Macroeconomic Theory and Policy

Lecture 14

Technology and Economic Growth

What is Technology ?

- technical knowledge (formula, codes, processes and mantras)which gives details of the process about how to make products.
- helps to produce same output with less inputs or more output with same inputs.
- It comes from invention and innovation.
- Incentives for inventions are provided either by protecting **patents** or by providing **subsidies** for research activities.

Three Ways of Technical Progress

Technological advancement in production may appear in three forms:

- Labour augmenting technology $Y = F(K, AL)$ Y:10 L:10; Y:10 L:5.

Same level of output can be produced by less amount of labour or same amount labour can produce more output. This is equivalent to increase in the productivity labour. Number of work hours decreases and wage rate increases with a rise in t productivity of labour.

- Capital augmenting technology $Y = F(AK, L)$ Y:10 K:10; Y:10 K:5.

This occurs as new capital is imbedded with more capacity. For instance consume spending same amount of money for a computer can buy newer and better products (wi more memories (RAM) and speed (MHrz)) as time goes on. More efficient machines the same job in less time or using less inputs.

- Neutral technology $Y = AF(K, L)$ Y:10 K:10; L:10; Y:10 L:7 K:7.

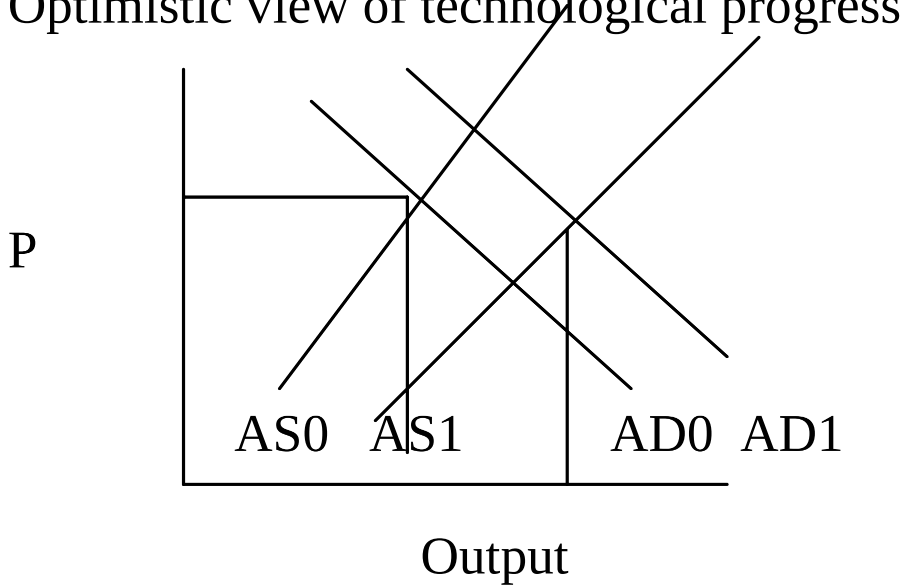
This occurs when a new method is introduced that increases productivity of both labo and capital equally. Advancement in managerial technique or better of of matchi between man and machine hours (network processing).

Solow Residual and Positive and Negative Effects of Technology

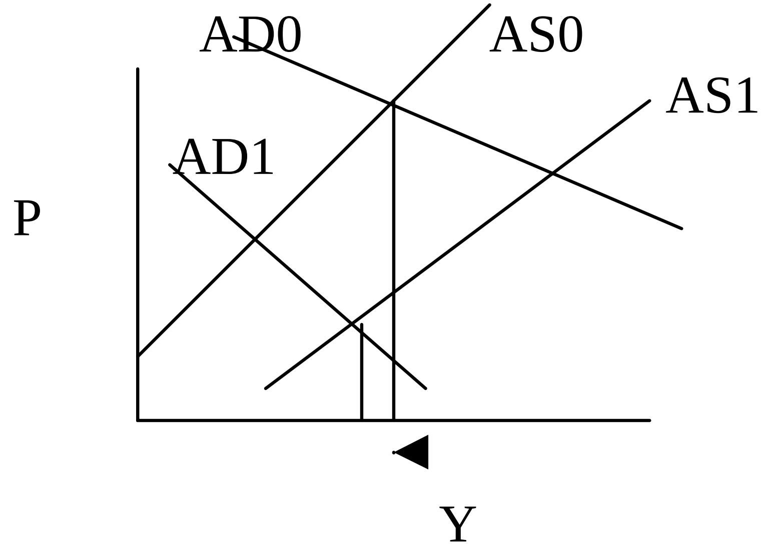
Total multi-factor productivity (Solow residual or TFP) $a = g_y - \alpha g_k - (1-\alpha) g_l$

For instance if output grows by 4%, capital grow by 4% and labour force grows by 2% and if $\alpha = 0.3$. Then TFP = 4%-0.3(4%) –0.7(2%) = 4%-2.6% =1.4%.

Optimistic view of technological progress



Pessimistic view



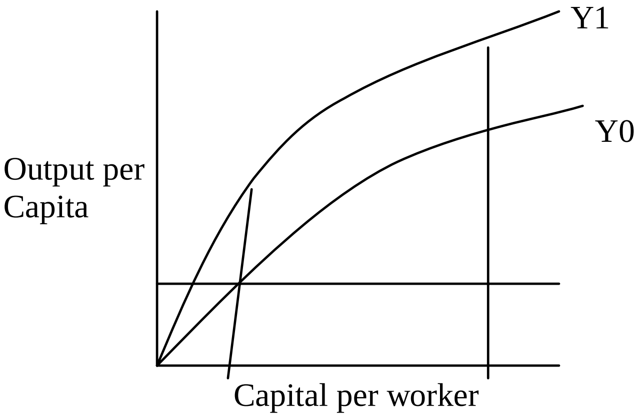
Arguments for and against technological progress (wages and unemployment)

- Optimistic view: New products, job creation, higher productivity, higher income, new skills, new jobs, short working hours: 2600hrs (50×52weeks) to 1700hrs (35×48 weeks): more output with fewer workers; division of labour, efficient market (classical economists such Adam Smith, Mills, Say and others) –**Creative destruction**.
- Pessimistic view: Job destruction, Luddites, Saboteurs, technical unemployment; same output with less workers: computer jobs replacing type writing jobs. (Malthus was pessimistic, who thought death rate will decrease with increase in income but diminishing return to land will eventually cause consumption per capita to drop and cause natural disasters raise death rate; production grows at the rate of arithmetic series and population at the rate of geometric series until such calamities occur). Structural change in Russian and former communist countries.
- Evidence: more jobs have been created in periods of high productivity growth; more unemployment in periods of low productivity growth; International competition in unskilled-labour intensive goods may cause no growth in wage rate of unskilled workers=> Job exports; protest against WTO negotiations.
- Reasons for technological gap in the world (16 to 20 fold)

Property rights; Opaque/non-transparent policies; Political instability; lack of entrepreneurship; poorly developed financial markets, corruption, vicious circle of poverty.

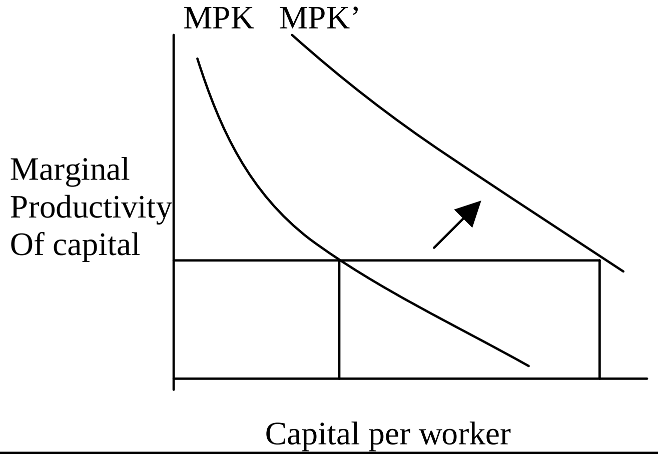
Economic Growth and Technology

Impact of technology on production

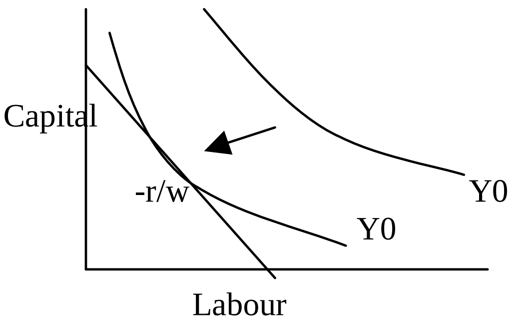


Technological advancement raises productivity

Impact of technology on marginal productivity of an input and investment



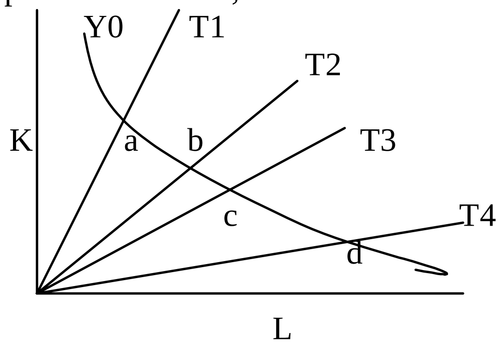
Technology and production



Technological progress can give same output with Less inputs of both capital and labour

Choice of technology

Capital intensive =a; labour intensive =d;

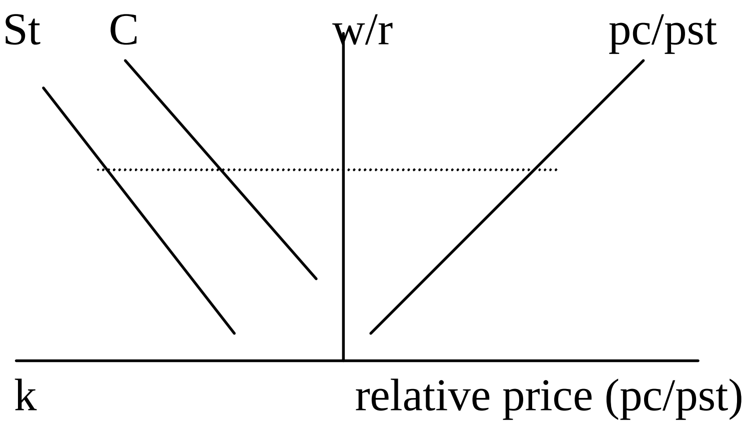


Same level of output can produced be a,b,c,d technology

Trade, technology and real wages

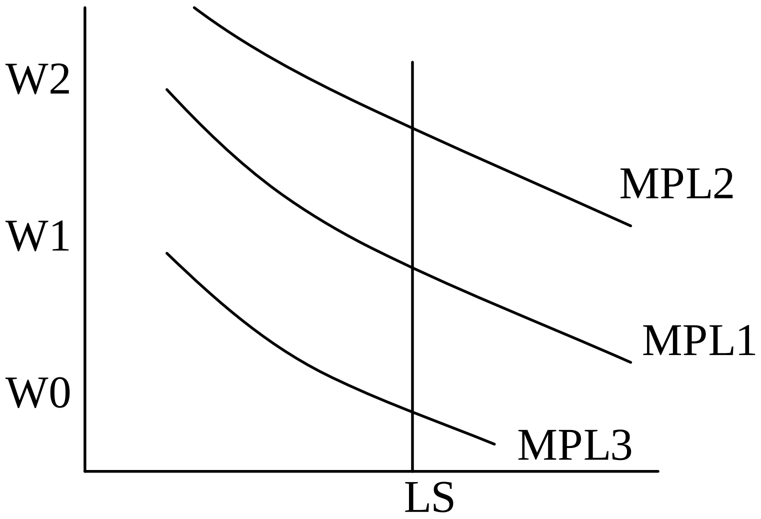
Trade and growth; technology and real wages

Steel = capital intensive sector
Corn = labour intensive sector



Which sector should grow? if corn sector grows and trades, corn prices and wages of worker working in corn sector go up at home, price, output and real wage in the corn sector decrease in country which imports corn.

Technology improves productivity and raises amount of capital applied to the production process and raises the real wage rate.



Assuming supply of labour is given

Labour Augmenting Technology and Growth

$Y = K^{\alpha}(AL)^{1-\alpha}$ => Divide both side by effective labour AL $\dfrac{Y}{AL} = \left(\dfrac{K}{AL}\right)^{\alpha}$

In steady state output and capital per effective labour input remains constant. This implies $g_y - g_A - g_L = 0 \quad g_y = g_A + g_L$. Similarly $g_k = g_A + g_L$

Per capita output and capital grows at the rate growth of technology: $g_y - g_L = g_A$ and $g_k - g_L = g_A$

The gross investment requirement now includes depreciation, growth rate of effective labour unit as given by the sum of growth rate of technology and the growth rate of labour input. Steady state gross investment requirement per worker thus is given by:

$$I = (\delta + g_A + g_L)\frac{K}{AN}$$

Saving is again a constant fraction of income. The change in capital stock then is given by the difference between savings and investment function. If saving is greater than the investment capital stock will increase if it is less than investment capital stock will decrease.

$$\dot{K} = sY - \delta K = sK^{\alpha}(AL)^{1-\alpha} - (\delta + g_A + g_n)K$$

Simple version of the Lucas Model

- Production function

$$Y = K^{\alpha} (\theta h L)^{1-\alpha} \qquad (1)$$

h = is human capital per worker
θ = fraction of time spent on working
L = labour supply –(assume this as given)
Example :
If K=100, L=100 h=3 θ =0.8, α =0.3

$$Y = 100^{0.3} (0.8 * 3 * 100)^{0.7} = 100 (2.4)^{0.7}$$

= 185 where with $Y = K^{\alpha} L^{1-\alpha}$ =100.

Lucas Model -2

Define output and capital stock per effective labour as:

$$k = \frac{K}{hL} \quad y = \frac{Y}{hL} \qquad (2)$$

Here *hL* total amount of effective work hours adjusted for human capital. Output per effective worker *y* depends on capital per effective worker *k* and time spent on studying which can be derived as

$$\frac{Y}{hL} = \frac{K^{\alpha}(\theta hL)^{1-\alpha}}{hL}$$

$$y = \theta^{1-\alpha} k^{\alpha} \qquad (3)$$

Lucas Model -3

Human capital grows faster when people spend more time in studying

$$\dot{h} = \phi(1-\theta)h \text{ or } g_h = \frac{\dot{h}}{h} = \phi(1-\theta)$$

where ϕ is the rate of creation of human capital per unit of time spent on studying and (*1*-θ) is the fraction of time spent on studying.

Stock of human capital for a given time

$$h_t = h_0 e^{\phi(1-\theta)t}$$

if h0 =1, ϕ=0.4, (1-θ)=0.2, time (t)=20

$$h_t = 1.e^{0.4(0.2)20} = 4.95$$

Lucas Model -4

Assuming a fixed saving
Rate

$$\frac{\partial k}{\partial t} = \dot{K} = sY - \delta K$$

where s is the saving rate and δ is the depreciation rate of the capital stock.
Then the change in capital stock per effective worker is given by:

$$\dot{k} = \frac{\dot{K}}{hL} - \frac{\dot{h}}{h}\frac{K}{hL} = \frac{sY}{hL} - \frac{\delta K}{hL} - \phi(1-\theta)k$$

In the steady state $\dot{k} = 0$:

$$\dot{k} = sy - (\delta + \phi(1-\theta))k = 0 \quad s\theta^{1-\alpha}k^{\alpha} = (\delta + \phi(1-\theta))k$$

this implies steady state capital stock

$$k_{ss} = \left(\frac{s\theta^{1-\alpha}}{(\delta+\phi(1-\theta))}\right)^{\frac{1}{1-\alpha}} = \theta \cdot \left(\frac{s}{(\delta+\phi(1-\theta))}\right)^{\frac{1}{1-\alpha}}$$

Romer (1990) Model: Main Points

Main features of the model

1. Constant return to K and L but increasing return to scale relative to all inputs
2. Imperfect competition in the intermediate goods sector
3. Inventors can extract profits by selling patent rights to producers of intermediate goods
4. Increase in stock of knowledge relates to number of people working in the research
5. Research drives up productivity in the whole economy by the arbitrage condition

$$w_r = \bar{\delta} p_A = w_y = (1-\alpha)\frac{Y}{L} \text{ but } r = \frac{\alpha^2 Y}{L}$$

Romer Model-1

- Production in the final goods sector

$$Y = L_y^{1-\alpha} \sum_{j=1}^{A} x_j \quad \text{where j=1….A}$$

$$Y = L_y^{1-\alpha} x_1 + L_y^{1-\alpha} x_2 + ... + L_y^{1-\alpha} x_A$$

It is a perfectly competitive sector and remuneration to factors are according to their marginal products:

$$w = (1-\alpha)\frac{Y}{L} \text{ and } p_j = \alpha L_y^{1-\alpha} x_j^{1-\alpha}$$

Romer Model-2

- Intermediate good sector receives new ideas from the research sector and embodies them in new tools. Firms in this sector buy licences to use technical know how

Profit: $\Pi_j = p_j x_j - r x_j$

MR =MC principle implies that

$$p'(x_j)x_j + p(x_j) = r \text{ or } p = \frac{1}{1+\frac{p'(x)x}{p}} r = \frac{1}{\alpha} r$$

- Research sector

$$dA = \bar{\delta} L_A^{\lambda}$$

$\bar{\delta}$ average productivity in the research sector

$$\bar{\delta} = \delta A^{\phi} L_A^{\lambda}$$

Romer Model-3

$$g_A = \frac{dA}{A} = \frac{\delta L_A^{\lambda}}{A^{1-\phi}}$$

Growth of technology is determined by the population growth rate

$$g_A = \frac{\delta n}{1-\phi}$$

Total labour resource can either be used in the knowledge sector or in the production of final goods sector:

$$L = L_y + L_A$$

Growth is prevented by lack of optimal research for the following reasons

1. Market values research according to the stream of profit that are earned from the new design but market does not see how the current research increases productivity in the future. There is a missing market for research. Also there is positive externality or "spill over" of current research and "standing on the shoulder" effect.
2. There is a danger of "stepping on toes" –there may be too many researcher either duplicating the same research work , which may provide negative externality.
3. There is "too little" research because of monopoly power due to patent rights though profit incentives are vital for innovation of new ideas.

Conditional Convergence

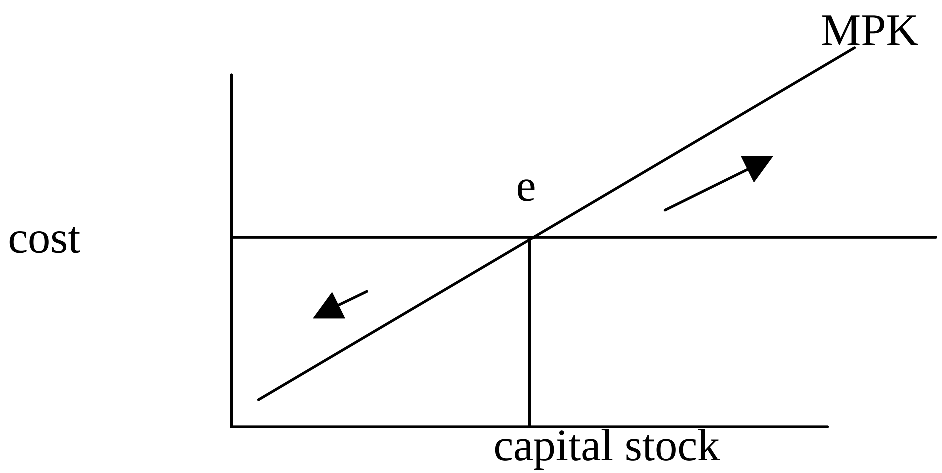
There is no relation between initial GDP (most studies take 1960 as the base year) and the growth rates if both developed and developing economies are taken together. However, many studies suggest evidence for convergence among OECD countries(so called rich country club), states of the US, provinces of Canada and prefectures of Japan. There are arguments suggesting that developing economies have different steady state than of developed economies.

Why?

Story of squirrel and elephant. Baby elephant grows to be a big elephant, baby squirrel cannot grow as elephant. Is this comparison right?

Poverty Trap and Marginal Productivity of Capital

Productivity of capital does not only depend upon the amount of capital but depends upon amount of human capital. Countries with lower human capital are in danger of being caught in poverty trap.



Marginal product of capital is less than the cost of capital and capital stock gradually diminishes before point e. Cost is less than MPK after e more capital is accumulated.

Why Africa has the Lowest Growth Rate?

Ethnic and linguistic diversity: not homogeneous, cause for ethnic tribal conflicts.
low investment low saving because of low level of income.
low education, high drop outs in primary and secondary level, high illiteracy.
lack of infrastructure: socio-ethnic conflict in building roads or other facilities
climate: tropical climate not good for growth, most technologies are developed for other climates.
disease: malaria and AIDS quite big problem
bad policies: persistent budgetary deficits, overvalued currencies
landlocked-ness: high transportation costs.
lack of transparent policies: when system is not democratic policies are opaque.

Can foreign aid promote growth ?

- donor interest: aid does not flow commonly to countries, colonial legacies.
- fungibility: aid to electric power project finances private mason for the rulers.
- aid does not work with bad policies
- aid cannot induce better policies, policies are made by people inside.

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