Over the past few centuries, standards of living in industrialized countries have reached levels almost unimaginable to our ancestors. Although comparisons are difficult, the best available evidence suggests the average real incomes today in the United States and Western Europe are between 10 and 30 times larger than a century ago. World wide growth is far from constant. Growth has been rising over most of modern history. Average growth rates in the industrialized countries were higher in the twentieth century than in the nineteenth century, and higher in the nineteenth than in the eighteenth. So, growth has an increasing pattern. There are also enormous differences in the standards of living across parts of the world. Average real incomes in such countries as the United States, Germany and Japan appear to exceed those in such countries as Bangladesh and Kenya by a factor between 10 and 20. Over the whole of the modern era, cross-country income difference have widened on average. The fact that average incomes in the richest countries at the beginning of the Industrial Revolution were not far above subsistence means that the overall dispersion of average incomes across parts of the world must have been much smaller than it is today. Indeed, the ultimate objective of research on economic growth is to determine whether there are possibilities for raising overall growth or bringing standards of living in poor countries closer to those in the world leaders. Our central concern in the subsequent sections is to understand the causes of economic growth. Hence, we will discuss the developments in the theory of economic growth over the past few centuries starting with Adam Smith who is considered the founder of Economics.

1.1. Classical Growth Theory

Although most economists would date the birth of the modern theory of economic growth to the 1950s, the classical economists: Adam Smith, Thomas Malthus, David Ricardo and Karl Marx, were the first to discuss many of the key elements of modern growth theory. Smith’s 1776 book, *An Inquiry into the Nature and Causes of the Wealth of Nations*, is regarded the basic reference of Classical Economics.

1.1.1. Adam Smith (1723-1790)

Adam Smith (1776) emphasized the role of specialization (*the division of labor*), *technical progress* and *capital investment* as the main engines of economic growth. Over and above, he stressed the importance of the *invisible hand*, the way in which self-interest pursued in free markets leads to the most efficient use of economic resources and makes everybody better off in the process.

The division of labor, according to Smith (1776), increases workmen’s skillfulness by focusing their attention on certain kind of work. It also saves the time lost in moving from one activity to another. Furthermore, the most important role of specialization is providing opportunities for the invention of machines that can save time and labor in the production process. Technological progress, from Smith’s viewpoint, could also increase overall growth. Smith saw improvement in machinery as engine to growth as it facilitated more specialization. Investment was endogenous determined by the rate of savings (mostly by capitalists). Thus, because savings is what creates investment and hence growth, Smith saw income distribution as being one of the most important determinants of the pace at which a nation would grow.

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To understand the *invisible hand* suggested by Smith, let’s read the following passage taken from his 1776 book:

“...every individual necessarily labours to render the annual revenue of the society as great as he can. He generally, indeed, neither intends to promote the public interest, nor knows how much he is promoting it. By preferring the support of domestic to that of foreign industry, he intends only his own security; and by directing that industry in such a manner as its produce may be of the greatest value, he intends only his own gain, and he is in this, as in many other cases, led by an *invisible hand* to promote an end which was no part of his intention. Nor is it always the worse for the society that it was no part of it. By pursuing his own interest he frequently promotes that of the society more effectually than when he really intends to promote it. I have never known much good done by those who affected to trade for the public good”.

Adam Smith saw that this is the mechanism by which economic society operated. Each one endeavors to become wealthy intending “only his own gain”. However, he has to exchange what he produces with others who adequately assess and value what he has. Hence, by division of labor and a free market, public interest is achieved.

### 1.1.2. Thomas Robert Malthus (1766-1834)

Thomas Malthus was born in 1766. He is the one who suggested the idea that there is a constant tendency for population to double itself every twenty five years. The Malthusian doctrine, as stated in "Essay on the Principle of Population," (1798) was expressed as follows: "population increases in a geometric ratio, while the means of subsistence increases in an arithmetic ratio"\(^4\). Talking about the world population, Malthus concluded\(^5\):

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“…the human species would increase (if unchecked) as the numbers 1, 2, 4, 8, 16, 32, 64, 128, 256, and subsistence as 1, 2, 3, 4, 5, 6, 7, 8, 9. [This would mean that] in two centuries the population would be to the means of subsistence as 256 to 9; in three centuries as 4096 to 13, and in two thousand years the difference would be incalculable.”

That is why Malthus is regarded as a ‘classical pessimist’⁶. He noted the imbalance between population growth and food supply growth, which would lead the per capita income to oscillate around the subsistence level, or to fall in what is called ‘low-level equilibrium trap’. Any increase in per capita income due to technical progress would lead to more births, which would consequently draw the per capita income back to the subsistence level, as the world's resources needed for life are limited. Therefore, Malthus suggested that, at some point, a check of some kind must, sooner or later, be opposed to the ever increasing population level. Malthus recognized certain checks and divided them into preventative and positive checks. Preventative checks are either sexual abstinence or the use of contraception; while positive could be epidemic, disease or famine. Malthus solution to the dilemma of ever-increasing population is “the postponement of marriage in a viceless society”⁷.

However, the Malthusian beliefs have not materialized in today’s world, with the exception of some parts in Africa and Asia. That is because of the stronger preventative checks and also because, contrary to Malthus’ assumption, food production does not grow at an arithmetic rate as technical progress in agriculture has offset its diminishing returns. So, as we see the undervaluation of technological progress rendered classical economists pessimists about the future.

1.1.3. David Ricardo (1772-1823)

In 1817, David Ricardo published his famous work Principles of Political Economy and Taxation, in which he added upon Adam Smith’s model and believed that land has

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⁶ ibid. p.131
⁷ ibid, quoted in p.132
diminishing returns. He said that land is “variable in quality and fixed in supply”\(^8\). That means as growth advances, more land must be cultivated, and because land is limited, capitalist economies will end up with a stationary state, with no growth. That is why he is considered one of the great classical pessimists.

Ricardo suggested two things that might restrain the law of diminishing returns: *technical progress* and *foreign trade*\(^9\). His position on technical progress changed in the third edition of his book from that of the first. In the beginning he recognized that technical advancement would help push the agricultural marginal product upwards and thus allow for more growth. However, he later modified his opinion and he noted that it is required to introduce labor-saving machinery for technical progress to take place. However, machinery displaces labor that might not be placed elsewhere; consequently, plenty of idle labor will create a pressure on wages that will go down. For the richness of all nations, Ricardo suggested his theory of *comparative advantage* in foreign trade. He used his famous model of two countries and two commodities to prove that trade would be beneficial even if one country held an *absolute* cost advantage over the other in both commodities. His argument was that there are gains from trade if each nation specializes completely in the production of the good in which it has a *comparative* cost advantage in producing, and then trades with the other nation for the other good. He argued that growth will take place with foreign trade, if necessary goods (not luxuries) are imported at a lower price than they cost domestically, thereby leading to a lowering of the real wage and a rise in profits. However, the most important outcome here is that overall income levels would rise in both nations\(^{10}\).

**1.1.4. Karl Marx (1818-1883)**

Karl Marx is famous of his book *Das Kapital* (1867), and his prediction of the collapse of capitalism. All members of the classical school believed in a declining rate of profit on capital as economy grew. But they had different reasons for that decline. Smith saw that

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\(^9\) ibid, *Schools of Thought* page.

\(^{10}\) ibid.
the decline in profits was due to competition among capitalists, while Ricardo believed the decline is brought about by the diminishing marginal productivity of land, and the ripped-up profits between rent and wages, leading to a stationary state. Marx also believed there was a long-run tendency for the rate of profit to decline, but he returned that to the “rising organic composition of capital”\(^\text{11}\).

‘Rising organic composition of capital’ is defined according to Marx as the ratio of constant capital to variable capital. Constant capital is plant and machinery and the raw materials used in production, while variable capital is the total wage bill. So, gross output consists of three elements: variable capital \(v\), constant capital \(c\), and surplus value or profit \(s\).

Labor wages are determined by the minimum subsistence level, which was called by Marx as the cost of reproducing the working class. The surplus or profit is the difference between output per worker and the minimum wage per worker. The surplus value, or what Marx called ‘the degree of exploitation’ is given by \(s/v\). The rate of profit is given by the ratio of surplus value to total capital as follows:

\[
\frac{s}{v + c} = \frac{s}{v} \frac{1}{1 + \frac{c}{v}}
\]

so the rate of profit can be expressed as a positive function of the exploitation rate \((s/v)\) and a negative function of the organic composition of capital \((c/v)\). Then Marx argued that the rate of exploitation \((s/v)\) tended to be fixed, while the organic composition of capital \((c/v)\) tended to rise over time, thus the rate of profit has a tendency to fall. Marx’s logic behind that thought is as follows: Assuming a static economy (i.e. no labor supply growth), then the surplus goes to capitalists who would invest it again to expand production. So output will rise over time while labor supply stays fixed. Thus, the number of workers will be increasingly, limited, so wages will rise up and profits will fall.

For Marx, wages are set by “bargaining” in the labor market. Therefore, even with the increase of population, workers will not be encouraged by the higher wages. However,

Chapter 1: Toward Endogenous Economic Growth

Marx thought that capitalists can increase their profits again by introducing labor-saving machinery in the production process. But this would worsen the problem by raising the \( c/v \) ratio.

As capital is substituted for labor, another problem appears: the labor cannot consume all the products produced and a crisis rises. According to Marx, capitalism would ultimately fall down due to its own pitfalls, and power would eventually go to the working class as fewer and fewer people will gain from capitalism. He foresaw that capitalism will be replaced by socialism where workers will possess the means of production, and the state will fade away\(^{12}\).

Marx’s predictions about capitalism have not come true. According to Thirlwall (2003), there are two main reasons behind this. The first is Marx’s confusion about money wages and real wages. Rising of money wages does not essentially indicate rising of real wages. But anyhow, an increase in real wages could be counteracted by a rise in productivity, leaving the rate of profit unaffected. The second reason is, like his predecessors, underestimating the effect of technical progress, but this time in industry. He undervalued the influence of technological advancement on labor productivity. If \( c/v \) is rising the rate of profit can stay unaffected if technical progress surpasses the wage growth rate by the same amount. With the technological progress, both real wages and rate of profit can rise.

1.1.5. Building on Classicals: Joseph Schumpeter (1883-1950)

Joseph Schumpeter has launched what is called a *structural* theory as it suggests that the economy should be considered in its disaggregated multi-sectoral structure. He is an Austrian economist associated with Austrian Economics and regarded as the founding father of Evolutionary Economics. Schumpeter introduced his theory in his 1911 classic book, *Theory of Economic Development*, and then later developed it in his *Business Cycles* (1939) and his *Capitalism, Socialism and Democracy* (1942)\(^{13}\).

\(^{12}\) ibid
Schumpeter has distinguished between ‘economic development’ and ‘economic growth’ in two aspects. While economic growth occurs almost continuously as a result of interactive forces in the economy, economic development is more or less a discontinuous process stimulated by technological innovations. Secondly, economic development is significantly described by evolution and diversity, whereas economic growth has a tendency towards stressing the steady state where the forces of economic growth tend to converge\textsuperscript{14}.

Schumpeter (1911, 1942) put a great stress on the role of the entrepreneur and innovation in the development process. What actually affects the rate of technical progress between countries, according to Schumpeter, is the lag between the creation of knowledge and its adoption, and the rate of dissemination of new knowledge. These two faces of innovation are in turn closely associated with the attitudes of society at large\textsuperscript{15}. Schumpeter introduced the entrepreneur as an innovator who improved growth by efficiently combining resources, adopting new technical enhancements in machinery and managing the division of labor. Progress, for Schumpeter, results from what he calls the process of creative destruction, in which old ways of doing things are endogenously destroyed and replaced by the new. The process of creative destruction is bound up with innovation and prompted by competition. Innovation, in turn, is the driving force behind competition, and it needs decision-takers; that is why Schumpeter stresses on the role of the entrepreneur. Many of the poor countries lack the availability of decision-takers and are characterized by a general risk-aversion spirit. Schumpeter thought that this could be a main reason behind a country’s stage of development\textsuperscript{16}.

Schumpeter’s starting point is the steady state, or the smoothly expanding economy. He, unlike Smith, considered population growth exogenous, and his savings rate constant or a residual but not a driver for growth. What boosts development, in Schumpeter’s

\begin{itemize}
\item \textsuperscript{15} A.P. Thirlwall (2003), Growth and Development. p.249. op.cit.
\item \textsuperscript{16} ibid
\end{itemize}
viewpoint, is, as mentioned above, the discontinuous changes in the economic environment bounced by entrepreneurial innovations\textsuperscript{17}.

In Schumpeter’s most popular book, \textit{capitalism, socialism and democracy} (1942), he started with a good treatment of Karl Marx. He agreed with Marx on his prediction of the downfall of capitalism and its being replaced by socialism, in spite of his fundamentally different reasons. He envisaged that the collapse of capitalism will be at the hands of the intellectual elite. He thinks that the success of capitalism will lead to a form of corporation and a fostering of hostility to capitalism, especially among the intellectuals. The intellectual and social climate needed for entrepreneurship will not exist in advanced capitalism, and it will be succeeded by some form of socialism\textsuperscript{18}.

Modern growth theory takes its basic elements from a classic article by the British economist Roy Harrod, \textit{An Essay in Dynamic Theory} (1939). It has led to the development of what we know now as Harrod-Domar growth model. This model has extremely influenced thinking about post-war development issues, and also it is still used in development planning.

\section*{1.2. POST-KEYNESIAN GROWTH THEORY: THE HARROD-DOMAR MODEL (1939 \& 1946)}

J.M. Keynes in his book \textit{General Theory} (1936) did not extend his analysis of demand-determined equilibrium into a theory of growth. However, the first to extend upon Keynes was Sir Roy F. Harrod (1939) who, concurrently with Evsey Domar (1946), introduced the Harrod-Domar model of growth\textsuperscript{19}.

The Harrod-Domar growth model\(^{20}\) tried to explain some of the dynamics of growth. The model’s target is to determine an equilibrium growth rate \(g\) for the economy. So, according to Harrod-Domar model, let \(Y\) be GDP and \(S\) be savings. The level of savings is a function of the level of GDP, \(S = sY\).

The level of capital \(K\) needed to produce an output \(Y\) is given by the equation:

\[
K = \sigma Y,
\]

where is \(\sigma\) called the capital output ratio. Investment \(I\) is a very important variable in the economy. It represents a vital part of the demand for output of an economy, and also the increase in capital stock. In this way, \(\Delta K = \sigma \Delta Y\). There has to be a balance between supply and demand for an economy’s output, to achieve equilibrium. The equilibrium condition could be reduced simply to \(I = S\). Thus,

\[
I = \Delta K = \sigma \Delta Y
\]

but, \(I = S\)

so,

\[
\sigma \Delta Y = sY
\]

Therefore, the equilibrium rate of growth \(g\) is given by

\[
g = \frac{\Delta Y}{Y} = \frac{s}{\sigma}.
\]

This result is very important, as it tells us that the economy can grow such that the output of the economy is matched by an equivalent demand.

However, for Harrod and Domar, \(s/\sigma\) is the “warranted growth path” of output\(^{21}\). In their model, \(s\) and \(\sigma\) are held constants and determined by institutional structures. This led to the famous “knife-edge” equilibrium in the Harrod-Domar model. If the economy deviates from it in either direction there will be a disaster in the economy. If the actual growth rate is slower than the warranted rate, there is an excess in capacity. The growth of the productive capacity of an economy is exceeding the demand growth. This excess will encourage less investment, which consequently will reduce demand further. In turn, more excess capacity will be generated the nest period.


Likewise, if actual growth is faster than the warranted growth, then the demand growth rate will be outpacing the productive capacity of the economy. Entrepreneurs will try to increase investment to meet demand growth. But that is itself a demand increase which will aggravate the shortage. So, according to Harrod and Domar, unless the demand and output are growing at the same rate, “the economy will either grow or collapse indefinitely”\(^2\).

1.3. **Neoclassical Growth Theory: The Solow-Swan Model (1956)**

The basic *neoclassical growth model* was mainly developed by Robert Solow\(^{23}\) and Trevor Swan in 1956, and has been influential in the analysis of growth ever since. Other neoclassicals who contributed to the development of the neoclassical growth theory are Ramsey (1928), Cass (1965), and Koopmans (1965). Prior to Solow, were also Harrod (1939) and Domar (1947). However, The Solow-Swan growth model (henceforth Solow model) is the starting point for almost all the analyses of growth. “Even models that depart fundamentally from Solow’s are often best understood through comparison with the Solow model”\(^{24}\).

This model focuses on four variables: output (Y), capital (K), labor (L) and “knowledge” or the “effectiveness of labor” (A). As we see here Solow-Swan model identifies (A), technical progress as *anything* that raises labor efficiency. At any time, the economy has some amounts of capital, labor, and knowledge, and these are combined to produce output. The production function takes the form:

\[
Y_t = F(K_t, A_t, L_t)
\]

where \(t\) denotes time.

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\(^{22}\) ibid

\(^{23}\) Robert Solow from the Massachusetts Institute of Technology (MIT) was awarded the Nobel Prize in economics in 1987, partly for his pioneering contribution to growth theory.

\(^{24}\) David Romer (2001): Advanced Macroeconomics. op.cit.
According to Solow model, the amount of output obtained from given quantities of capital and labor rises over time only if the amount of knowledge (A) increases. The model here is built so that the ratio of capital to output, $K/Y$, is eventually constant (as A multiplies only $L$, and is referred to as effective labor).

So, if $K/Y = \text{constant}$

Then

$$(K/Y) = 0$$

And this implies that the growth rate of per capita capital to per capita output is:

$$[(K/L)/(Y/L)] = 0$$

Then,

$$(K/L) - (Y/L) = 0$$

That is

$$k = y$$

And accordingly

$$y = k = g$$

The model’s critical assumption is that the production function has constant returns to scale. That is, doubling the quantities of capital and effective labor doubles the amount produced.

i.e. \[ F(cK, cAL) = cF(K, AL) \quad \text{for all } c \geq 0 \]

The second assumption is that inputs other than capital, labor, and knowledge are relatively unimportant. In particular, the model neglects land and other natural resources. If natural resources are important, doubling capital and labor could less than double output.

The initial levels of capital, labor, and knowledge are taken as given. Labor and knowledge grow at constant rates:

$$\dot{L}_t = nL_t$$

$$\dot{A}_t = gA_t$$

where $g$ is given as exogenous parameter and where a dot over a variable denotes a derivative with respect to time.

\[ ^{25} \text{ibid} \]
The principal conclusion of the Solow model is that the accumulation of physical capital cannot account for either the vast growth over time in output per person or the vast geographic differences in output per person. The model treats other potential sources of differences in real incomes as either exogenous, and thus not explained by the model (in the case of technological progress), or absent altogether (in the case of positive externalities from capital, for example). Therefore, for the economists to address the central questions of growth theory, they had to move beyond the Solow model of exogenous growth.

In the Solow model, long-run growth of output per worker depends only on technological progress. But short-run growth can result from either technological progress or capital accumulation. And in order to determine the sources of growth, Abramovitz (1956) and Solow (1957) started a process called Growth Accounting. It provides a way of decomposing the growth of output per worker into the contribution of capital to growth and a remaining term called the Solow Residual. The Solow residual is sometimes interpreted as a measure of the contribution of technological progress.

1.4. New (Endogenous) Growth Theory

For several decades, the neoclassical growth model remained the benchmark model of economic growth. Starting the 1980s, however, a number of newer, more sophisticated growth models have been introduced. A key feature of these new models is that, unlike the neoclassical growth model, technical progress is not assumed to be exogenous. Therefore, the new growth models are usually called “endogenous growth models”, as one of their key tasks is to explain where technologically driven productivity growth comes from. In the new growth models, the accumulation of knowledge plays a key role in driving productivity growth.

A wave of cross-sectional studies and research on the applied economics of growth, since the mid-1980s, attempted to understand and explain the differences in the rates of output
growth and per capita income growth across the world. It was provoked by three factors:

- The increased concern with the economic performance of the poorer regions of the world, and the notable differences between some regions.
- The increased availability of standardized data (e.g. Summers and Heston data), that could allow more reliable empirical work.
- Some pioneering studies (e.g. Baumol, 1986), that did not find convergence of per capita incomes of the world, contrary to the neoclassical growth theory.

The last factor was significant and mainly inspired the development of the new growth theory, by trying to relax the assumptions of the neoclassical growth theory, especially the assumption of diminishing returns to capital. Furthermore, many questions have been avoided by the neoclassical model, and endeavoring to answer them was another motive behind the emergence of the new (endogenous) growth models. The following are a sample of these questions. Who produces technical progress and why? How is it transmitted? What payment does it get and where does this payment come from? These questions are totally avoided by the neoclassical model, by assuming that the technical progress is “exogenously given”. However, the Solow residual tells us that a big portion of output growth is owing to technical progress. Consequently, we can safely say that an important reason behind output growth “goes unexplained”.

Yet, Valdés (1999) justified the exogenous technical progress with being produced outside the realm of the private, profit-maximizing firms, quoting Solow’s own words: “To say that the rate of technological progress is exogenous is not to say that it is always mysterious”. Thus, according to Valdés, it could, for instance, be provided by the state.

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29 ibid
with tax revenues collected from the public and finally makes their output of technical progress accessible to all firms. However, it is against reality to attribute the whole technical production to the R&D firms financed by the state. Actually, much of technical progress is produced by private, profit maximizing firms, that incur a cost in producing it and they sell it to other profit-maximizing firms at a certain price. Hence, the Solow model doesn’t actually recognize the role of private, profit-maximizing firms in the generation of technical progress.

1.4.1. The Arrow-Romer Model (1986)

The theory of endogenous economic growth owes much of its present form to Paul Romer (1986 and 1990)\textsuperscript{31}, as he has done his doctoral dissertation in 1983 in that field, and Robert Lucas (1988)\textsuperscript{32}. Romer introduced, in a series of articles\textsuperscript{33}, many of the ideas on which endogenous growth theory is based upon. There assumed to be positive externalities associated with human capital formation (for example, education and training) and research and development (R&D) that prevent the marginal product of capital from falling and the capital-output ratio from rising\textsuperscript{34}.

To start with, it will be useful to clarify Romer’s understanding of “technical progress”, which is central to his theory. The Solow model identifies technological progress with “anything that raises labor efficiency”, as quoted by Valdés (1999). Romer is more specific: he identifies it with increases in the stock of knowledge, that is, with new knowledge on how to produce more efficiently. “There are many channels through which societies accumulate knowledge including formal education, on-the-job training, basic scientific research, learning-by-doing, process innovations, and product

innovations”\textsuperscript{35}. Discoveries, whether being major or small, plus the know-how to use them in production, are another channel for increasing the society’s stock of knowledge, as discoveries by themselves cannot increase labor efficiency\textsuperscript{36}.

New discoveries come from R&D activity and job-practice, and the know-how results form job-practice and formal training, or education. Arrow (1962)\textsuperscript{37} was the first to propose an ingenious model of knowledge generation by job-practice. Paul Romer’s first contributions to the theory of endogenous economic growth (Romer 1986, 1987) are based on it. Specifically, he combines Arrow’s analysis with the assumption of instantaneous and costless dissemination (“spillover”) of knowledge. The result is his model that will be presented briefly afterwards\textsuperscript{38}.

Romer’s starting point is Arrow’s (1962) hypothesis that the accumulation of knowledge (that is the discovery of new methods to produce more efficiently and the development of the necessary skills to use them in production) is largely a byproduct of mechanization\textsuperscript{39}. An example can make this point clear. Imagine that a firm has 20 workers and two machines and that a new machine is brought in, thus raising the firm’s level of mechanization (a higher capital-labor ratio). Several things will happen. First, as the firm’s workers operate the new equipment, they progressively become accustomed to it, know it better and learn how to obtain the most out of its use. Second, in the process of adapting to the larger and newer equipment they often devise new forms of organization of production and/or fine new ideas to improve on the equipment itself (by making, for instance, a change in the structure of some of its components). This process is known as “learning-by-doing”\textsuperscript{40}.

\textsuperscript{40} See B. Valdés (1999): Economic Growth. p.100. op.cit.
Romer (1986) makes an assumption that technological knowledge spills over instantaneously and all firms can use it without paying for it. This could happen only if the firm is unconscious of possessing the new knowledge. Romer’s assumption was that every firm has free access to all knowledge as new knowledge is produced unconsciously by firms.

Accordingly, Arrow’s hypothesis of learning-by-doing (1962) plus Romer’s assumption of instantaneous, complete and free of charge dissemination of knowledge lead to the conclusion that an index for the level of technology is given by the following equation.

\[ A_t = \xi (K_t/L_t)^\theta \]

where \( \xi \) is a constant, \( K_t/L_t \) is the level mechanization and \( \theta \) is the learning-by-doing elasticity of \( A_t \) with respect to \( K_t/L_t \).

Note that with this index, the value of \( A_t \) in a given period is no longer exogenously determined it depends on the period’s capital-labor ratio, which is decided by the firms. Accordingly, the Arrow-Romer model was described as follows:41

There is a large number of firms named \( i \) (\( i=1,2,\ldots,N \)) in the economy, all identical, and with labor-augmenting production function

\[ Y_{it} = F (K_{it}, A_t L_{it}) \]

which for simplicity, we assume to be of the Cobb-Douglas type, that is

\[ Y_{it} = K_{it}^a (A_t L_{it})^{1-a} \quad (0<\alpha<1) \]

The number of firms, \( N \), is sufficiently large to ensure that none of them has market power; therefore they are price-takers. It is also assumed that new knowledge (i.e. technical progress) is “learning-by-doing” generated, and by Romer’s (1986) assumption, that all firms can use it without paying for it.

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As we see, this model is the same as Solow model in its mathematical form but differs in nature as $A_t$ is now an endogenous variable, for it depends on the level of mechanization (the capital-labor ratio) that the firms choose at each time. Thus, the technical progress is the true engine of growth in Arrow-Romer model and in Solow model, but the difference is that technical progress here is endogenous in the former, i.e. determined within the model, and is exogenous in the latter, i.e. determined outside the model.

1.4.2. Romer’s Neo-Schumpeterian\textsuperscript{42} Model (1990)

In the previous section, the Arrow-Romer model presented technical progress as endogenous, which is resulting from “things people do”. Yet, the model was not entirely satisfactory, for it assumes that technical progress results from “things people do unconsciously”. Thus, technical progress occurs as an “unintended by-product” of the economic activity of the firms. However, in real life, technological progress is deliberately sought; there are firms whose activity is specifically the invention of new ways to increase economic efficiency, i.e. “to produce” technical progress; we may refer to them as R&D firms. So, technical progress requires a conscious investment for which the firms that acquire it must be compensated.

Therefore, the Arrow-Romer model needs to be corrected according to reality; i.e. we need models of economic growth in which technical progress is both endogenous and user-reattributed as input. Accordingly, Paul Romer (1990)\textsuperscript{43} has built his pioneering work, building on some basic ideas of Schumpeter (1942)\textsuperscript{44} and others, such as Marris and Mueller (1980)\textsuperscript{45}.

\textsuperscript{42} Models of economic growth that explicitly introduce the idea of market power are usually called “Schumpeterian”, as Schumpeter (1942) in his book \textit{Capitalism, Socialism and Democracy} recognized explicitly that market power exists in real economies.
In his model, Romer (1990) uses four key inputs: capital, human capital (i.e. skilled labor), raw (i.e. unskilled) labor, and the level of technology (i.e. the stock of knowledge). His model economy is divided into three sectors: (1) the research sector, (2) the final good sector, and (3) the intermediate capital-goods sector.

The research sector uses human capital and the stock of knowledge to produce new knowledge. Actually, in real life the research sector also uses unskilled labor as an input. But, for simplicity, it is assumed that it uses only skilled labor, or we can say that it is a human capital-intensive sector. The final-good sector uses human capital, raw labor and available intermediate capital-goods to produce a final good output, which can be either consumed or saved. The intermediate capital-goods sector produces intermediate capital-goods using as inputs the output not consumed (i.e. saved) of the final good sector together with the designs produced by the research sector.

The production function of the final output of this model can be described as follows:

$$Y_t = H_y^a L_t^\beta \left( \sum x_t^{1-a-\beta} \right)$$

where $H_y$ is the human capital engaged in producing the final output. $L$ is the raw labor, $x$ is the intermediate capital good, and here each intermediate capital good corresponds to a particular “design” and each design is a piece of knowledge, thus, at any time $t$, the level of knowledge, $A_t$, can be measured by the existing number of designs, therefore, by the number of intermediate capital goods discovered, and hence, available to that date.

In other words, in this model technological progress takes the form of an increase in the number of designs, therefore in the number of intermediate capital-goods discovered and hence, available.

Romer says that his model is basically “the one-sector neoclassical model with technological change, augmented to give an endogenous explanation of the source of the technological change”\textsuperscript{46}. The central conclusions of his model are that the stock of human capital determines the rate of growth, integration with world markets will increase

growth rates (that is why, in Romer’s opinion, developed economies are experiencing rates of growth in per capita income that are unmatched in human history), and an economy with a larger total stock of human capital will experience faster growth.


It is a version of the Arrow-Romer model, when $\theta$ is exactly equal to 1. It is a linear growth model proposed by Rebelo (1991). In his paper of 1991, Rebelo studied a class of growth models which shares with Romer’s model the property of endogenous growth. However, these proposed economies, in contrast to Romer’s assumption, display constant returns to scale technologies, and have steady state growth paths. The simplest model among them is the one-sector economy with standard preferences and a production function that is linear in the capital stock. “These models are generally referred to as AK models, because they result in a production function of the form $Y = AK$, with $A$ constant”48. Rebelo shows that the A-K model should be understood as a reduced form of more complex endogenous growth models, and that K should be considered as a general capital consisting of physical and human capital.

As mentioned above, The A-K model is in the form:

$$Y_t = AK_t$$

where $A$ is a constant of proportionality. We cannot say that according to this model output can be produced without using any labor. But, what the model says is that the level of output happens to be in proportion to the capital stock.

In the steady state, the per capita variables, according to this model are:

$$y = k = i = c = sa - (\delta + n)$$

where $s$ is saving rate, $\delta$ is the depreciation rate, $n$ is the labor rate, and $a$ is just a constant of proportionality. According to this equation, $y$ is positively affected by $s$.

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That is to say, an increase (decrease) in the rate of savings will raise (lower) the growth rate of per capita income.

This also happens in the Solow model, but only during the transition to the new steady state. Once the latter is achieved, the growth rate of per capita income reverts to its previous value (equal to the exogenous growth rate of technical progress).

However, in the present model, the effect is permanent, that is, an increase (decrease) in \( s \) raises (lowers) \( y \) permanently. Hence, the model predicts that countries with higher rate of savings will, other things being equal, tend to grow faster in per capita terms.

As we have seen from the equation, \( y \) is negatively affected by \( n \) and \( \delta \), this also true in the Solow model; the difference, once again, is that in the present model the effect is permanent, whereas in the Solow model it is only transitory. Thus, the model predicts that other things being equal, countries with higher rates of population growth and/or depreciation of the capital stock will tend to grow more slowly in per capita terms.

Therefore, an increase in the rate of population growth raises the growth rate of labor supply, thus lowering the growth in real wages, thereby revising the relative price of capital, \( p/w \). Firms respond to this distortion in relative factor prices by using more of the relatively cheaper input (in this case, labor) and less of the relatively more expensive one. Accordingly, “an increase in the rate of growth of the labor force, with implied decrease in the rate of growth of wages, could cause a decrease in innovation, and hence a decrease in knowledge spillovers from innovation”\(^{49}\).

This implies that the reverse, that is, an increase in the growth rate of real wages, tends to raise labor efficiency, as follow: the higher real wage growth lowers the relative price of capital relative to the level that it would otherwise have, and firms respond by using relatively more capital and less labor, thus raising their capital-labor ratios. This leads to a higher accumulation of knowledge (through greater learning-by-doing and spillover of

\(^{49}\) Paul Romer (1987) as quoted by B. Valdés, p. 116. ibid
knowledge) and, thereby, to a higher efficiency of labor. Hence, the model suggests that a policy of high growth in real wages tends to spur economic growth. This suggested policy could raise the level of unemployment in the short-to-medium run as a result of labor-displacing.

1.5. Other Extensions

Romer’s 1990’s article has been extended by other economists such as Grossman and Helpman (1991)\(^{50}\), and Aghion and Howitt (1992)\(^{51}\). In these models, an effort is made to model microeconomic environment in which firms accumulate knowledge. Particularly, the assumption of perfect competition is relaxed. Firms are assumed, in these models, to compete in a monopolistically competitive environment, and per capita output growth will happen boundlessly since the economy will not run out of ideas.

A two-country model of endogenous innovation and imitation has been developed by Grossman and Helpman (1991), in order to study the interactions between these two processes. “Innovation entails the creation of new processes and products. Imitation is one means by which new ideas percolate through the economy”\(^{52}\). These two forms of learning cause, to a great extent, what we call ‘technological progress’. The interaction between innovation and imitation is of particular significance in the context of trade between the North and the South, as the North is usually the source of former and the South is the pool of the latter. So, one main task of Grossman and Helpman’s (1991) research is to illustrate whether trade between developed and developing countries boosts or impedes growth in each of their regions. So, they developed a model of quality competition with concurrent innovation and imitation. In this model, every product exists in a quality ladder. The entrepreneur in the North tries to upgrade the quality of each product by devoting resources to R&D; however, the entrepreneur in the south spent


money to imitate the production techniques developed in the North. The steady state equilibrium is described by continuing product upgrading and improvement and by product cycles.

The main contribution of endogenous growth economists, led by Romer (1986) and Lucas (1988), has been to endogenize the source of growth of per capita output that is the accumulation of knowledge. Accumulation of knowledge can occur through many ways as mentioned early in this section; however, Aghion and Howitt (1992) have discussed another way that was not given attention to before in literature. It is the *industrial innovations that improve the quality of products*. Via this way, Aghion and Howitt introduced into the endogenous growth theory the idea of *obsolescence*; “better products render previous ones obsolete”\(^{53}\). Thus, they build on Schumpeter’s (1942)\(^{54}\) idea of creative destruction. In their model, the expected growth rate of the economy depends upon the economy-wide amount of research. They assume that individual innovations can affect the entire economy.

Learning models are considered also as extensions to research on endogenous growth theory. “Not only is R&D effort a source of technological improvement; many are by-products of production itself”\(^{55}\). As mentioned above, Arrow (1962), in his seminal work, has highlighted the concept of *learning-by-doing*. Arrow was concerned to explain how productivity increases as a result of production. On the other hand, Rosenberg (1982) as quoted in Malecki (1991) suggested another form of learning which is *learning-by-using*. This type of learning is based on experience. It involves not just steady improvements in productivity but also incremental increases in understanding of design and performance of a product and the machinery with which it is produced. The most elementary form of learning is *learning-by-operating*, a variant of learning-by-doing or by using. However,


\(^{54}\) See J. Schumpeter (1942). *Capitalism, Socialism and Democracy*, op.cit.

the enhancements to operating capacities that result from this learning process are rather small.\footnote{ibid}

Another form of learning is \textit{learning-by-changing} which is improving upon equipment and techniques subsequent to gaining experience with them. A fifth form of learning involves monitoring and recording the performance of a technology and is called \textit{system performance feedback}. This form of learning can generate understanding about why certain things work and others do not. It is clear that this information is neither automatic nor costless. Instead, it depends on the allocation of resources to generate the flow of data. A sixth type of learning is called \textit{learning-through-training}. This type retains an explicit element of dependence on external sources of technology. A further form of learning is \textit{learning-by-hiring}. This form allows firms to create technological capacity, not simply to accumulate it. Finally, \textit{learning-by-searching} assumes that an organization has the capability to investigate various sources of information, to absorb disembodied knowledge and information about several types of technology, and to select the most suitable one.\footnote{ibid}

\section*{1.6. Comparison between Growth Theories}

The \textbf{classical growth theory} differs in many ways from the \textbf{neoclassical theory}, although they have the same view of gradual change and the tendency toward equilibrium. However, neoclassicals are more optimistic, and they believe that growth can be perpetual. In addition, while the classical view sees growth as primarily a function of capital accumulation, the neoclassicals believe growth to be the result of a combination of factors: investment in physical capital, technological progress, improvements in human capital, and improvements in efficiency. The \textit{main drawback} of the neoclassical growth theory is that it does not explain how or why technological progress occur, the case which led to the development of the endogenous growth theory.

\footnote{ibid} \footnote{ibid}
The endogenous growth theorists tried to overcome the failure of the neoclassicals to explain the origin of growth, by relaxing the assumption of diminishing returns to capital and endogenizing the rate of technological progress. That is, technological progress is now determined within the model. Output and productivity growth do not rely anymore on exogenous technical progress. In contrast with the neoclassical growth theory, endogenous growth theorists argue that policy measures, such as subsidies, research and development (R&D) or education, can influence the long run growth rate of an economy.

The main drawback of the endogenous growth theory is its failure to explain non-convergence, i.e. to explain why some countries are still richer than others. The following figure represents a comparison of the reviewed models (see figure 1.1).

To conclude, one of the greatest concerns of economists, since the early days of economic science, is to understand the nature and causes of the wealth of nations. Therefore, due to their research, many theories were introduced and several reasons were suggested until research reached the theory of endogenous growth. Through endogenous growth models, the key source of growth which is technology was explained endogenously, as it goes unexplained in the previous theories. In the new growth models, the accumulation of knowledge plays a key role in driving productivity growth. Apparently, many developing countries believed in this theory and tried to catch up with the developing countries through the accumulation of knowledge. Among these countries, South Korea will be under study in the current research as one of the fast growing developing countries. It has a distinguished record in seizing high technology and investing in research and development to catch up with the developed countries. Therefore, the following chapter will discuss and analyze Korea’s patterns of growth.
Schumpeter distinguished between economic growth and economic development, and stressed the role of the entrepreneur in the development process.

Classical Growth Models

Schumpeter (1883-1950)

Ricardo (1772-1823)

Multhus (1766-1834)

Marx (1818-1883)

Building on Classicals

Neoclassical (Exogenous)

Solow-Swan (1956)

Rebelo (1991)

Endogenous Growth Models

Arrow-Romer (1986)

Romer's neoschumpeterian (1990)

Models assume diminishing returns to capital
Models believe that growth can be perpetual
Models fail to explain non-convergence

Source: The flow chart is constructed by the researcher.