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# The New Theory of Economic Growth: Endogenous Growth Model

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## I. INTRODUCTION

For increasing returns not only the capital but also the labour must expand. K.J. Arrow assumes knowledge as a side product of investment. Ideas are essential for the growth of an economy. It has been proved by Japan's rapid economic growth despite very little natural resources. Japan did this miracle due to open exposure to western ideas, import of modern machines from US and manufacturing of better prototypes of machines.

The Lucas Model is based on the assumption that investment on education leads to production of human capital which is a crucial determinant in the growth process. The new growth theory also emphasizes the role of private sector in technological research and development. The combination of recent endogenous growth theories and neo-classical growth model will provide the best framework for understanding the determinants of economic growth.

Research on economic growth was very active from the late 1950s through the 1960s. The work through the 1960s produced the "neo-classical growth model", which is a core-conceptual framework used now by most economists. The model stresses the accumulation of capital, broadly defined as a source of growth. An important predication of this model is convergence, thatis, a tendency for poor economics to catch up to rice ones. However, the model is less interesting in its predictions about long-run economic growth, which depends entirely on unexplained factors, especially the exogenous rate of technological progress.

Economic growth became a vigorous are of research again in the late 1980s, propelled by a new line of theory that focused on the origins of the technological change. The work stressed that technological advance amounted to the creation of new ideas, which differed from standard inputs to production became ideas could be used freely by any numbers of producers. This idea meant that some kind of monopoly power over new products or processes-that is, a type of imperfect competition was necessary for motivating the discovery of better technologies. Numerous model with these features are described as endogenous growth models because they determine within model the rate of technological change and, hence the economy long terms growth rate. The new theory of economic growth is an endogenous growth model is one in which the long run growth rate of an economy on the basis of endogenous factors, not an exogenous factors as in a neo classical growth model like those following from Ramsey, R.M. Solow, T.W. Swan, Cass Koopmans.

In the Solow-Swan Model, the growth rate does not depend upon the saving rate, in the position of steady state both output per worker and capital per worker being constant, the growth rate is not affected by the saving rate. As the long run growth depended on exogenous factors, the neo classical theory had few policy implications. As pointed out by Paul Romer, "In models with exogenous technical change and exogenous population growth it never really muttered what the government did", The new growth theory docs not simply criticize the neo-classical growth theory. Rather, it extends the latter by introducing endogenous technical progress in growth models. The endogenous growth models have been developed by Kenith J. Arrow, Paul Romer, Lucas and other economists. This new theories are based on the following assumptions:

There, are many firms in a market, knowledge or technological advance is a non-rival good, there are increasing returns to scale to all factors taken together and constant returns to a single factor, at least for one, Technological advance is based on the creation of new ideas, it assumes constant marginal product of capital at the aggregate level or at least, that the limit or the marginal product of capital does not tend towards zero, many individuals and firms have market power and earn profit from their discoveries. This assumption arises from increasing, returns to scale in production that leads to imperfect competition.

These are models with two sectors, produces of final output and R&D sector. The R&D sector develops ideas that they are granted a monopoly over. R&D firms are assumed to be able to make monopoly profit selling ideas to production firms, hut the free entry condition means that these profits are dissipated on R&D spending.

## II. ARROW'S "LEARNING BY DOING" MODEL

K. J. Arrow (1962) was the first economists to introduce the concept of learning by doing in 1962 by regarding it as endogenous in the growth process. He took on the view that the level of the "learning" coefficient is a function of cumulative investment (i.e. past gross investment). Unlike Kaldor, Arrow sought to associate the learning function not with the rate of growth ill investment but rather with the absolute level of knowledge already accumulated. Because Arrow claimed that the new machines are improved and more productive versions of those in existence, investment does not only induce productivity growth of labour on existing capital (as Kaldor would have it), but it would also improve the productivity of labour upon all subsequent machines made in the economy.

The trick is to utilize the concept that while firms face constant returns, the industry or economy as a whole takes increasing returns to account.

This can be easily formalized. Taking the Cobb - Douglas production function $y=AK^aL^{l-a}$ there is constant returns to scale for all inputs together (Since a+ (l-a) =l). Therefore, as noted the Solow model it might seem as if output per capital and consumption per capita does not grow unless the exogenous factor, A, grows too. To endogenizeA, let us first establish the Cobb-Douglas production function for each individual firm:

$$\mathbf{y_i= A_i K_i^a L_i^{i-a}}$$

Where, one can note the output of an individual firm is related with capital, labour as well as the augmentation factor, might thus written look specific to the firm, but it is in fact related to knowledge in the economy. This knowledge and experiences Arrow argued, is common to all firms.

So the first question is how knowledge is accumulated. Arrow argued that it arises from past cumulative investment of all firms.

Let us call this cumulative investment G. Thus, Arrow assumed that the technical augmentation factor is related to economy wide aggregate capital in a process of "learning by doing". In other words, the experience of particular firm is related to the stock of total capital in the economy, G, by the function:

$$\mathbf{A_i=G^z}$$

Thus, as the physical capital stock G accumulates, knowledge used by a particular firm also accumulate by a proportion Z such that 0<1. Transferring to the production function for an individual firm, then:

$$\mathbf{y_i = G^Z K_i^a L_i^{i-a}}$$

Where, note only G does not have a subscript I, (i.e. is not particular to the firm), it is a productive force external to the firms (i.e. a Marshallian externality) and assumed a free public good. This force is free and any firm employing it will not implicate on another firm's consumption: it is freely-available knowledge. But in the aggregate, however, G = K. since it is only the accumulated stock of capital for the economy. Therefore the "economy wide" aggregate production function is:

$$\mathbf{Y = K^{a+z}L^{l-a}}$$

Arrow (1962) assumed that a-z <1.

Therefore, increasing only capital (or only labour) does not lead increasing returns. We can obtain increasing returns to scale as a+z+(l-a) = "z">0, but capital and labour must both expand. However, by adding this restriction, Arrow's original model exhibits non-increasing returns to scale in aggregate if the rate of growth in an economy is steady.

Romer (1986) presented a variant on Arrow's model which is known as learning b 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

$$\mathbf{Y=A\ (R)\ F\ (Ri, Ki, Li)}$$

Where y is aggregate output: A is the public stock of knowledge from research and development R, Ri is the stock of results tram expenditure on research and development b firm i; and Ki and Li are capital stock and labour stock of firm respectively. He assumes the function F homogeneous of degree one in all its inputs Ri, Ki and Li and treats Ri as a rival good.

In this model three key elements include by Romer namely externalities, increasing returns in the production of output and diminishing returns in the production of ne knowledge. According to Romer, it is spillover 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 spillover 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. The other firms also make use of the new

knowledge due to the inadequacy of patent protection and increase their production. Thus the production of goods from increased knowledge displays increasing return and competitive equilibrium is consistent with increasing aggregate returns owing to externalities. Thus Rorner takes investment in research technology as endogenous factor in terms of the acquisition of new knowledge by rational profit maximization firms.

Further Romer presented model of Endogenous Technical Change of 1990 identifies a research sector specializing in the production of ideas. This sector invokes human capital along with the existing stock of knowledge to produce idea or new knowledge. According to Romer, ideas are more important than natural resources. He cites the example of Japan which has very few natural resources but it was open to new western ideas and technology. It imported machines from the United States, dismantled then to see how they worked and manufactured their better prototypes. Therefore, ideas are essential for the growth of an economy. These idea relate to improved designs for the productive of producer durable goods for final production.

In the model, new knowledge enters into the production process in three ways. A new design is used in the intermediate goods sector for the production of a new intermediate input. In the final sector, labour, human capital and available producer durables produce the final product. And a new design increases the total stock of knowledge which increase the productivity of human capital employed ill the research sector.

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. The new design can be used by firm and in different periods without additional cost and without reducing the value of the input.
8. It is also assumed that the low cost of using an existing design reduces the cost of creating new designs.
9. When firms make investments on research and development and invent a new design, there are externalities that are internalized by private agreements.

Romer can be explained in terms of the following technological production function.

 **A = F (KA, HA, A)**

ΔA is the increasing technology F is the production function for technology. K, amount of capital invested in producing the new design, HA is the amount of human capital employed in R&D of the new design. A, is the existing technology of designs.

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.>A is more further the existing technology, A also leads to the production of new technology, >A. Since it is assumed that technology is a non-rival input and partially excludable, there are positive spillover effects of technology which can be used by other firms. Thus the production of new technology can be increased through the use of physical capital, human capital and existing technology.

## III. THE LUCAS MODEL

In Lucas Model, Lucas assumes that investment on education leads to the production of human capital which is the crucial determinant in the gross process. He makes a distinction between the internal effects of human capital where the individual worker undergoing training becomes more productive and external effects which spillover 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 spillover effects that increase the level of technology.

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 spillover effect 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 point of view 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.

**Critical Evaluation of Endogenous growth theory:**

Despite the fact that new growth theory has been regarded as an improvement over the neo classical growth theory still. It has many critics.

- 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.
- To, Olson, the new growth theory lays too much emphasis on the role of human capital and neglects the role of institutions.
- 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.
- One of the main failings of these theories is the collective failure to explain non convergence. That is, to explain why some countries are still much richer than other. It is widely felt that new growth theory has proven no more successful than exogenous growth theory in explaining the income divergence between the developing and developed worlds.

According to Solow, "The idea of endogenous growth so captures the imagination that growth theorists often just insert favorable assumption in an unearned way and then when they put in their thumb and pull out the very plum they have inserted, there is a tendency to think that something has been proved. It may not be generally recognized how restrictive [the assumption of constant returns to capital] is. The conclusion has to be that this version of the endogenous growth model is very un-robust. It cannot survive without exactly constant returns to capital. But you would have to believe in the tooth fairy to expect that kind of luck".

## IV. CONCLUSION

According to Grossman and Help man and Puck, The new growth theories are useful in a more academic way. They have shown that potentially developing countries stand to gain more from trade with developed countries by drawing upon new knowledge, research and development and new technologies of developed countries. This is possible with openness in trade which further offers opportunities to firms to participate in international capital markets for 1inalldllg investment.

The new growth theory emphasizes the role of private firms for investment in technological research and development. But external increasing returns in such cases will be too low. Therefore, public policy can be more effective in making large provision for making investments in creating human capital and on research and development of new knowledge. This call helps to increase the rate of accumulation of both physical and human capital and thus the long-run growth rate of developing countries.

Lucas favours subsidies by the state or schooling in developing countries because investment in education has a spillover effect on the productivity of other people. He also advocates incentives to such firms which invest more on research and development of new technologies.

In contrast, empirical analysis has thus far been less successful in verifying the importance of the recent endogenous growth theories, notably their implications for technological progress.

Hence, we will ultimately find that some combination of the recent endogenous growth theories with the neo-classical growth model will provide the best framework for understanding the determinants of economic growth.

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