Understanding the nature and causes of the wealth of nations, the reasons why some countries are rich and others are poor, was the main principle of inquiry for economic science since its early days of existence. Classical economists, such as Adam Smith (1776), Thomas Maltus (1798) and David Ricardo (1817), and much later, Frank Ramsey (1928), Allyn Young (1928), Joseph Schumpeter (1934), Frank Knight (1944) and Kenneth Arrow (1962) provided many of the basic ingredients that appear in modern theories of economic growth. New growth theory attempts to explain the process of long run growth through endogenous forces such as human capital, knowledge spillover and technology. It mainly differs from the neoclassical theory, which explains steady state growth rate in terms of the exogenous rate of technological progress.

The process of endogenous technical change was perhaps pointed out, for the first time in modern economic literature, by Trygve Haavelmo in his publication A Study in the Theory of Economic Evolution (1954). However, the theory of endogenous economic growth owes much of its present form to Paul Romer, who started it with his 1983 doctoral dissertation. Paul Romer identified the technical progress as increases in the stock of knowledge; that is new knowledge on how to produce more efficiently. This includes scientific discoveries plus the know-how to use them in production. For discoveries alone do not, by themselves, increase labor efficiency. According to Romer (1986 & 1987), new discoveries come from research and development (R&D) activity.

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and job-practice, and the know-how results from job-practice and formal training, or education\(^4\).

Paul Romer built his model on some basic ideas of Schumpeter (1942); therefore his model was “neo-Schumpeterian in spirit”\(^5\). This neo-Schumpeterian approach, adopted by Romer, was stated vividly in his 1993 seminal paper, as follows: “Our knowledge of economic history, of what production looked like 100 years ago, and of current events, convinces us beyond any doubt that discovery, invention and innovation are of overwhelming importance in economic growth and that economic goods that come from the three activities are different in a fundamental way from ordinary objects”\(^6\). Therefore, high-tech industries acquire a strategic value to LDCs' economies, because the new technology is the engine of long-run growth.

Regressions have been done before, using different variables to examine the effect of R&D on growth. Among the most notable regressions are those which were formulated by Paul Romer (1987). Romer thought of endogenizing growth by letting technological change \(A\) determined locally by knowledge spillovers building on Arrow’s (1962) treatment of knowledge spillovers\(^7\). Based on that, he conducted a regression to capture the effect of investment rate and initial income on growth, and the results were positive and negative, respectively.

Other regressions have been conducted by Barro and Sala-i-Martin (1992)\(^8\). However, they based their regressions on an alternative to the neoclassical model in which they relaxed the assumptions of closed economy and identical technology for all regions. Technology, according to the new model, differs in different regions. The variation in \(A\) causes variation in both per capita capital \(k\) and per capita output \(y\). According to Barro and Sala-i-Martin, the flow of knowledge from the technology leader makes the

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technology grow faster in the **follower country**. Accordingly, per capita income will grow faster in the follower as diffusion closes what has been called the **technology gap**\(^9\), i.e. Barro and Sala-i-Martin suggested that growth could occur in the follower countries due to knowledge spillover effects.

In a third approach, Gregory Mankiw, David Romer, and David Weil (1992) have taken the closed-economy, identical-technology neoclassical growth model (Solow’s Model) and allowed for capital to split to physical capital \(K\) and human capital \(H\). They concluded from their cross-country growth regressions that \(Y = A(t)K^{\alpha}H^{\beta}L^{\gamma}\) is a reasonable specification for aggregate output. However, this is a constant-returns-to-scale model contrary to Raul Romer’s model. The augmented Solow model states that the differences in saving, education, and population growth should explain cross country differences in income per capita\(^{10}\).

Studies have been conducted at firm level as well. Griliches and Mairesse (1981), and Cuneo and Mairesse (1983) used time series data to estimate the contribution of R&D, based on the production function model, for the U.S. and French firms, respectively. Both have come up with a strong relationship between firm productivity and the level of R&D investments. They found that the approximate output elasticity of R&D capital lies between 0.06 and 0.10. Wang and Tsai (2003) have found that R&D output elasticity was around 0.18 for the Taiwanese manufacturing firms; and with dividing their sample into high-tech and other firms, they observed that R&D elasticity is around 0.3 and 0.07, respectively. So, the high-tech firms have a more significant R&D elasticity than the other firms. Marginal product of research capital, or rate of return on R&D investment, was estimated by many researchers. Clark and Griliches (1982), Griliches (1986) and Lichtenberg and Siegel (1989) showed that in US manufacturing firms, the rates of return on R&D investment were 20%, 39% and 13.2%, respectively. Wakelin (2001) demonstrated that the rates of return on R&D capital were around 27 per cent in UK

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manufacturing firms. The average rate of return on R&D investment in the Taiwanese high-tech firms was around 35 per cent, according to Wang and Tsai (2003). However, in an earlier study using 1970s’ data, Griliches (1980), found that the R&D coefficient in US manufacturing industries failed to achieve statistical significance. Others have found the same results, as quoted in Lichtenberg and Siegel (1989), notable among them are E.C. Agnew and D.E. Wise in 1978, Albert Link in 1981, and F.M. Sherer in 198111.

At the industry level, using mostly the R&D intensity model12, Griliches and Lichtenberg (1982), and Scherer (1993) found that the relationship between an industry’s R&D intensity and its productivity growth did not disappear and ‘there is no evidence that technological innovation, measured by private sector R&D expenditures, lost its ability to drive productivity growth”13. Goto and Suzuki (1989) concluded in their research that the rates of return on R&D investment in Japanese manufacturing industries tended to be around 40 per cent. However, it should be noted here that Scherer (1983) concluded that R&D had insignificant impact on productivity.

I.1. STARTING RESEARCH AND SCOPE OF WORK

Upon starting this research, the aim was to assess the role of R&D in the Asian growth experiences, especially for India, China and the tigers in the field of R&D contribution to the growth and development. Asian growth experiences were accompanied by an increase in the R&D expenditures (see Appendix C, Table C.1). Almost two-thirds of the developing world's R&D dollars were spent by countries in Asia. Even the small- and medium-size R&D systems such as Pakistan and Malaysia have also expanded their R&D

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12 ‘Intensity’ of R&D investment is measured as the ‘R&D to sales’ ratio.
finance. It was estimated, in 1988, that 3 out of 4 R&D dollars in the developing world were spent by East and South-East Asian countries. For 1994, more than six out of ten researchers in the developing world were Asians.

However, the evolution of R&D and innovation indicators among these developing countries is not recorded regularly. Furthermore, R&D statistics did not even exist for a number of developing countries. Apparently, R&D and innovation are not among the major priorities of their national statistical agencies, except for one country which is The Republic of Korea (henceforth called South Korea).

Given the relatively inadequate state of R&D statistics in those counties, the path of this research had to drift and try another route which is a comparative study between one of the Latin American countries namely Argentina, Brazil or Mexico for their progress in R&D and growth, and the one South Asian country which has full data statistics, South Korea, in order to compare between the two continents' experiences in R&D and its role in growth process.

Latin America and the Caribbean region, in the early 1980s, had more than a quarter of R&D funds among the developing countries. Brazil, Argentina and Mexico have the largest R&D systems and they kept relatively high rates of R&D expansion even in the time of severe fiscal problems (see Appendix C, Table C.1). Yet, it is worth noting that in the 1990s, the Latin American region was lagging behind in R&D spending.

Nonetheless, the Latin American case was of no difference from the other Asian countries. Lack of data dominated most of the variables relevant to its countries. Hence, due to the differences in the availability as well as the quality of data, a comparative analysis between countries was not possible.

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15 Ibid
16 Data of some countries have anonymous sources on the internet, and others have unreliable local sources.
At long last, the idea of this research has been crystallized and landed on studying the case of South Korea, given the availability of data statistics, considering its position as one with the highest growth rates compared with the industrialized countries. Salomon (1994) has cited that, by 1980, Korea and Japan together accounted for, to a large extent, more than the whole third world R&D spending. According to the latest statistics, Korea's yearly R&D expenditures have grown even further. As shown in Appendix C, Table (C.2), its gross domestic spending on R&D in 2003 almost tripled since 1990. The total number of scientists, engineers and technicians in 1980 represented a tenth of their numbers in 2003, and nearly tripled since 1990. Korea is one of the south Asian countries that have a remarkable record of high and sustained economic growth. From 1965 to 1990, the twenty three economies of East Asia grew faster than all regions of the world\(^\text{17}\).

### I.2. RESEARCH OBJECTIVE

South Korea, the focus of this research, is one of the four tigers and high-performing Asian economies\(^\text{18}\), during the last three decades of the 20th century (1970-2000s). Therefore, I shall attempt to evaluate its investment in research and development (R&D) in the growth process. **The main question of this research will be whether and to what extent R&D has played a significant role in the growth process of South Korea.**

As one of the Four Tigers of East Asia\(^\text{19}\), Korea has achieved an incredible record of growth and integration into the high-tech modern world economy. Many decades ago, GDP per capita was comparable with levels in the poorer countries of Africa and Asia. Today its GDP per capita is roughly 20 times North Korea’s and equal to the lesser economies of the European Union. After the financial crisis in 1997, growth strongly recovered to 10.8% in 1999 and 9.2% in 2000\(^\text{20}\).


\(^{18}\) The eight high-performing Asian economies (HPAEs) are: Japan, Hong Kong, the Republic of Korea, Singapore, Taiwan, Indonesia, Malaysia and Thailand. ibid

\(^{19}\) The four tigers are: South Korea, Singapore, Taiwan and Hong Kong.

Numerous questions have been met in this research. How has Korea achieved such amazing results? What is the role of the technological progress in its growth? What lessons could developing countries in general, and Egypt in specific, learn from Korea's experience? Could that experience be truly replicated?

In addition, there were contradictions, as mentioned above, between the results demonstrated theoretically in literature and those produced empirically by many economists. This research tries to apply the new growth theory on the case of South Korea, and examine whether the economic growth of South Korea has to do with its R&D efforts. Does its growth conform to the results demonstrated theoretically, or contradict them as some of those produced empirically?

That is why this research is going to study the factors that have contributed to its growth, and to assess the R&D endogenous effort in the growth experience of South Korea. Was this effort powerful in enhancing this particular economy? And did it provoke growth of this country? Therefore, the main hypothesis of this study is that R&D has a significant role in the growth process of South Korea over the last three decades (1970-2004). On the other hand, the alternative hypothesis would be that R&D has an insignificant effect on Korea's economic growth.

This thesis has three main purposes: to evaluate the role of technological progress in Korea's growth process, to shed light on major contributing factors to the "Korean Miracle", and to address the question of what lessons a developing country can draw from the Korean experience. To reach the objective of this study, we will test the relationship between the growth of South Korea represented in the increase in the gross domestic product (GDP) on the one side, and certain economic variables that might explain the change in the growth rate on the other side, over the period from 1970 to 2004. These variables are: past investments in R&D, stock of scientists & engineers, flow and stock of physical capital, the average working hours of labor per week, and the total number of laborers employed in all industries.
Enabling factors and constraints will be investigated as well. One of the most important concerns of this study is to examine the conditions that led to the prominence of South Korea among the industrialized world, and the development of its home economy. Many conditions and factors will be under study, notable among them: R&D efforts, investment in human capital, and government policies.

Therefore, this research consists of four chapters. A historical background of the major growth theories is presented in the first chapter. Chapter two examines Korea's growth performance since the early 1960s, when the nation began its phenomenal growth, and provides a discussion of one of its growth patterns which is research and development (R&D) in Korea, and how Korea built its technological capabilities. The Roles of the government and the private sector in encouraging R&D will be discussed in this chapter as well. Chapter three is devoted to assess the role of R&D in Korea's growth process through an empirical investigation, and to discuss its results. Chapter four concludes this research, and addresses the lessons learnt for the developing countries in general, and for Egypt in specific.