The Impact of Research and Development on Economic Growth in Egypt

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Abstract

This research aims at analyzing and estimating the impact of research and development on economic growth in Egypt during the period from 1990 to 2020 using several tests such as Unit Root, Granger Causality, ARDL, and other tests, with a hypothesis that states that research and development has a positive impact on economic growth in Egypt. There are several shreds of evidence from the previous economic literature that proves the significant, positive relationship between research and development and economic growth. Such as Aghion and Howitti (1992) and Lee (2005).

The research concluded that research and development have a positive and significant impact on economic growth in Egypt through economic analysis and the economic model.

Keywords: Economic Growth, Research and development, Egypt, Expenditures, Researchers.

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أثر البحث والتطوير على النمو الاقتصادي في مصر

الملخص

يهدف هذا البحث إلى تحليل وتقدير تأثير البحث والتطوير على النمو الاقتصادي في مصر خلال الفترة من 1990 إلى 2020 باستخدام عدة اختبارات مثل Unit Root و Granger Causality و ARDL وغيرها من الاختبارات ، مع فرضية تنص على أن البحث و التنمية لها تأثير إيجابي على النمو الاقتصادي في مصر. هناك العديد من الأدلة من الأدبيات الاقتصادية السابقة التي تثبت العلاقة الإيجابية المهمة بين البحث والتطوير والنمو الاقتصادي. مثل أجيون وهويتي (1992) ولي (2005).

وخلص البحث إلى أن البحث والتطوير لهما تأثير إيجابي وهام على النمو الاقتصادي في مصر من خلال التحليل الاقتصادي والنموذج الاقتصادي.

الكلمات المفتاحية: النمو الاقتصادي ، البحث والتطوير ، مصر ، الانفاق، الباحثون.

1. Introduction:

Sustained economic growth is fundamental to any government seeking to improve its standard of living. There are four main factors affecting economic growth: (1) Human resources as growth in population eventually leads to growth in the labor force. (2) Natural resources as countries having plenty of natural resources enjoy a better level of economic growth. (3) Capital formation plays a great role in increasing output. (4) Technological progress refers to the application of scientific methods to existing production techniques. Lately, growth theories have marked the great importance of technological change as an effective source of economic growth. These theories point out that the key driver for economic growth in most governments' economies is innovation. Moreover, many studies proved the link between innovation and the growth of economies. This study will clarify the relationship between innovation and economic growth by examining research and development activities. The aim is to find the basis for the link between innovation and economic growth.

1. Research Problem:

The main problem of this study is the low expenditure on research and development in Egypt and its impact on the economic growth rate in Egypt due to several reasons such as (1) Low productivity. (2) Inadequate infrastructure. (3) High tax rates. (4) Macroeconomic instability. (5) Too little technology and lack of innovation. For example, in the financial year 2014/2015, the GDP growth rate in Egypt averaged around 3.4% while in the financial year 2015/2016 the GDP growth rate slowed down to around 2.3%. In the financial year 2016/2017, the GDP growth rate reached around 3.6%.

2. Hypothesis:

The hypothesis of the study is: that there is a positive relationship between research and development and economic growth in Egypt. Whereas, the main idea of the study states that the expenditure on research and development in Egypt will increase productivity which will increase the wages of workers and encourage them to buy more goods and services which leads to increased profits for the businesses; this will encourage producers to invest more, hire more employees and increase the production which will eventually lead to economic growth in Egypt.

3. Research Objective:

The objective of the study is to test the veracity of the previously mentioned hypothesis to illustrate the main relationship between research and development and economic growth in some countries and so, determine if the expenditure on research and development should be increased in Egypt or not.

4. Methodology:

The study depends on the deduction approach where we will study the literature review (economic theories) about the relationship between research and development and economic growth and we will apply that to some advanced countries and Egypt to test the relationship between the last two variables. The study will also depend on the induction approach to generalize the results of the samples from Egypt and South Korea.

We will test the last hypothesis by using the following model**: (Coe and Helpman, (1995), Bronzini and Piselli, (2006):**

$$GDP = f(RD, I, P, L, INF, EXP, IMP)$$

Whereas: Y represents the economic output, **RD** the research and development expenditure, **GDP** is the gross domestic product in US dollars, **I** is the gross capital formation, **P** represents the population, **L** is the labor force, **INF** is the inflation rate in the country, **X** is exports, and **M** is imports.

5. Literature Review Regarding Research and Development and its Determinants:

Research and development are considered fundamental and most important source of progress in all societies and all countries' sectors (economic, political, social, and cultural sector), as it is the core of the development process.

Neither science nor technology can flourish in any economy without an effective base for scientific research activities that aim for development.

It is a set of innovative and creative procedures and projects which are implemented in an organized and integrated manner to increase the cultural and knowledgeable background of humans and use this knowledge in improving their standards of living, increasing economic growth, and increasing production efficiency. (OECD, 2015, pp. 45-46)

From here, we can differentiate between scientific research and development:

5.1 Scientific Research

From the point of view that scientific research is a set of targeted activities to increase scientific knowledge and its implementation in practical reality, it can be classified to:

a) **Basic Research:** It is the theoretical work and scientific experiments which are done to get new information, mainly targeting discovering and understanding the phenomena and natural laws.

   Although basic research doesn't necessarily aim to find new techniques, it greatly contributes to the innovation of these techniques.

b) **Applied Research:** It aims to get new knowledge linked to specific applied goals such as research and experiments in the field of Nuclear Physics, Chemistry, Engineering, and others. (OECD, 2015, pp. 50-51).

5.2 Development

Development is defined as any systematic activity based on the existing knowledge, which was reached through basic or applied research or scientific experience, which is intended to innovate and produce new materials or products and machines to be used in new processes or making improvements to used products, machines, and systems. (OECD, 2015, pp. 51).

Development is considered the result of the work of scientific research, whereas the impact of research and development can be measured on creative technology depending on the level of creativity achieved. The levels of innovation are classified into:

a) Cumulative Creativity which results from simple and continuous improvements in products and methods of

production. This means the continuous process of building new ideas to improve previous existing ones.

b) Radical Creativity refers to creativity in products and methods of production depending on a completely new and different basis. This means completely fresh and new ideas that haven't been achieved before.

A clear difference between the concepts "Scientific Research" and "Development" is shown from the previous.
Whereas the main target of scientific research is the production of new knowledge regardless of whether the research is theoretical or applied, in other words, its purpose is not practical.
On the other hand, development is organized research targeted to increase scientific knowledge and its final purpose is practical which aims to renew and improve products and produce innovations. (Maxim et al., 2013, pp. 20-25).

6. The five Core Criteria for Identifying Research and Development Activities:

Research and development activities can be easily identified through some common features even if those activities are performed by different performers. Although everything is previously planned, research and development activities are generally uncertain about the time needed, resources, or its final results but it always aims for new findings. Therefore, for an activity to be considered a research and development activity, it must meet the five main criteria:

1) **Aiming for Novelty and New Findings:** Any research and development activity is expected to result in new

knowledge which has to be adapted to different situations. For example, in universities, research projects are expected to continue advancements. In the sector of business enterprise, the possibility of the novelty of the research and development projects must be evaluated by comparing it with the already existing knowledge. In the industry. In the industrial sector, research and development activities must result in new findings to benefit the industry. Novelty may sometimes lead to an already existing outcome. (Ojanen, 2002, pp. 119-128).

2) **Creativity Based on Original Hypotheses:** A research and development project must include new goals and ideas that help enhance the already existing knowledge. This excludes all routine changes that are made to products. This means that to consider a project as a research and development project must include the contribution of a human researcher.

3) **Being Uncertain about Outcomes:** Research and development should involve uncertainty. At the beginning of any research and development project, the results, costs of the project, and time allocation are usually not determined. In basic research cases which aim to extend knowledge boundaries, there is a great possibility of not achieving the desired goals. (Brockoff, 2003, pp. 333-348).

4) **Being Systematic, Planned, and Budgeted:** The activities of the research and development project have to be performed systematically. Which means that it should

be managed in a planned order. In other words, everything in the project has to be already well planned and recorded including the sources of funding, purposes, and expected outcome. This applied to small-scale projects as well as large-scale ones.

5) **Leading to Transferable Results**: Another condition to consider a project as a research and development project is that it should result in the ability to transfer new knowledge. It should also be ensured that the resulting new knowledge can be applied and allow other researchers to reuse the outcomes in their own new projects. This includes projects with negative outcomes or failed hypotheses because the main purpose of research and development is to spread knowledge not only generate new results. (Fernandeza, 2015, pp. 725-738).

7. Requirements of Research and Development:

The success of scientific research and development in any country depends on the presence of a group of elements that offers a suitable atmosphere. The requirements can be classified into:

7.1 General Requirements:

a) **Economic Policies:** Research and development greatly require the presence of economic procedures which participates in developing scientific research and development activities. These economic policies include fiscal, monetary, trade, and investment policies.

b) **Political Attention:** The political system greatly affects the development of scientific research, whereas the direction of interests of the political ruling class to education, either as something valuable in its core or as a method for solving problems that face society, participates in giving education its importance in the society. (Dunya and Alburaki, 2017, pp. 28-30).

c) **Social Cultural Society:** Social and cultural society is considered as one of the important requirements to encourage the researchers for creativity, innovation, and continuous research.

d) **Legislative Requirements:** Scientific research and development require the existence of rules such as copyrights to insure the rights of inventors and researchers legally to protect their products. It also helps regulate the relations between the different economic institutions and the researchers working on those activities. (Dunya and Alburaki, 2017, pp. 28-30).

7.2 Private Requirements:

a) Scientific Research and Development Institutions: Institutions that practice research and development activities are one of the most important inputs of research and development. An example of these institutions is the higher education institutions such as universities, specialized research centers, and scientific research organizations.

b) Researchers in the Field of Research and Development: Experienced, effective, and highly educated human resources

are considered to form the most important inputs in scientific and creative activities.

c) Expenditure on Scientific Research and Development: Expenditure on scientific research and development is an essential requirement used in measuring the efficiency of research and development on growth. The most common indicator is represented in the percentage of expenditure on research and development relative to the gross domestic product. (Graversen, and Siune, 2008, p. 7).

8. Challenges Facing Research and Development:

Innovation is widely considered as the engine of economic growth in both developing and developed countries; therefore, it is essential for limiting the level of poverty. Despite the great efforts being made, some developing countries may face challenges while trying to apply the required standards of innovation in their country. These are some of the challenges that are relevant to developing countries:

a) The Lack of Connection between Homogeneous Research and Development Groups.

Developing countries are a group of non-homogeneous, which varies from the least developed countries to the starting-up economies. Therefore, their innovation systems and associated research and development measurement systems show a huge range of varieties internally and internationally. Despite the growing existence of developing countries in the field of global research and development, there is still a noticeable decline in demand for innovational, technological, and

scientific indicators from policymakers in developing countries. (UNESCO, 2010, p. 7).

b) Absence of Research Strategies.

One of the reasons for the diminutive size of expenditure on scientific research is the lack of most of the scientific institutions and Arab universities for devices that are specialized in marketing of the scientific researches and their results according to an economic plan. (Ahmed and Alburaki, 2017, pp. 28-34).

c) Lack of Efficiency and not having Expert Human Force.

Most of the Arab countries suffer from lack of specialized labor force in the sector of scientific research. There is a huge gap between the number of researchers in developing countries, working in the sector of research and development, and the number of those in developed countries. (Galliard, 2008)

d) Low Rates of Spending on Research and Development.

Lack of research and development expenditure can be a major obstacle to research and development of any country. As low spending rates will cause a deficit in governmental and private sectors which will make new projects' set ups very difficult that would eventually cause the sector of research and development in that country to decline. (Galliard, 2008)

e) Low Productivity of Numbers of Research.

Many empirical studies proved that in developed countries the number of annually published research is very low compared to the

number of university staff members. These low rates of research productivity negatively affect the overall research and development of a country. Awareness should be raised about the fact that universities' academician's role shouldn't only be teaching. Research is becoming an important factor in education at universities. It also helps in spreading knowledge and increasing a nation's welfare level. (Iqbal, 2011, pp. 188-189).

9. Variables Affecting the Economic Growth in Egypt:

Investing in research and development can have a great impact on creating new technology, enhancing innovation and eventually increasing economic growth. Research and development therefore may be considered as a main input of the economic growth process. In order to clarify and prove that. This section will test the hypothesis of the study by using the following model**: Coe and Helpman, (1995), Bronzini and Piselli, (2006):**

$$Y = f (RD, GDP, I, P, L, INF, X, M)$$

Whereas: Y represents the economic output, **RD** the research and development expenditure, **GDP** is the gross domestic product in US dollars, **I** is the gross capital formation, **P** represents the population, **L** is the labor force, **INF** is the inflation rate in the country, **X** is exports, and **M** is imports.

The following table 1-1 represnts all the previous mentioned variables in Egypt during the period from 1990 to 2020.

Table 1-1 Variables affecting economic growth in Egypt

Year	RD (Expenditure % of GDP)	GDP (Billion USD)	I (Billion USD)	P (Population)	L (Labor)	INF (Annual %)	X (Billion USD)	M (Billion USD)
1990		43.0	12.4	56,134,478	15,516,692	16.8	8.8	14
1991		37.4	8.9	57,424,552	15,909,214	19.7	10.3	13.2
1992		41.9	8.2	58,666,812	16,473,915	13.6	11.9	12.9
1993		46.6	9.2	59,880,656	17,155,233	12.1	12.0	14.6
1994		51.9	10.7	61,095,804	17,974,863	8.2	11.7	14.6
1995		60.2	12.1	62,334,025	18,093,219	15.7	13.6	16.7
1996	0.21	67.6	12.3	63,601,632	18,370,170	7.2	14.0	17.7
1997	0.2	78.4	13.8	64,892,269	18,628,900	4.6	14.8	19.5
1998	0.2	84.8	18.2	66,200,259	18,882,756	3.9	13.8	21.8
1999	0.19	90.7	19.6	67,515,591	20,061,904	3.1	13.7	21.1
2000	0.19	99.8	19.5	68,831,561	20,088,977	2.7	16.2	22.8
2001		96.7	17.7	70,152,662	20,073,204	2.3	16.9	21.6
2002		85.2	15.3	71,485,044	19,861,134	2.7	15.6	19.3
2003		80.3	13.6	72,826,102	20,892,446	4.5	17.5	19.6
2004	0.27	78.8	13.3	74,172,073	21,942,395	11.3	22.2	23.3
2005	0.24	89.6	16.1	75,523,576	22,992,916	4.9	27.2	29.2
2006	0.26	107.4	20.1	76,873,670	24,046,624	7.6	32.2	33.9
2007	0.26	130.4	27.2	78,232,124	25,101,035	9.3	39.5	45.4
2008	0.27	162.8	36.5	79,636,081	25,445,320	18.3	53.8	62.9
2009	0.43	189.2	36.3	81,134,789	26,180,947	11.8	47.2	59.8
2010	0.43	219.0	42.7	82,761,244	27,557,027	11.3	46.8	58.2
2011	0.53	236.0	40.4	84,529,251	27,814,540	10.1	48.5	58.3

2012	0.51	279.1	44.7	86,422,240	28,199,906	7.1	45.8	67.9
2013	0.64	288.4	41.0	88,404,652	28,717,575	9.5	49.1	67.4
2014	0.64	305.6	41.7	90,424,668	29,084,186	10.1	43.5	69.3
2015	0.72	329.4	47.1	92,442,549	28,961,629	10.4	43.4	71.4
2016	0.71	332.4	50.0	94,447,071	29,254,321	13.8	34.4	66.2
2017	0.68	235.7	36.0	96,442,590	28,747,249	29.5	37.3	69.1
2018	0.72	249.7	41.6	98,423,602	28,245,855	14.4	47.2	73.3
2019		303.1	55.2	100,388,076	28,036,701	9.2	53.0	78.0
2020		365.3	50.4	102,334,403	27,870,211	5	47.9	75.4

Source: The World Bank.

The data of the study which is represented in table (1-1) was tested to find the impact of research and development on economic growth in Egypt.

10.1 Descriptive measures of the study variables:

Table 1-2 Basic measures of the study variables of Egypt

	GDP	I	L	INF	P	M	RD	X
Mean	156.9803	26.82903	2310261 5	2.123686	18.14238	40.59097	0.433590	29.34161
Median	99.84000	19.61000	2299291 6	2.251292	18.13996	29.22000	0.430000	27.19000
Maximum	365.2500	55.20000	2925432 1	3.384390	18.44376	78.01000	0.783885	53.80000
Minimum	37.39000	8.150000	1551669 2	0.832909	17.84326	12.94000	0.160282	8.750000
Std. Dev.	105.5355	15.19616	4751165 .	0.641195	0.179217	24.34906	0.220414	15.99198
Skewness	0.575310	0.359619	-0.07129	-0.37669	0.035926	0.253700	0.257074	0.155864

Kurtosis	1.818596	1.575340	1.453772	2.419734	1.857030	1.299134	1.494616	1.331259
Jarque-Bera	3.512870	3.289820	3.114403	1.168050	1.694076	4.069267	3.268601	3.722416
Probability	0.172659	0.193030	0.210725	0.557649	0.428683	0.130728	0.195089	0.155485

The null hypothesis: The time series of the study variables follows a normal distribution.

The alternative hypothesis: The time series of the study variables does not follow a normal distribution.

- By studying the descriptive measures of the time series of the GDP variable for the time period 1990 to 2020, we found that the average GDP reached 156.98, and the median value reached 99.84, which did not differ much from the average value, which gives an indication of the absence of abnormal values in the time series data, and then the moderation of the data. It is also clear from the table that the skewness coefficient has reached a value of 0.575, which is very close to zero, which indicates that there is no skewness in the data, which is an indication of the moderation of this time series, and the Kurtosis coefficient reached 1.81, which is within the acceptable limits (± 3). This is an indication that the variable follows the normal distribution, and this was confirmed by the (Jarque-Bera) test, where the probability of the distribution reached 0.172, which is greater than the level of significance of 5%. Hence, the average GDP follows the normal distribution, and this is a condition that must be met in the data (the condition of moderation).

- By studying the descriptive measures of the time series of the I variable for the time period 1990 to 2020, we find that the average I reached 26.82, and the median reached 19.61, and it did not differ from the average value, which gives an indication of the absence of abnormal values in the time series data and

then the moderation of the data, as shown From the table, the skewness coefficient has reached a value of 0.359, which is very close to zero, which indicates that there is no skewness in the data, which is an indication of the moderation of this time series, and the Kurtosis coefficient reached 1.57, which is within the acceptable limits (±3). This is an indication that the variable follows the normal distribution, and this was confirmed by the (Jarque-Bera) test, where the probability of the distribution was 0.193, which is greater than the level of significance of 5%.

- By studying the descriptive measures of the time series of the L variable for the time period 1990 to 2020, we find that the average L did not differ from the value of the median, which gives an indication of the absence of abnormal values in the time series data and then the moderation of the data, as it is clear from the table that the skewness coefficient) has reached a value of -0.071, which is very close to zero, which indicates that there is no distortion in the data, which is an indication of the moderation of this time series, and the Kurtosis coefficient reached 1.45, which is within the acceptable limits (±3), and this is an indication that the variable follows The normal distribution was confirmed by the (Jarque-Bera) test, where the probability of the distribution was 0.210, which is greater than the level of significance 5%, and then the average L follows the normal distribution, and this is a condition that must be met in the data (the condition of moderation).

- The case was not different for the rest of the variables, as the results confirmed that they all follow the normal distribution, as the test significance reached values greater than the 5% level of significance.

From the previous, it was found that all the variables of the study follow a normal distribution. Thus, one of the hypotheses of the regression model was achieved to study the relationship between variables and other tests.

10.2 Unit Root Test

The null hypothesis: There is a unit root problem in the time series of the study variables.

The alternative hypothesis: There is no unit root problem in the time series of the study variables.

Table 1-3 The unit root test for Egypt model

Variables	t-Statistic	Prob	Stationarity
GDP	0.389687	0.9791	LEVEL 1
	-3.563	0.0132	
I	-0.447	0.8882	LEVEL 1
	-5.659	0.0001	
L	-1.493	0.5228	LEVEL 1
	-3.000	0.0467	
INF	-2.142	0.2307	LEVEL 1
	-5.676	0.0001	
M	-0.068	0.9442	LEVEL 1
	-4.188	0.0029	
P	0.343406	0.9761	LEVEL 1
	-4.300	0.0133	
RD	-0.912	0.7704	LEVEL 1
	-4.068	0.0039	
X	-0.901	0.7738	LEVEL 1
	-4.632	0.0009	

The test was carried out using the expanded Dickie Fuller method on the variables under study and it was shown through table (1-3) that all the variables of the model were not stable at the level and accordingly the first difference was taken for all the variables as all variables were stabilized for the first difference between the level of confidence of 95% and the level of 99% confidence. Since the variables are not static and all the variables are stable at the same rank, the conditions for conducting the co-integration test have been fulfilled.

Table 1-4 Dickie Fuller method for Egypt Model

Hypothesized	Trace			Max-Eigen		
	Statistic	Critical Value	Prob.**	Statistic	Critical Value	Prob.**
None *	354.4424	159.5297	0.0000	114.2027	52.36261	0.0000
At most 1 *	240.2397	125.6154	0.0000	72.16215	46.23142	0.0000
At most 2 *	168.0776	95.75366	0.0000	62.12482	40.07757	0.0001
At most 3 *	105.9527	69.81889	0.0000	45.67054	33.87687	0.0013
At most 4 *	60.28221	47.85613	0.0022	30.78468	27.58434	0.0187
At most 5	29.49753	29.79707	0.0541	17.83113	21.13162	0.1363
At most 6	11.66640	15.49471	0.1736	11.17407	14.26460	0.1457
At most 7	0.492332	3.841466	0.4829	0.492332	3.841466	0.4829

Table (1-4) shows the co-integration test between the variables of the model, and it was found that there is integration at the

level up to the fourth level for both methods (Trace, Max-Eigen) at a confidence level of 95%, and then it is possible to test the error correction model.
And with a number of non-static variables that have settled at the first difference, and with a number of static variables, the optimal model that fits the nature of the variables and their level of stability is the ARDL autoregressive model.

10.3 Granger Causality Test

Table 1-5 Granger test for causality for Egypt model

Null Hypothesis:	F-Statistic	Prob.
I does not Granger Cause GDP	1.69053	0.2057
GDP does not Granger Cause I	0.03169	0.9688
L does not Granger Cause GDP	5.33618	0.0121
GDP does not Granger Cause L	2.67274	0.0895
INF does not Granger Cause GDP	1.10724	0.3468
GDP does not Granger Cause LINF	0.65927	0.5263
P does not Granger Cause GDP	7.50460	0.0029
GDP does not Granger Cause LP	4.32519	0.0249
M does not Granger Cause GDP	9.61545	0.0009
GDP does not Granger Cause M	0.52545	0.5979
RD does not Granger Cause GDP	2.14186	0.1393
GDP does not Granger Cause RD	11.2324	0.0004
X does not Granger Cause GDP	10.2766	0.0006
GDP does not Granger Cause X	3.15197	0.0609

- Table (1-5) shows the Granger test for causality in order to study the direction of the relationship between (I) and (GDP).

The results showed that there is no causal relationship to and from the two variables, as the significance of the test reached 0.205 and 0.968, which are greater than the error level of 5%.

- The results showed that there is a causal relationship from (L) to (GDP) at a level of confidence of 95%, and it was also shown that there is a causal relationship from (GDP) to (L) at a level of confidence of 90%, and accordingly there is a mutual causal relationship between the two variables.
- Table (15) shows the Granger causality test to study the direction of the relationship between (INF) and (GDP). The results showed that there is no causal relationship to and from the two variables, as the significance of the test reached 0.346 and 0.526, which are greater than the error level of 5%.
- The results showed that there is a causal relationship from (P) to (GDP) at a level of confidence of 99%, and it was also shown that there is a causal relationship from (GDP) to (P) at a level of confidence of 95%, and accordingly there is a mutual causal relationship between the two variables.
- The results showed that there is a causal relationship from (M) to (GDP) at a level of confidence of 99%, and it was also shown that there is no causal relationship from (GDP) to (M), as the test significance reached 0.597, which is greater than the level of significance of 5%, and therefore there is a relationship One-way causality from (M) to (GDP).
- The results showed that there is a causal relationship from (GDP) to (RD) at a level of confidence of 99%, and it was also shown that there is no causal relationship from (RD) to (GDP), as the test significance reached 0.139, which is greater than the level of significance of 5%, and therefore there is a relationship One-way causation from (GDP) to (RD).

- The results showed that there is a causal relationship from (X) to (GDP) at a level of confidence of 99%, and it was also shown that there is a causal relationship from (GDP) to (X) at a level of confidence of 90%, and accordingly there is a mutual causal relationship between the two variables.

10.4 Correlation matrix

Table 1-6 The correlation matrix between the foreign direct investment logarithm and the study variables

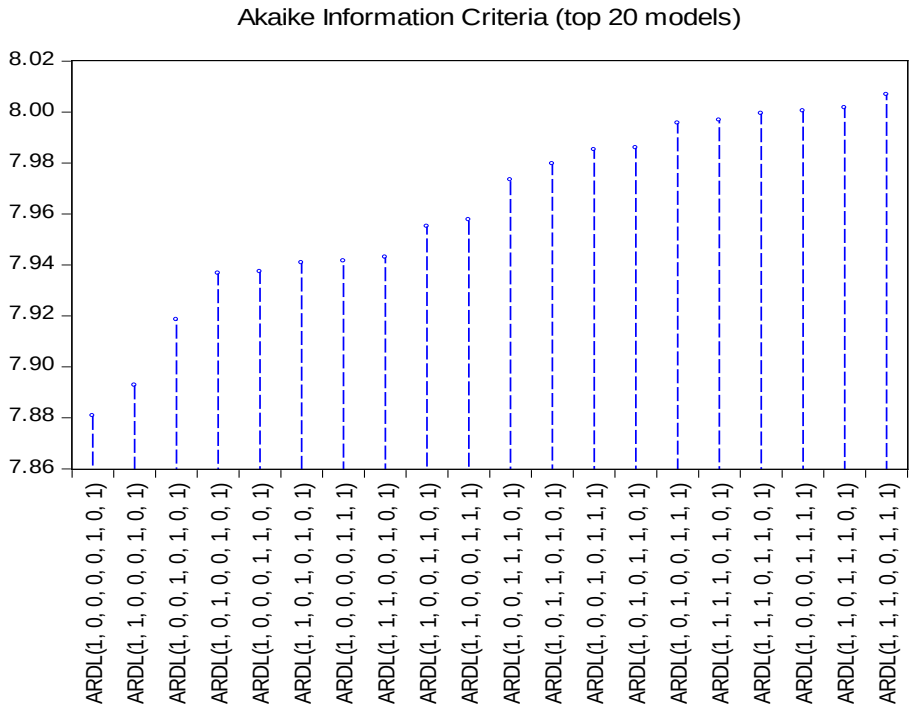
	GDP	I	L	INF	P	M	RD	X
GDP	1							

I	0.971	1						
	0.000	-----						
L	0.927	0.934	1					
	0.000	0.000	-----					
INF	0.190	0.217	0.222	1				
	0.307	0.241	0.230	-----				
P	0.928	0.923	0.966	0.136	1			
	0.000	0.000	0.000	0.466	-----			
M	0.954	0.974	0.961	0.320	0.945	1		
	0.000	0.000	0.000	0.080	0.000	-----		
RD	0.649	0.603	0.469	0.613	0.480	0.612	1	
	0.000	0.000	0.008	0.000	0.006	0.000	-----	
X	0.854	0.912	0.933	0.298	0.887	0.951	0.462	1
	0.000	0.000	0.000	0.104	0.000	0.000	0.009	-----

Table (1-6) shows the correlation matrix between the GDP and the variables of the study, and the results have been shown.

- There is a statistically significant relationship between GDP and I, L, LP, M, and X at a confidence level of 99%, as the significance of the test is all less than the error level of 1%. The correlation values ranged between 0.649 and 0.971, and they were all positive between very strong.
- There is no statistically significant relationship between GDP and LINF at the 95% confidence level, as the test significance was 0.307, which is greater than the 5% error level.

Figure 1-1 Different ARDL Models According to AIC Standard for Egypt Model



The analysis resulted in multiple decelerating autoregressive models, and the results showed that ARDL (1.0.0.0.0.1.0.1) is the best model available according to the AIC criterion for error measurement, as it is the least, and this is a criterion for judging the quality of the model.

10.5 Regression model coefficients

Table 1-7 Estimation parameters of the GDP model for Egypt

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
GDP(-1)	0.581072	0.140268	4.142573	0.0006
I	2.715733	0.768683	3.532967	0.0024
L	5.83E-06	3.95E-06	1.474327	0.1577
INF	-14.2139	6.217366	-2.28615	0.0346
P	4835.784	1583.264	3.054313	0.0068
M	-0.98963	1.115125	-0.88746	0.3865
M(-1)	-2.715	0.924588	-2.93645	0.0088
RD	82.94444	25.6336	3.23577	0.0046
X	1.458515	1.218436	1.197039	0.2468
X(-1)	4.112431	0.981212	4.191176	0.0005
C	-86418.8	28297.12	-3.05398	0.0068
@TREND	-97.9175	32.28161	-3.03323	0.0071
R-squared		0.993		
Adjusted R-squared		0.990		
F-statistic		249.661		
Prob (F-statistic)		0.000		
Durbin-Watson stat		2.689		

Table (1-7) shows the coefficients of the ARDL autoregressive model of GDP, and the results showed the significant significance of the model at a confidence level of 99% (significance = 0.000, which is less than the significance level of 1%). The value of the calculated F-test was 249.661, which indicates the quality of reconciliation Sample.
The results also showed that the modified identification parameters of the model had a value of 0.990, and this indicates that the model variables explain 99.0% of the changes that occur in the gross domestic product, which is a very high interpretation rate.

10.6 Serial autocorrelation test for residuals

The results of table (19) also showed that the Durbin-Watson coefficient reached 2.689, which is close to the optimal value 2. This coefficient was tested through the Breusch-Godfrey Serial Correlation LM Test
Where this test is based on studying the problem of serial autocorrelation between the residues and each other, which is an important criterion for judging the quality of the model obtained from the analysis.

Table 1-8 The serial autocorrelation problem of the residuals of Egypt model

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	2.25533	Prob. F(2,16)	0.1371
Obs*R-squared	6.597534	Prob. Chi-Square(2)	0.0369

Table (1-8) shows the serial autocorrelation of the residuals of the ARDL regression model for GDP. The results confirmed that there is no serial autocorrelation problem between the residuals and each other. The test significance reached between 0.137, which is greater than the significance level of 5%, and then the zero hypothesis was accepted. The absence of the problem of serial self-correlation between the residues and each other. Thus, another criterion of judging the quality of the model was achieved.

10.7 Random residual variance test

Table 1-9 Randomized Residue test for Egypt Model

Heteroskedasticity Test: ARCH			
F-statistic	1.604401	Prob. F(1,27)	0.2161
Obs*R-squared	1.626589	Prob. Chi-Square(1)	0.2022

Table (1-9) shows the test of randomness of residual variances for the GDP model. The significance of the test was 0.216, which is greater than the significance level of 5%. Therefore, the null hypothesis was accepted stating that the residual variances are random for the GDP model in Egypt, which is a criterion for judging the quality of the model.

10.8 The normal distribution test of the residuals for Egypt model

Figure 1-2 The normal distribution test of the residuals for Egypt model

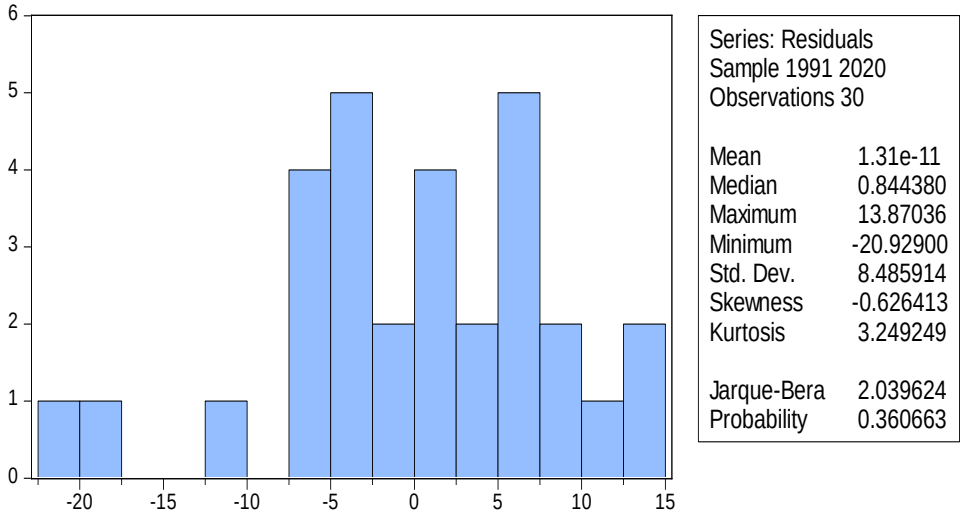


Figure (1-2) shows some measures that indicate the normality of the residuals, where the torsion coefficient reached 0.626 and it is very close to zero, which indicates that there is no torsion in the residual curve. The results of the Jarque-Bera test showed that the residuals of the model follow the normal distribution, as the test significance reached 0.360, which is greater than the 5% level of significance, which is an indicator for judging the quality of the model.

10.9 Long-term relationship test

This test studies the long-term relationship between the variables of the model, where the zero hypothesis assumes that there is no long-term relationship between the variables, and this hypothesis is accepted if the significance of the test is greater than the 5% level of significance.

Table 1-10 The long-term correlation of Egypt model

Test Statistic	Value	k
F-statistic	5.523557	7
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	2.38	3.45
5%	2.69	3.83
2.50%	2.98	4.16
1%	3.31	4.63

Table (1-10) shows the long-term correlation test. The results showed that the calculated value for the test is 5.523, which is greater than the critical value at the different levels of significance, which indicates the rejection of the null hypothesis and the acceptance of the alternative hypothesis that there is a long-term relationship between the variables at a confidence level of 99%.

1- The effect in the short term:

Table 1-11 The impact in the short term of the Egyptian model

Cointegrating Form				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(I)	2.716	0.769	3.533	0.002
D(L)	0.000	0.000	1.474	0.158
D(INF)	-14.214	6.217	-2.286	0.035

D(P)	4835.784	1583.264	3.054	0.007
D(M)	-0.990	1.115	-0.887	0.387
D(RD)	82.944	25.634	3.236	0.005
D(X)	1.459	1.218	1.197	0.247
D(@TREND())	-97.917	32.282	-3.033	0.007
CointEq(-1)	-0.419	0.140	-2.987	0.008
Cointeq = GDP - (6.4826*I + 0.0000*L -33.9291*INF + 11543.2376*P -8.8431*M + 197.9922*RD + 13.2981*X -206285.6627 -233.7335 *@TREND)				

• Table (1-11) shows the effect of the independent variables on the GDP in Egypt at the short-term level. The results showed that there is an effect of (I) at time T on the GDP at a confidence level of 99%.
• There is an effect of the inflation logarithm at time T on the gross domestic product at the 95% confidence level, as the test significance was 0.035, which is less than the 5% error level.
• There is an effect of LP at time T on GDP at a confidence level of 99%, where the test significance was 0.007, which is less than the error level of 1%.
• There is an effect of RD at time T on the GDP at a confidence level of 99%, where the test significance was 0.005, which is less than the error level of 1%.
• At the short-term level, and through the results of table (21), it was found that the value of the error correction coefficient was -0.419 at a confidence level of 99%, and this indicates that 0.419 of the short-term errors are automatically corrected to reach the long-term equilibrium.

2- The effect in the long term:

Table 1-12 The impact in the long term of the Egyptian model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
I	6.483	2.973	2.180	0.043
L	0.000	0.000	1.688	0.109
INF	-33.929	16.831	-2.016	0.059
P	11543.238	5598.613	2.062	0.054
M	-8.843	5.494	-1.610	0.125
RD	197.992	78.393	2.526	0.021
X	13.298	7.233	1.839	0.083
C	-206285.663	100008.441	-2.063	0.054
@TREND	-233.734	113.417	-2.061	0.054

• Table (1-12) shows the impact of the independent variables on the GDP in Egypt at the long-term level. The results showed that there is an effect of (I) on the GDP at a confidence level of 95%, as the test significance reached 0.043, which is less than the error level of 5%. .

• There is an effect of the inflation logarithm at time T on the GDP at the 90% confidence level, as the test significance was 0.059, which is less than the 10% error level.

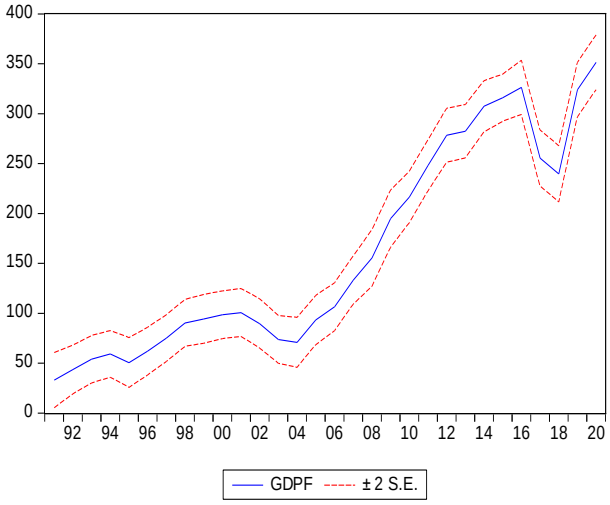
• There is an effect of (LP) at time T on the GDP at a confidence level of 90%, where the test significance was 0.054, which is less than the error level of 10%.

• There is an effect of (RD) at time T on the GDP at a confidence level of 95%, where the test significance was 0.021, which is less than the error level of 5%.

• There is an effect of (X) at time T on the GDP at a confidence level of 90%, as the test significance was 0.083, which is less than the error level of 10%.

10.10 Predictive ability of the Egyptian model

Figure 1-3 The predictive ability of the foreign direct investment logarithm model in Egypt



Forecast: GDPF	
Actual: GDP	
Forecast sample: 1990 2020	
Adjusted sample: 1991 2020	
Included observations: 30	
Root Mean Squared Error	8.343284
Mean Absolute Error	6.676205
Mean Abs. Percent Error	5.548147
Theil Inequality Coefficient	0.021834
Bias Proportion	0.000000
Variance Proportion	0.001633
Covariance Proportion	0.998367

Figure (1-3) shows some of the error criteria of the model as well as the extent of the model's ability to predict the future values of Egypt's GDP. It was found that the square root of the mean squared error had a value of 8.343, while the mean absolute error was 6.676, and Thiel's coefficient was 0.021, which is less of 0.10 and then it is possible to rely on this model to predict the gross domestic product in Egypt.

From the all the previous, the validity of the model has been validated according to the existence of a statistically significant

effect of research and development on the gross domestic product in Egypt.

11. Conclusion:

The research concluded that research and development in Egypt are positively associated with economic growth. This research shows that Egypt has the qualifications to that allows it to invest in the field of research and development but it needs more focus from the government to direct its resources. The study included the importance of some factors which enhance the knowledge base of any country that will eventually positively affect the economy. These factors are industry-academia collaboration, the mobility of the researchers and funding of research and development. The research included an applied model to test some variables that affects the overall economic growth of Egypt. The results of the model were as follows: by studying the descriptive measure of the time series of RD, research and development expenditure, variable and some other variables affecting the economic growth from 1990 to 2020, all results were noticed to follow the normal distribution which agrees with the hypothesis of the study and that encouraged testing the relation between the variables and each other. Results showed that there is a significant effect of research and development on the gross domestic product of Egypt.

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