



**[Academic Script]
[Economics Growth (Part III)]**

Subject:	Business Economics
Course:	B.A., 4 th Semester, Undergraduate
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Objectives:

- To understand the loop-holes in Solow Model.
- To understand the three main Endogenous growth theory.
- To understand their implications, features and criticisms.

Introduction:

The endogenous growth theory was developed as a solution to the deficiencies present in the Solow model. It is a new theory which explains the long-run growth rate of an economy on the basis of endogenous factors as against exogenous factors of the neoclassical growth theory.

Endogenous growth can be briefly explained that policies, internal processes and investment capital, are important factors affecting economic growth rather than external factors.

The Solow model explains the long-run growth rate of output based on two exogenous variables: that are

1. **the rate of population growth** *and*
2. **the rate of technological progress**

both variables are being independent of the saving rate.

In the neoclassical theory, the long-run growth rate depends on exogenous factors, hence it has few policy implications. Such as government policies really does not matter as this theory depends on exogenous technical change and exogenous population growth.

The new growth theory hence is an extension of the neoclassical growth theory, introducing endogenous technical progress in growth models. The endogenous growth models are majorly developed by three Economist namely Arrow, Romer and Lucas. We will study the model given by these three economist by observing their main features, criticisms and policy implications.

The Endogenous Growth Models:

The endogenous growth models emphasise technical progress resulting from **the rate of investment, the size of the capital stock, and the stock of human capital.**

Assumptions:

The new growth theories are based on Some assumptions:

1. There are ***many firms*** in a market.
2. Knowledge or technological advance is a ***non-rivalry***.
3. There are ***increasing returns to scale*** to all factors taken together, whereas ***constant returns to scale*** if single factor is applied.
4. ***Technological advance*** comes from new creation that people do.
5. ***Market leaders*** have ***market power*** and thus they ***earn profits from their discoveries***. This ***assumption*** arises from increasing returns to scale in production that leads to ***imperfect competition***.

As a matter of fact, these are the requirements of an endogenous growth theory. Given these assumptions, we explain the three main models of endogenous growth.

A. The Arrow Model:

Arrow was the first economist to introduce the concept of learning, regarding it as endogenous in the growth process. His hypothesis was that at any moment of time if new capital good is built with all the available knowledge, particularly based on accumulated experience, then their productive deficiencies cannot be changed by subsequent learning. Arrow's model can be represented as

$$Y_i = A(K) F(K_i, L_i)$$

where Y_i denotes output of firm i , K_i denotes its stock of capital, L_i denotes its stock of labour, K without a subscript denotes the aggregated stock of capital and A is the technology factor. He showed that if the stock of labour is held constant, growth ultimately comes to a halt because socially very little is invested and produced. Therefore, Arrow did not explain that his model could lead to sustained endogenous growth.

B. The Lucas Model:

Uzawa developed an endogenous growth model based on investment in human capital which was used by Lucas. It was

assumed by Lucas, that investment on education leads to the production of human capital as it is crucial determinant in the growth process.

He makes a distinction between the internal effects of human capital where the individual worker who is undergoing a training becomes more productive, and external effects which spill-over and increase the productivity of capital and of other workers in the economy. It is investment in human capital rather than physical capital that have spill-over effects that increase the level of technology. Thus the output for firm i take the form

$$Y_i = A(K_i).(H_i).H^e$$

where A is the technical coefficient, K_i and H_i are the inputs of physical and human capital used by firms to produce goods Y_i . The variable H^e is the economy's average level of human capital representing the strength of the external effects from human capital to each firm's productivity.

In the Lucas model, each firm faces constant returns to scale, while there are increasing returns for the whole economy. Further, learning by doing or on-the-job training and spill-over effects involve human capital.

Each firm benefits from the average level of human capital in the economy, rather than from the aggregate of human capital. Thus it is not the accumulated knowledge or experience of other firms but

the average level of skills and knowledge in the economy that are crucial for economic growth.

In the model, technology is endogenously provided as a side effect of investment decisions by firms. Technology is treated as a public good from the view point of its users. As a result, firms can be treated as price takers and there can be equilibrium with many firms as under perfect competition.

C. The Romer Model:

Romer in his paper on endogenous growth presented a variant on Arrow's model which is known as learning by investment. He assumes creation of knowledge as a side product of investment. He takes knowledge as an input in the production function of the following form

$$Y = A(R) F (R_i, K_i, L_i)$$

where Y is aggregate output; A is the public stock of knowledge from research and development R ; R_i is the stock of results from expenditure on research and development by firm i ; and K_i and L_i are capital stock and labour stock of firm i respectively. He assumes the function F homogeneous of degree one in all its inputs R_i , K_i , and L_i , and treats R_i as a rival good.

Romer took three key elements in his model, namely externalities, increasing returns in the production of output and diminishing returns in the production of new knowledge. According to Romer, it is spill-over from research efforts by a firm that leads to the creation of new knowledge by other firms. In other words, new research technology by a firm spills-over instantly across the entire economy.

In his model, new knowledge is the ultimate determinant of long-run growth which is determined by investment in research technology. Research technology exhibits diminishing returns which means that investments in research technology will not double knowledge.

Moreover, the firm investing in research technology will not be the exclusive beneficiary of the increase in knowledge. The other firms also make use of the new knowledge due to the inadequacy of patent protection and thus increase their production.

Thus the production of goods from increased knowledge displays increasing returns and competitive equilibrium is consistent with increasing aggregate returns owing to externalities. Thus, Romer takes investment in research technology as an endogenous factor in terms of the acquisition of new knowledge by rational profit maximisation firms.

Romer's model of Endogenous Technical Change, identifies a research sector specialising in the production of ideas. This sector involves human capital alongwith the existing stock of knowledge to

produce ideas or new knowledge. To Romer, ideas are more important than natural resources. He cites the example of Japan which has very few natural resources but it was attained a shift in its economic development or growth with its new creative ideas. It imported machines from the United States during the Meiji era, dismantled them to see how they worked and manufactured their better prototypes. Therefore, ideas are essential for the growth of an economy. These ideas relate to improved designs for the production of producer durable goods for final production.

In the Romer model, new knowledge enters into the production process in three ways.

- **First**, a new design is used in the intermediate goods sector for the production of a new intermediate input.
- **Second**, in the final sector, labour, human capital and available producer durables produce the final product.
- **Third**, and a new design increases the total stock of knowledge which increases the productivity of human capital employed in the research sector.

It's Assumptions:

The Romer model is based on the following assumptions:

1. **Economic growth** comes from **technological change**.
2. **Technological change is endogenous**.
3. **Market incentives** play an important role in making technological changes available to the economy.

4. Invention of a ***new design requires*** a specified amount of ***human capital***.
5. The ***aggregate supply*** of human capital ***is fixed***.
6. Knowledge or a ***new design*** is assumed to be partially ***excludable and retainable by the firm*** which invented the new design. It means that if an inventor has a patented design for a machine, no one can make or sell it without the agreement of the inventor.

On the other hand, other inventors are free to spend time to study the patented design for the machine and acquire knowledge that helps in the design of such a machine. Thus patents provide incentives to firms to engage in research and development, and other firms can also benefit from such knowledge. When there is partial excludability, investment in research and development leading to an invention by a firm can only bring in quasi-rent.

7. Technology is a ***non-rival***. Its use by one firm does not prevent its use by another.
8. The ***new design can be used by firms and in different periods*** without additional costs and without reducing the value of the input.
9. It is also assumed that the low cost of using an existing design reduces the cost of creating new designs.
10. When firms make investments on research and development and invent a new design, there are externalities that are internalised by private agreements.

The Model:

Given these assumptions, the **Romer model** can be explained in terms of the following technological production function.

$$\Delta A = F (K_A, H_A, A)$$

where ΔA is the increasing technology, K_A is the amount of capital invested in producing the new design (or technology), H_A is the amount of human capital (labour) employed in research and development of the new design, A is the existing technology of designs, and F is the production function for technology.

The production function shows that technology is endogenous when more human capital is employed for research and development of new designs, then technology increases by a larger amount, i.e., ΔA is greater. If more capital is invested in research laboratories and equipment to invent the new design, then technology also increases by a larger amount i.e., ΔA is more. Further, the existing technology, A , also leads to the production of new technology.

Since it is assumed that technology is a non-rival input and partially excludable, there are positive spill-over effects of technology which can be used by other firms. Thus the production of new technology (knowledge or idea) can be increased through the use of physical capital, human capital and existing technology.

Criticisms of Endogenous Growth Theory:

Despite the fact that the new growth theory has been regarded as an improvement over the new classical growth theory, still it has many critics:

1. According to Scott and Auerbach, the main ideas of the new growth theory can be traced to Adam Smith and increasing returns to Marx's analysis.
2. Srinivasan does not find anything new in the new growth theory because increasing returns and endogeneity of variables have been taken from the neoclassical and Kaldor's models.
3. Fisher criticises the new growth theory for depending only on the production function and the steady state.
4. To Olson, the new growth theory lays too much emphasis on the role of human capital and neglects the role of institutions.
5. In the various models of new growth theory, the difference between physical capital and human capital is not clear. For instance, in Romer's model, capital goods are the key to economic growth. He assumes that human capital accumulates and when it is embodied in physical capital then it becomes a driving force. But he does not clarify which is the driving force.
6. By using secondary school enrolment as a proxy for human capital in their model, Mankiw, Romer and Weil find that physical and human capital accumulation cannot lead to perpetual economic growth.

Summary:

In this chapter we have learnt about the Endogenous Growth theory in detail. We also learnt about the policies to increase rate of savings, and productivity. Finally we critically evaluated the theory.

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Website Links

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- <http://blogs.worldbank.org/futuredevelopment/convergence-or-divergence-development>

Assignments

- ✓ Explain Romer Model
- ✓ Explain Arrow Model
- ✓ Explain Lucas Model
- ✓ Explain in detail the Endogenous Growth Model

Glossary:

- **Endogenous Growth:** Endogenous growth can be defined as the notion that policies, internal processes and investment capital, rather than external factors, are chiefly responsible for economic growth.
- **Exogenous Growth:** Exogenous growth is the belief that economic growth arises due to influences outside the economy or company of interest. Exogenous growth assumes that economic prosperity is primarily determined by external rather than internal factors.
- **Balanced growth:** It is balancing growth between rural and urban, rich and poor, and eradicating imbalances between all the sectors of economy. It plans the policies in such a way that there is balance between the sectors and within the sectors too.

- **Capital Stock:** Growth in physical capital stock i.e. investment in equipment, tools or machines etc. leading to a rise in capital per employee. It is also known as capital deepening.
- **Labour Force:** With the improvement in education level there is growth in the size of the active labour force available for production. The growth in the quality of labour can also attributed to skills, if the available human resources are educated with the required skills the quality of labour increases.

Frequently Asked Questions:

1. What is Endogenous growth theory?

Endogenous growth can be defined as the notion that policies, internal processes and investment capital, rather than external factors, are chiefly responsible for economic growth.

2. Explain the impact of increase in Government Savings.

Increase in Government savings helps the economy to reduce its deficits. It results, change in incident of taxes levied by government, reduction in money supply, and hence aggregate demand falls.

3. State the two exogenous variables on which Solow Model is based on:

The Solow Model is based on following two exogenous variables:

- the rate of population growth *and*
- the rate of technological progress

4. State three criticisms of Endogenous Growth Theory.

Critics of Endogenous Growth theory can be listed as

1. In the new growth theory because increasing returns and endogeneity of variables have been taken from the neoclassical and Kaldor's models.
2. The new growth theory for depending only on the production function and the steady state.
3. The new growth theory lays too much emphasis on the role of human capital and neglects the role of institutions.

5. State five assumptions of Romer Model.

The Romer model is based on the following assumptions:

1. Economic growth comes from technological change.
2. Technological change is endogenous.
3. Market incentives play an important role in making technological changes available to the economy.
4. Invention of a new design requires a specified amount of human capital.
5. The aggregate supply of human capital is fixed.

6. State the economists who contributed to Endogenous Growth Theory.

The three main contributors to Endogenous Growth Theory are Arrow, Romer and Lucas.

7. Name the two exogenous variables of Solow Model.

The Solow model explains the long-run growth rate of output based on two exogenous variables: that are

3. **the rate of population growth** *and*
4. **the rate of technological progress**

8. State the three main assumption of Endogenous growth theory.

The new growth theories are based on Some assumptions:

6. There are ***many firms*** in a market.
7. Knowledge or technological advance is a ***non-rivalry***.

8. There are ***increasing returns to scale*** to all factors taken together, whereas ***constant returns to scale*** if single factor is applied.

9. State the difference between Arrow and Romer Model.

In Romer's model it is assumed that endogenous growth is presented as a variant on Arrow's model which is known as learning by investment. He assumes creation of knowledge as a side product of investment. He takes knowledge as an input in the production function

10. State the three ways in which knowledge enters the production function.

Romer describes that new knowledge enters into the production process in three ways.

- ***First***, a new design is used in the intermediate goods sector for the production of a new intermediate input.
- ***Second***, in the final sector, labour, human capital and available producer durables produce the final product.
- ***Third***, and a new design increases the total stock of knowledge which increases the productivity of human capital employed in the research sector.

Multiple Choice Questions

1. The theory of Endogenous growth was developed by

_____.

- a. Romer
- b. Robert A
- c. Arrow
- d. **Both a & c**

2. Endogenous theory tries to explain the sources of

_____.

- a. Industrial growth
- b. **Productive growth**
- c. Both a & b
- d. None of the above

3. The MP_K remains constant due to existence of

_____.

- a. Capital
- b. Labour
- c. **Both a & b**
- d. None

4. Human Capital is full of knowledge, skills and also has training of _____force.

- a. **Labour**
- b. Capital
- c. Land
- d. Entrepreneur

5. The Human Capital grows as population of a country

_____.

- a. Falls
- b. **Grows**

c. Remains Constant

d. None

6. The Growth of human capital rises in the same proportion as _____ rises.

a. Capital

b. **Physical Capital**

c. Both a & b

d. None

7. There are _____ to scale to all factors taken together.

a. decreasing returns

b. Constant

c. **increasing returns**

d. None of the above

8. In the Romer model, new knowledge enters into the production process in _____ ways.

a. Two

b. **Three**

c. Four

d. Five

9. The neo-classical theory is based on _____ variables.

a. Endogenous

b. Exogenous

c. Both a & b

d. None of the above

10. In endogenous growth theory the technology is _____.

a. **Non-rivalry**

b. Rivalry

c. Constant

d. None of the above