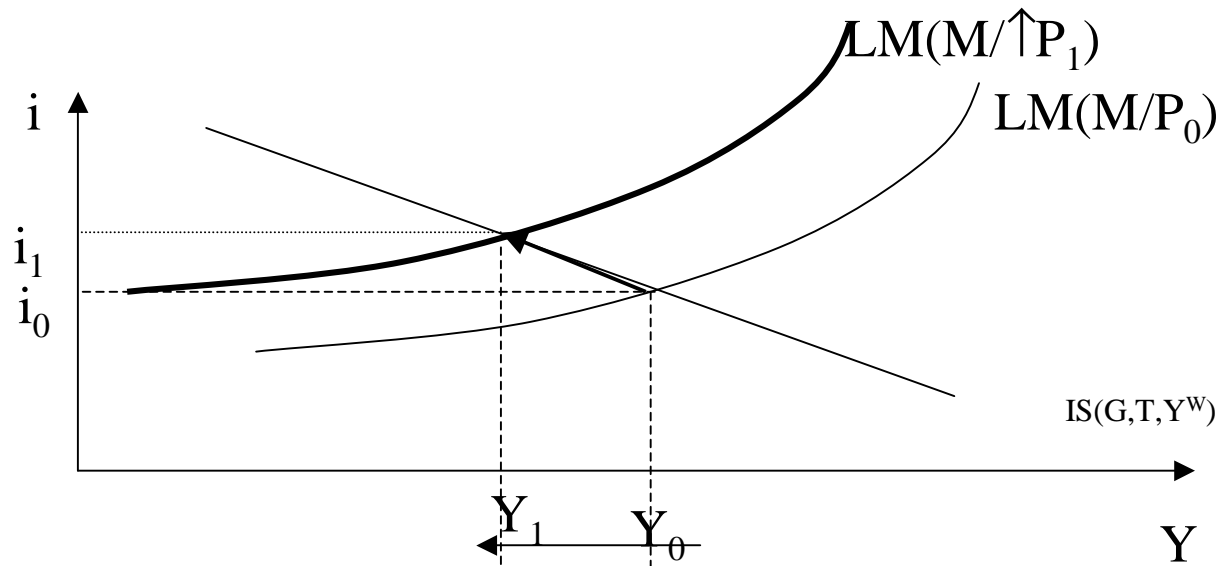
$$F(1-Y_n/LA, z) = A/(1+\mu)$$

The Medium Run

- a) AD- definition & derivation
- b) AS- definition & derivation
- c) General equilibrium in the medium run-
definition & derivation

XII(a). AD Curve- Definition & Derivation

- The aggregate demand (**AD**) curve is the intersection of the IS-LM curves for different price levels for domestic GDP.
- It shows the pairs of GDP and P that support equilibrium in both markets- products and financial markets (for given monetary and fiscal policies) → Endogenising P
- **How does P affect LM?** [Hint: $\uparrow P \rightarrow \downarrow(M/P)$]
- **How does P affect IS?** [Hint: $\uparrow P \rightarrow \downarrow(\text{Bonds prices} \rightarrow \downarrow(\text{Wealth}))$] (sometimes we ignore this effect for simplicity)
- **Therefore,** $\uparrow P \rightarrow \downarrow Y$, which means AD is downward sloping in the axis P-Y.

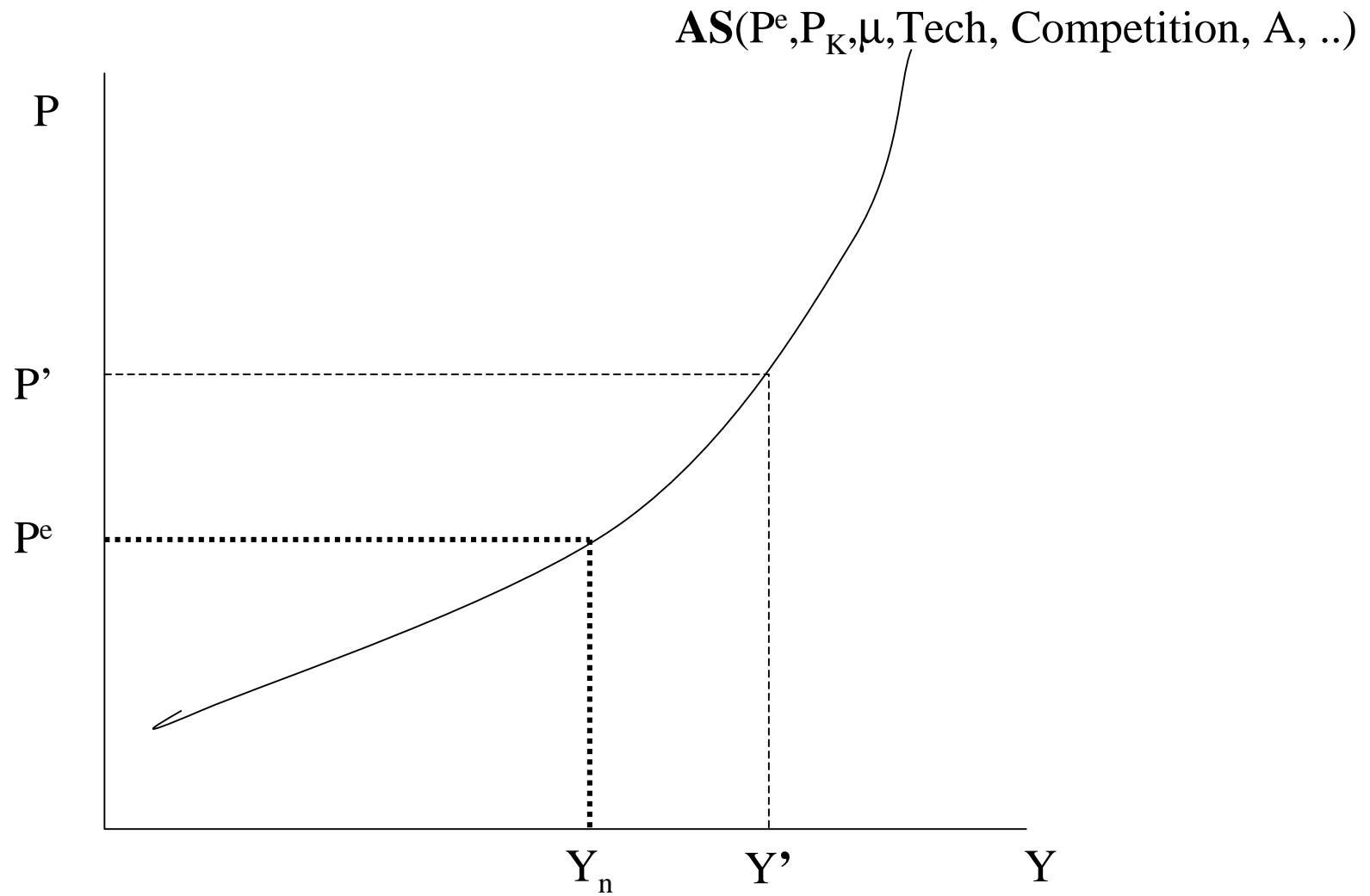


XII(b). AS Curve- Definition & Derivation

- The aggregate supply (AS) curve is the GDP that firms will supply for different price levels for domestic GDP.
- Therefore, it's the horizontal summation of the individual firms' supply curve, which are the upward sloping MC curves.
- Therefore, the AS curve is upward sloping curve in the Y-P space.
- AS curve also **represents the pairs (Y,P) that support equilibrium in the labor market**, so it can be derived by combining:
 - The wages setting equation: $W = P^e F(1-Y/LA, z)$
 - The price setting equation: $P = (1+\mu) W$

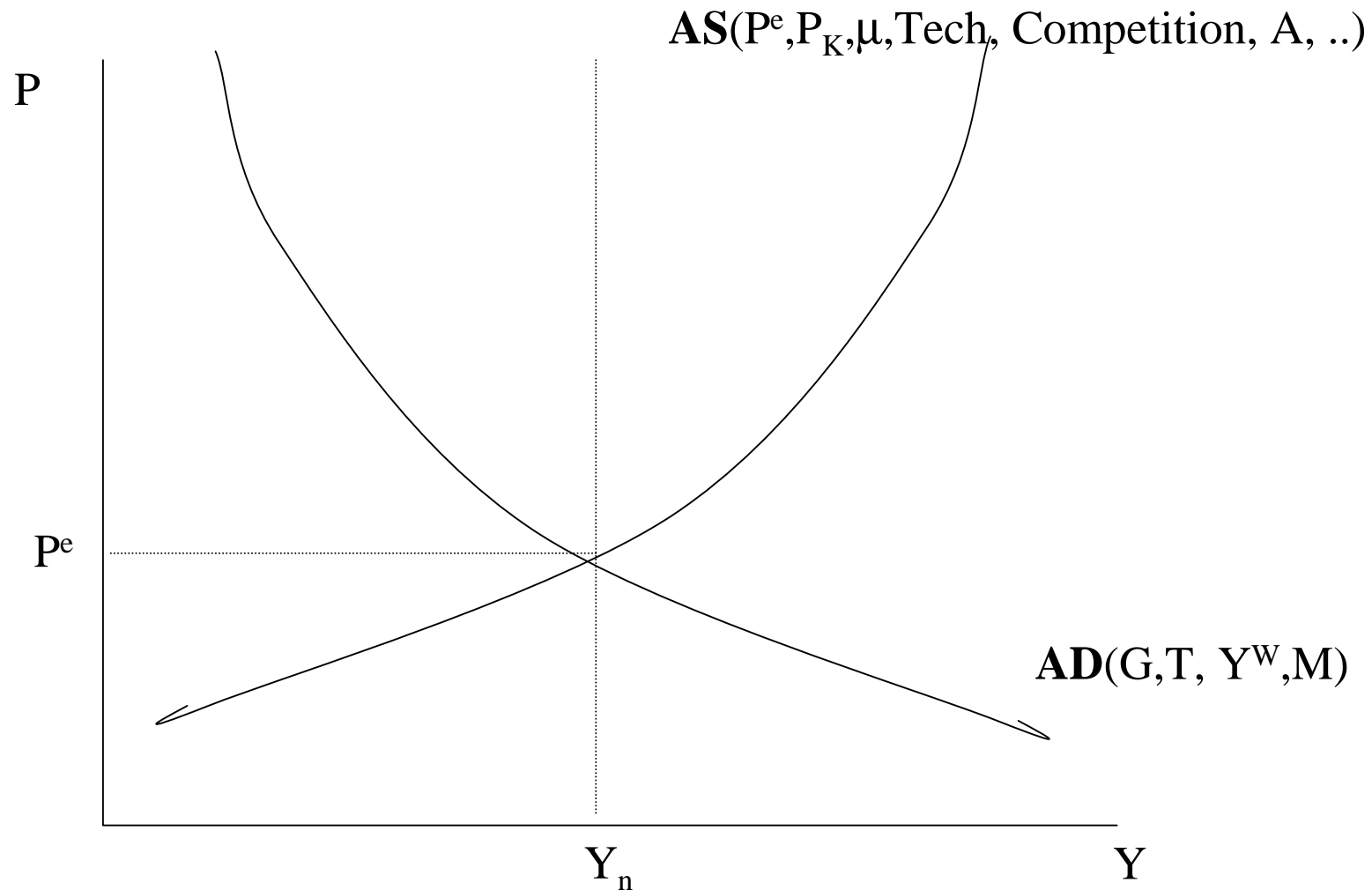
$$\Rightarrow P = P^e (1+\mu) F(1-Y/LA, z).$$

$$\Rightarrow \text{If } Y \uparrow \rightarrow N \uparrow \rightarrow u \downarrow \rightarrow W \uparrow \rightarrow P \uparrow$$



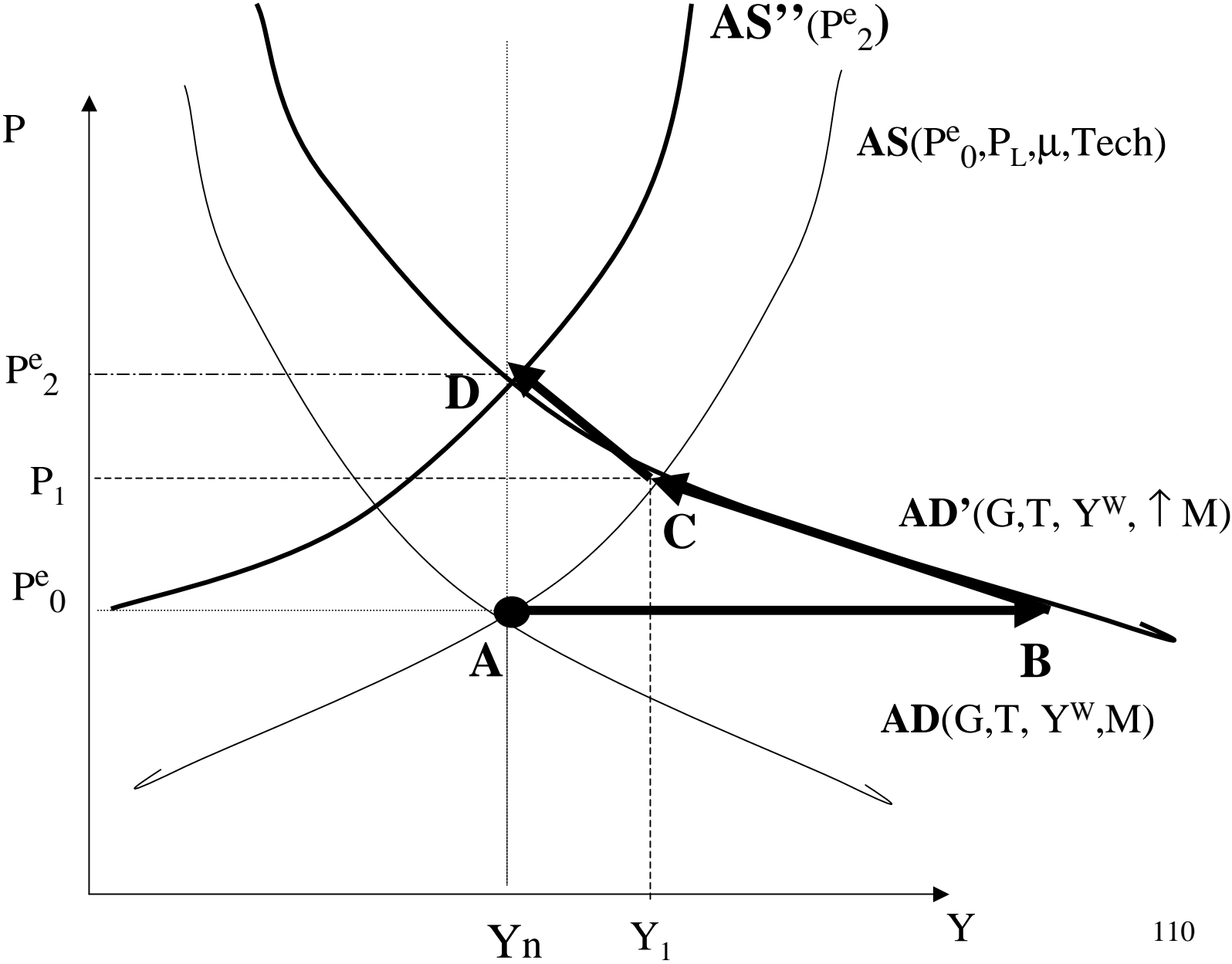
- **Note: If $Y' > Y_n \Rightarrow P' > P^e$**

XII(c). General equilibrium in the medium run



- **General equilibrium in the short run is when when $AS=AD$.**
- **General equilibrium in the medium run is when $AS=AD$ at $Y=Y_n$ (or equivalently, at $P=P^e$)**

XII(d). Money neutrality in the medium run



In the short run

- If $M \uparrow \rightarrow$ LM shifts right \rightarrow AD shifts right \rightarrow move from A to B. Since we are not in equilibrium in labor market at B, we will move along the AD curve to C $\rightarrow P \uparrow \rightarrow$ LM shifts back to the left, but still not back to the original point because we know that $Y > Y_n$.
- Therefore, in the **short run**:
 - $Y \uparrow$
 - $P \uparrow$
 - $C \uparrow$: $Y \uparrow$ (no change in taxes) $\rightarrow Y^d \uparrow \rightarrow C \uparrow$, also, $i \downarrow \rightarrow C \uparrow$, therefore, for sure C increases in the short run.
 - $I \uparrow$: $Y \uparrow \rightarrow I \uparrow$, also, $i \downarrow \rightarrow I \uparrow$, therefore, for sure I increases in the short run.
 - $u \downarrow$: $Y \uparrow \rightarrow u \downarrow$.

In the medium run

- At C, $P > P^e$, therefore, price setters are going to make a gradual adjustment of their expectations (between the short run and medium run) $\rightarrow P^e \uparrow \rightarrow AS$ shifts up $\rightarrow P \uparrow \rightarrow LM$ shifts back to the left. This will continue as long as $Y > Y_n$. (or equivalently, as long as $P > P^e$).
- The economy will hit the medium run equilibrium once $AS=AD$ at $Y=Y_n$. (or equivalently, at $P=P^e$).
- *Compare medium run with initial:*
 - $Y =$
 - $P \uparrow$
 - $C =$: $Y =$ (no change in taxes) $\rightarrow Y^d =$ $\rightarrow C =$, also, $i =$ $\rightarrow C =$, therefore, for sure C is the same.
 - $I =$: $Y =$ $\rightarrow I =$, also, $i =$ $\rightarrow I =$, therefore, for sure I remains the same.
 - $u =$: $Y =$ $\rightarrow u =$.

- *Compare medium run with short run:*
 - $Y \downarrow$: why always, in the medium run, goes back to Y_n .
 - $P \uparrow$
 - $C \downarrow$: $Y \downarrow$ (no change in taxes) $\rightarrow Y^d \downarrow \rightarrow C \downarrow$, also, $i \uparrow \rightarrow C \downarrow$, therefore, for sure C decreases to its initial value.
 - $I \downarrow$: $Y \downarrow \rightarrow I \downarrow$, also, $i \uparrow \rightarrow I \downarrow$, therefore, for sure I decreases to its initial value.
 - $u \uparrow = : Y \downarrow \rightarrow u \uparrow$
- ➔ *Nominal money is neutral in the medium run: it has no effect on the real variables.*

XII(d). Fiscal policy's effect in the medium run

- Does a fiscal expansion has the same results? No. (Hint: The aggregate demand in the new medium run equilibrium is the same (equal to Y_n); however, the combination is now different:

$$Y_n = C\downarrow(Y=,i\uparrow) + G\uparrow + I\downarrow(Y=,i\uparrow)$$

XII(d). Oil prices' effect in the medium run

Short run:

- The oil price \uparrow (a) \rightarrow PS shifts down $\rightarrow u_n \downarrow$; and (b) $\mu \uparrow \rightarrow$ AS shifts up.
- *Compare Short run with initial:*
 - $Y \downarrow$
 - $P \uparrow$
 - $C \downarrow$: $Y \downarrow$ (no change in taxes) $\rightarrow Y^d \downarrow \rightarrow C \downarrow$, also, $i \uparrow$ ($M/P \downarrow \rightarrow$ LM shifts left) $\rightarrow C \downarrow$.
 - $I \downarrow$: $Y \downarrow \rightarrow Y^d \downarrow \rightarrow C \downarrow$, also, $i \uparrow$ ($M/P \downarrow \rightarrow$ LM shifts left) $\rightarrow C \downarrow$.
 - $u \uparrow$: $Y \downarrow \rightarrow u \uparrow$.

Medium run:

- $P > P^e$, therefore, price setters are going to make a gradual adjustment of their expectations (between the short run and medium run) $\rightarrow P^e \uparrow \rightarrow AS$ shifts up $\rightarrow P \uparrow \rightarrow LM$ shifts left. This will continue as long as $Y > Y_n$ (or equivalently, as long as $P > P^e$):
- *Compare medium run with initial:*
 - $Y \downarrow$
 - $P \uparrow$
 - $C \downarrow$: $Y \downarrow$ (no change in taxes) $\rightarrow Y^d \downarrow \rightarrow C \downarrow$, also, $i \uparrow$ ($M/P \downarrow \rightarrow LM$ shifts left) $\rightarrow C \downarrow$.
 - $I \downarrow$: $Y \downarrow \rightarrow Y^d \downarrow \rightarrow C \downarrow$, also, $i \uparrow$ ($M/P \downarrow \rightarrow LM$ shifts left) $\rightarrow C \downarrow$.
 - $u \uparrow$: $Y \downarrow \rightarrow u \uparrow$.

$$Y_n \downarrow = C \downarrow(Y=, i \uparrow) + G + I \downarrow(Y=, i \uparrow)$$

Inflation and Phillips Curve

XII(b). Augment Phillips Curve

$$P = P^e (1+\mu) F(u, z).$$

- Assume an explicit function of the form:

$$F(u, z) = 1 - \alpha u + z$$

- Therefore:

$$P = P^e (1+\mu) (1 - \alpha u + z)$$

- Some manipulations, and we get a relation between the difference between expected and actual inflation (relative changes of price, not level as before) and unemployment rate:

$$\pi - \pi^e = (\mu + z) - \alpha u$$

- People adjust their expectations such that:

$$\pi^e = \theta \pi_{-1}$$

- If $\theta=1$, and by the definition of the NAIRU, then:

$$\pi - \pi_{-1} = -\alpha (u - u_n)$$

- This is the **Augment Phillips Curve**.

- **Note:**

- When $\theta=0$, we get the **original Philips curve**, a relation between the level of inflation rate and the level of involuntary unemployment rate, which prevailed until the 1950s.
- When $\theta=1$, we get the **accelerationist Philips curve** (or *modified or expectations-augmented Philips curve*), a relation between the change in the inflation rate and level of the involuntary unemployment rate, which prevailed since the 1960s.
- Higher expected inflation leads to higher inflation.
- The higher the mark-up and the factors affect wage determination, the higher the inflation

XII(c). Okun's Law

- In general, we can state the Okun's law:

$$u_t - u_{t-1} = \beta [g_{y(\text{avg})} - g_{y(t)}]$$

- **There is a cyclical relation between unemployment and real growth: The change in the unemployment is half the growth rate difference between potential and actual GDP growth. Or, the level of unemployment is half the % gap of the potential and actual GDP.**

The Long Run

- a) Facts about growth
- b) Aggregate production function
- c) Example

XI(d) Aggregate Production Function

- Aggregate production function provides the relationship between aggregate units of output (goods and service) and aggregate units of input of production factors (capital (K) & labor (N)), for a given “quality”:

$$Y = F (K, N, \text{“quality” of K\&N}).$$

- Two reasonable assumptions:

1. Constant return to scale: $f(xK, xN) = xF(k, n) = xY$.

- In effect we clone the original economy.

- Therefore, output per worker is: $y/n = F(K/N, 1) = f(k/n) \Rightarrow y = f(k)$.

2. Diminishing return to factor (capital or labor): $d^2f/dk^2 < 0$.

- An increase in capital leads to a smaller and smaller increase in output as level of capital increases.

