# Digitalization and energy consumption impact on Egypt economic growth
# تأثير الرقمنة واستهلاك الطاقة على النمو الاقتصادي في مصر

**Ahmed Mahmoud Haridy Mahmoud Hammam**
ahmed.haridy@live.com

**Principal Supervisor**
**Prof. Dr: Doaa Salman Abdou, PhD. Professor of Financial Economics**
**MSA**

**Co- Supervisor**
**Prof: Ahmed Elsedawy**
**College of Management and Technology**
**AASTMT**

**المستخلص:**

تتناول هذه الدراسة العلاقة المعقدة بين التكنولوجيا الرقمية واستهلاك الطاقة والنمو الاقتصادي في مصر. تقوم الدراسة بتقييم مدى التكنولوجيا الرقمية في مختلف قطاعات الاقتصاد المصري وتحليل مصادر وأنماط استهلاك الطاقة. يتم إجراء مقارنة بين تقدم مصر في التكنولوجيا الرقمية والمقاييس العالمية، مع التركيز على السياسات والمبادرات القائمة التي تهدف إلى تعزيز التكنولوجيا الرقمية وإدارة استهلاك الطاقة. تستكشف البحث تأثير التكنولوجيا الرقمية على الإنتاجية والابتكار وخلق فرص العمل والقدرة التنافسية في الاقتصاد المصري. كما تبحث في الارتباط بين استهلاك الطاقة والنمو

الاقتصادي الشامل، مع التركيز على العواقب الاقتصادية والبيئية المحتملة لممارسات الطاقة غير المستدامة. تكشف النتائج التحديات التي تواجه استنزاف الطاقة واتجاهات استخدام الإنترنت، مع التأكيد على ضرورة التدخلات الاستراتيجية لتحسين تأثير التكنولوجيا الرقمية واستهلاك الطاقة على النمو الاقتصادي في مصر. من خلال استخدام المتغيرات الماكرواقتصادية وتطبيق نموذج ARDL، تتحدى هذه الأطروحة الافتراضات السابقة من خلال اقتراح أن استنزاف الطاقة واستخدام الإنترنت لم يسهما مباشرة في النمو الاقتصادي في مصر. تؤكد الاستنتاجات أهمية مواءمة استراتيجيات التكنولوجيا الرقمية والطاقة مع أهداف التنمية الاقتصادية المستدامة. وتدعو إلى اتخاذ تدابير سياسية مستهدفة وجهود تعاونية للمساعدة في التحول نحو اقتصاد رقمي مع التخفيف من التأثيرات السلبية على استهلاك الطاقة والنمو الاقتصادي

**الكلمات المفتاحية: الرقمنة، استهلاك الطاقة، النمو الاقتصادي، المعايير العالمية، السياسات والمبادرات الحالية، الاقتصاد المصري، ممارسات الطاقة الغير مستدامة، لمتغيرات الاقتصادية الكلية، نموذج ARDL، استراتيجيات الطاقة.**

# Abstract:

This paper examines the complex relationship between digitalization, energy consumption, and economic growth in Egypt. The study assesses the extent of digitalization in different sectors of the Egyptian economy and analyzes the sources and patterns of energy consumption. A comparison is made between Egypt's digitalization progress and global benchmarks, highlighting existing policies and initiatives aimed at promoting digitalization and managing energy consumption. The research investigates the impact of digitalization on productivity, innovation, job creation, and competitiveness in the Egyptian economy. It also explores the correlation between energy consumption and overall economic growth, emphasizing the potential economic and environmental consequences of unsustainable energy practices. The findings reveal the challenges posed by energy depletion and internet usage trends, emphasizing the need for strategic interventions to optimize the impact of digitalization and energy consumption on Egypt's

economic growth. By using macroeconomic variables and applying the ARDL model, this thesis challenges previous assumptions by suggesting that energy depletion and internet usage did not directly contribute to economic growth in Egypt.

The conclusion emphasizes the importance of aligning digitalization and energy strategies with sustainable economic development goals. It calls for targeted policy measures and collaborative efforts to navigate the transition towards a digital economy while mitigating adverse effects on energy consumption and economic growth.

**Keywords: Digitalization, Energy Consumption, Economic growth, Global Benchmarks, Existing policies, Egyptian Economy, unsustainable energy practices, macroeconomic variables, ARDL model, energy strategies.**

# 1. Introduction

In recent years, digitalization has emerged as a powerful force shaping economies worldwide. This global trend, coupled with the increasing consumption of energy resources, has created compelling challenges and opportunities for nations striving for sustainable economic growth. Egypt, with its significant economic potential and rapid digitization efforts, stands at the forefront of this transformation. Recognizing the importance of this issue, this research proposal aims to investigate the impact of digitalization and energy consumption on Egypt's economic growth. (Lange et al, 2020).

Egypt, as one of the most populous countries in Africa and the Middle East, has consistently experienced economic fluctuations influenced by numerous factors. The government's sustained efforts in promoting digitalization further highlight its commitment to harnessing the potential benefits of this phenomenon. Concurrently, the surging demand for energy consumption poses both challenges and opportunities for Egypt's economic development. As the country seeks to modernize its infrastructure, expand industries, and attract foreign investments, understanding the dynamics between digitalization, energy consumption, and economic growth becomes paramount.

The objective of this research proposal is to comprehensively examine how digitalization and energy consumption influence Egypt's economic growth. By analyzing the interdependencies of these factors, policy interventions and strategies can be formulated to optimize resource allocation, enhance national competitiveness, and mitigate potential adverse effects. Leveraging both qualitative and quantitative research methods, this study aims to provide empirical evidence to guide policymakers, industry stakeholders, and researchers in understanding the complex relationship between digitalization, energy consumption, and economic growth in the Egyptian context.

The research will involve collecting relevant data from various sources, including governmental reports, industry statistics, and academic literature. Ultimately, the findings of this research proposal will contribute to the existing body of knowledge on the relationship between digitalization, energy consumption, and economic growth in Egypt. The outcomes can serve as a foundation for evidence-based policy formulation, guiding economic decision-making and sustainable development efforts. Additionally, they will inform businesses and investors on the potential opportunities and challenges prevalent within Egypt's evolving digital landscape.

In conclusion, this research proposal seeks to investigate the impact of digitalization and energy consumption on Egypt's economic growth. By examining the interplay of these factors, this study aims to contribute to policymaking efforts, enhance resource allocation, and optimize economic development strategies. Through a rigorous research methodology, this research proposal aims to offer valuable insights into the complex relationship between digitalization, energy consumption, and economic growth specifically tailored to the Egyptian context.

Based on the previous, this research seeks to investigate two hypotheses have been established for the researcher to test through secondary research data **as following:**

**Hypothesis One:** The adoption and integration of digitalization in various sectors of the Egyptian economy will have a negative significant impact on economic growth.
**Hypothesis Two:** The depletion of non-renewable energy sources will cause adverse effects to economic growth in Egypt.

# 2. Literature review

The following section explores the importance of the two main variables and their contribution the overall economic performance in general. Also, the main aspects and pillars of digitalization and energy will be examined in the upcoming section. This will be examined through illustrating the results of the recent previous studies. In addition to, the main existing theories explaining the importance of the main independent variables will be further discussed.

## 2.1. Theoretical Literature review

**Energy & Neoclassical economics**: Until the late 1960s, all of the economists were not concerned at all with the relationship between the environment and economy. The economic analysis did not put into consideration the environmental costs that can result from any economic activity in terms of pollution and depletion of the existing resources. After that, in 1962 specifically, Rachel Carson's in his book Silent spring & Paul Ehrlich's in 1969 in his report The Population Bomb and the Club of Rome's Report gained the attention for the environmental concerns. These reports and publications mainly focused on the environmental damages that were caused especially after the second world war.
Therefore, the Neoclassical economists established the economics of natural resources which was founded mainly by Malthus and Jevons in the nineteenth century. This enlightened the optimal usage of the renewable energy resources. Following it the Pigouvian taxes which was mainly concerned with correcting the externality or market failure causing damage to the environment through corrective taxes. Also, the neoclassical

economists begun to look for the pareto efficiency outcomes while doing cost-benefit analysis for the determine whether energy sources are allocated efficiently or not (Chester, 2017).

**Energy & Hoteling's theory**: This theory stated that the owners of non-renewable energy resources have to start production of such products only when the revenues coming from them exceeds greatly the costs of the financial instruments. This is mainly used by economists in determining the prices of an energy resource. Also, there are three main assumptions for such theory: the market is completely efficient, constant technological advancements during the estimated period and other external factors affecting the pricing or the production of the resources are not existing (CFI, 2015).

**Energy & Game theory**: Game theory which was firstly founded and discovered by the Mathematician John Van Neumann & the economist Oskar Morgenstern in 1940s shed the light on the importance of analyzing situations when individual players have conflicting goals. So, game theory is correlated with the energy in terms of providing incentives to the consumers in order to change their behavior towards energy consumption. This can take place through offering rewards or penalties which are consistent with their interests (Ayyathurai, 2023).

**Technology & Classical Economics**: According to Adam Smith, the division of labor will thus enhance the level of inventions created in the economy as employees will focus on working and enhancing the productivity of a specific area. Also, Adam Smith explained that innovations are enhanced and developed as a result of human curiosity. He also stated the importance of creating new machines in facilitating the efficiency of the workers with at least cost (Smith. C, et al. 2006).

**Technology & Paul Romer theory**: Paul Romer developed a theory called Romer's theory in 1986 stated the importance of creating new sources and areas of knowledge of the firms that can lead to creating positive spillovers and externalities. He also stated that technology and innovation can be considered as a public good since other firms can benefit if one of the firms had access to the latest innovative methods (Henri Kouam, 2023).

**Decoupling theory**: There is a discussion in ecological and environmental economics about whether economic growth can be separated from environmental factors like energy consumption, and whether digitization may contribute to a reduction in energy use. Four debates are at the center of the theoretical work on the decoupling of energy and economic growth. The first discussion centers on the idea that energy and physical capital are complementary rather than interchangeable. The second point of contention concerns whether boosting energy efficiency reduces energy use, as it may have the opposite effect and negate any potential energy savings. The third argument is on the connection between economic activity and energy consumption and is predicated on the theory that energy is more important than neoclassical economists have traditionally assumed. The Environmental Kuznets Curve idea is the subject of the fourth dispute (Lange et al, 2020).

## 2.2. Digitalization in Egypt

Digital transformation and technological innovation have the power to change businesses and support economic expansion, job creation, human capital development, and poverty alleviation. Policymakers and business owners need to continuously innovate and adapt as change picks up speed to stay competitive. With some advanced acceptance by specific segments, expanding adoption by tech-enabled start-ups and services, early use of electronic government services, and negligible ICT deployment by private sector firms, Egypt has demonstrated progress in digitalization. Egypt's economy may be significantly impacted by digital transformation if ICT infrastructure and connectivity are further widely distributed, (Salman, D., & Hosny, N. A. (2021); Kamel, (2021).

Enhancing service delivery and increasing demand for digital services requires accelerating digital transformation and scaling out end-to-end digital government services on reliable public sector platforms. It might be possible to increase market competitiveness, make the most use of the capacity that is already

available, and build out fiber networks. To completely preserve and utilize Egypt's human capital, a comprehensive plan for acquiring both fundamental and advanced digital skills is essential. Lastly, encouraging inclusion in financial services would greatly contribute to the growth of the digital economy; however, this requires the collaboration of public and private parties. It's time for Egypt to update its regulatory environment to promote faster growth and further incentivize investment and innovation. The nation won't be able to fully realize the digital economy's promise for long-lasting revolutionary change until then. (World bank, 2021)

With the advent of the digital revolution, nations are competing to leverage digital technology to build smart, sustainable cities by utilizing all their resources and potential. Egypt's digital transformation is a very complicated process that calls for making the most of all that the technological revolution and next-generation technologies have to offer by utilizing them in line with the strategic vision of the state. This is especially true in the new cities of Upper Egypt. The study makes recommendations for Egypt's digital transformation to use technology to create smart and sustainable cities. Every study proposal includes a series of integrated processes that call for additional integrated research integrating several technical, strategic, and planning disciplines. (Omayer et al., 2022).

Previous findings by Aly.S & Salah.A (2022), indicate that the average per capita carbon emissions in the short and long terms, as well as the average life expectancy at birth in the long and short terms, were clearly impacted by the digital transformation. This supports the role that technology and the digital realm play in achieving the environmental and social dimensions of sustainable development. Egypt must thus develop and support the digital transformation process in order for it to eventually provide benefits on the economic component represented by the GDP per capita, even though the influence of digital transformation on the economic dimension has not been accomplished over time.

Undoubtedly, digital transformation is having an impact on society. It makes new technologies more approachable,

knowledgeable, competitive, and adaptable. It also facilitates improved decision-making, which means it can act as a catalyst for growth and the achievement of the Sustainable Development Goals (SDGs). Because it facilitates efficient resource use, lower costs, time savings, and other benefits. Egypt is therefore using ICT to achieve sustainable development. Additionally, the public-private partnership (PPP), which is seen as the most significant actor in implementing digital projects and efforts for development, is crucial to attaining the SDGs. (Elgohary, 2022)

Egypt has made significant progress toward facilitating its shift to a legislative and policy framework appropriate for the digital economy, as well as its digital transformation. A broad range of initiatives aimed at transforming Egypt into a digital society over the next 10 years are supported by the SDS and the Digital Egypt strategy. This covers ministries and regulatory bodies in various industries, as well as cooperative activities within the ICT sector. (ITU, 2023)

To realize Egypt Vision 2030, the Egyptian government is putting into practice an integrated national strategy to create work systems in every industry and digitize Egypt. The global language of digital transformation fosters collaboration, harmonizes financial regulations, and increases financial inclusion. Global crises like the coronavirus and the Ukrainian-Russian war have confirmed the nation's proactive commitment to digital transformation. The objectives of this plan are to facilitate simple access to a range of services, increase export and production activities, and encourage investment. As a result, the Egyptian government's integrated system approach to digital transformation has been strengthened and solidified. (Mahmoud, N et al, 2023).

Moussa & Tarek, 2023 illustrated that with its digital economy, Egypt is a major force behind economic growth in the process of digital transformation. To do this, the nation must create digital innovations and skills through capacity building, stakeholder collaboration, technological and organizational capabilities, and laws. The government needs to make sure that its plans are flexible enough to respond to new and emerging cyberthreats. The government can ensure adequate execution of

digitalization by adopting a comprehensive approach, taking into consideration national and regional legislative frameworks, focusing on the workforce in the digital field, addressing the weaknesses of the country's technology industries, and enhancing the role of research and innovation in economic and social development. Digital transformation is crucial for the creation of jobs and economic growth.

## 2.3. Energy Consumption in Egypt

Egypt has increasing energy demand, natural gas supply difficulties, outdated generation and transmission infrastructure, and stagnating energy sector investment, all of which compound the country's energy issues. The Egyptian government decreased subsidies for heavy enterprises and residential electricity use as part of a policy shift to address these problems. The $26 billion in subsidies provided in 2012 were a contributing factor to both the growing energy consumption and the budget deficit. To maximize the efficiency of subsidies, a smart card system was implemented to target the poorest individuals. Increasing the amount of power produced by renewable resources, especially solar and wind, may also be a good idea. Comprehending these matters is vital to formulate efficacious energy reform strategies in Egypt. (Mesbah, 2016).

Egypt's Vision 2030 seeks, within the context of sustainable development, to establish a balanced, competitive, and diverse economy. The Ministry of Electricity and Renewable Energy published the Integrated Sustainable Energy Strategy to 2035 in 2015, outlining the important role that renewable energy would play. To effectively foster the accelerated deployment of renewable electricity and stimulate private investor participation, a set of rules, regulations, and implementation strategies have been created. However, throughout project implementation, various challenges have been encountered by developers and investors of renewable energy sources for power. (IRENA, 2018)

Energy use is heavily influenced by actions made in the home, so lowering energy use at home is essential to lowering carbon emissions and enhancing environmental quality. The

household sector has the most unrealized potential for energy savings, especially in the building sector, but the shift will not be easy. Although promises have been made to lower energy use and boost efficiency, the willingness and ability of millions of people will determine if they are successful. In most nations, it is critical to develop effective regulations to encourage energy efficiency investments because residential power savings have fallen short of expectations. Policymakers can benefit greatly from the study's insightful analysis of how household energy use affects carbon emissions. It implies that a variety of energy consumption drivers, personal characteristics, and the interaction between people and their surroundings all have an impact on residential energy usage. Policies that are aimed at particular groups can increase energy efficiency and provide high energy consumers with low-energy devices. The study recommends using behavioral change strategies to educate convenient consumers about the advantages of conserving energy and to gently push them toward eco-friendly behavior. This strategy can aid in the expansion of successful energy-saving measures in residential environments. (Bélaïd & Rault, 2021)

The energy sector accounts for 13.1% of GDP overall, and in 2019 there were 0.97 tonne of energy consumed per person, comprising 1550 kWh of electricity. 41% of energy use is accounted for by households, with industry accounting for 29% and services for 20% (2019). 2019 saw a 2% decrease in CO2 emissions through fuel burning. Egypt intends to construct two environmentally friendly coal-fired power plants and an extra thermal power plant between 2022 and 2027. By 2030, Egypt alone will require EGP 2 trillion in climate-smart investments. By 2022, renewable energy will generate 20% of power, and by 2035, 42%. (Informa Markets, 2022)

Abdallah Mostafa & Selmey, (2022) used Artificial Neural Networks (ANN) in this study to examine Egypt's energy use, a developing nation that has a big influence on social justice. This study, which is exclusive to Egypt, focuses on rising governmental debt, swings in global energy prices, and the COVID-19 pandemic. According to the study, Egypt's energy usage is mostly determined by trade openness, economic growth,

and global energy costs. Egypt's export-driven economy, which mostly depends on energy-consuming industries, is to blame for this. The study also discovered that the influence of other factors on Egypt's energy consumption is minimal, including inflation, industrialization, population increase, and foreign direct investment.

## 2.4. The effect of digitalization and Energy consumption on the economic growth

The digitalization of an economy has become a major driver of economic growth in the modern era. The adoption of digital technologies across various sectors can lead to increased productivity, efficiency, and innovation. Digitalization facilitates the creation and dissemination of knowledge, enabling businesses to develop new products and services, streamline processes, and access new markets. Furthermore, the digital economy promotes entrepreneurship, job creation, and human capital development, thereby contributing to overall economic expansion and poverty alleviation (Zhang et al. 2022).

Energy consumption is another critical factor influencing economic growth. Energy is an essential input for industrial production, transportation, and various economic activities. Ensuring a reliable and affordable energy supply is crucial for sustaining economic growth. However, excessive energy consumption, particularly from non-renewable sources, can have adverse environmental impacts, leading to concerns about sustainability. As a result, many countries are focusing on increasing energy efficiency and transitioning towards renewable energy sources to achieve sustainable economic growth (Wang et al. 2019).

The relationship between digitalization, energy consumption, and economic growth is complex and multifaceted. On one hand, digitalization can contribute to reducing energy consumption by enabling more efficient processes, smart grid technologies, and optimized resource utilization. On the other hand, the growing demand for digital services and the energy requirements of data centers and IT infrastructure can lead to increased energy consumption. Striking the right balance between

leveraging the benefits of digitalization while minimizing energy consumption is a key challenge (Teng et al. 2023).

In the context of Egypt, the government has recognized the importance of both digitalization and energy management in achieving its Vision 2030 for sustainable development. Efforts have been made to enhance digital infrastructure, promote e-government services, and develop digital skills. Simultaneously, Egypt is exploring ways to increase its renewable energy production, improve energy efficiency, and address energy subsidies. The successful integration of digitalization and sustainable energy strategies can potentially unlock economic growth opportunities while mitigating environmental concerns (ElMassah and Mohieldin, 2020).

Ultimately, the interplay between digitalization, energy consumption, and economic growth requires a holistic approach that considers economic, social, and environmental factors. Policymakers need to create an enabling environment that fosters digital innovation, incentivizes energy efficiency, and promotes sustainable practices. Collaboration between the public and private sectors, as well as international cooperation, will be crucial in navigating this complex landscape and achieving long-term, inclusive, and sustainable economic growth (Lange et al. 2020).

## 2.5. Summary of literature review

The literature review covers various aspects related to the importance of energy consumption, digitalization, and their impact on economic performance, particularly focusing on Egypt. Here's a summary of the key findings from the reviewed studies:

Energy & Neoclassical Economics: Historically, economists overlooked the environmental costs associated with economic activities until the late 1960s. However, reports like Rachel Carson's "Silent Spring" and Paul Ehrlich's "The Population Bomb" drew attention to environmental damages post-World War II. Neoclassical economics began addressing optimal usage of renewable energy resources, advocating for Pigouvian taxes to correct market failures, and pursuing Pareto efficiency in energy allocation (Chester, 2017). Energy &

Hotelling's Theory: Hotelling's theory provides insights into pricing non-renewable energy resources based on revenue exceeding costs. It assumes market efficiency, constant technological advancements, and minimal external factors influencing pricing or production (CFI, 2015).

Energy & Game Theory: Game theory highlights the importance of analyzing situations where individual players have conflicting goals, suggesting the use of incentives to influence consumer behavior towards energy consumption (Ayyathurai, 2023).

Technology & Classical Economics: Adam Smith's theories emphasize the role of division of labor in enhancing productivity and innovation, stressing the importance of creating new machines for efficiency (Smith. C, et al. 2006). Technology & Paul Romer's Theory: Romer's theory underscores the significance of creating new knowledge sources leading to positive spillovers and externalities. Technology and innovation are considered public goods benefiting multiple firms (Henri Kouam, 2023). Decoupling Theory: There's debate in ecological economics about whether economic growth can be separated from environmental factors like energy consumption, and if digitization can reduce energy use. Key discussions involve the complementary nature of energy and physical capital, the impact of energy efficiency on consumption, and the Environmental Kuznets Curve (Lange et al, 2020).

Digitalization in Egypt: Digital transformation can drive economic expansion, job creation, and poverty alleviation in Egypt. There's progress in digitalization, but efforts are needed to scale digital government services, enhance ICT deployment, and promote digital skills development and financial inclusion (Kamel, 2021; World Bank, 2021).Energy Consumption in Egypt: Egypt faces challenges like increasing energy demand, supply difficulties, and outdated infrastructure. Strategies include reducing subsidies, increasing renewable energy usage, and focusing on household energy efficiency. Egypt's Vision 2030 aims for a balanced, competitive, and diverse economy with a

significant focus on renewable energy deployment (Mesbah, 2016; IRENA, 2018; Informa Markets, 2022).

These studies collectively emphasize the intertwined nature of energy consumption, digitalization, and economic development, highlighting the need for comprehensive strategies to address environmental concerns, promote technological innovation, and achieve sustainable growth in Egypt.

# 3. Research Methodology

## 3.1. The Conceptual Framework

According to the previous section (literature review), the most important variables that define the topic will be as follows:

**1. The independent Variables:**
a) Digitalization: This encompasses the adoption and integration of digital technologies, including internet usage as a percentage of the Egyptian total population.
b) Energy Depletion rate : This refers to the amount of energy resources utilized by different industries, households, and transportation systems in Egypt and the stock available to the upcoming generations.

**2. Dependent Variables:** Economic Growth: This represents the overall expansion of the Egyptian economy, measured by indicators such as Gross Domestic Product (GDP).

## 3.2 Methods of Data Collection

Data Collection from Secondary Sources: Utilize existing datasets and statistical information from reputable sources such as the Central Agency for Public Mobilization and Statistics (CAPMAS), International Energy Agency (IEA), and World Bank. These sources can provide quantitative data on energy consumption, economic growth indicators, and digitalization metrics.

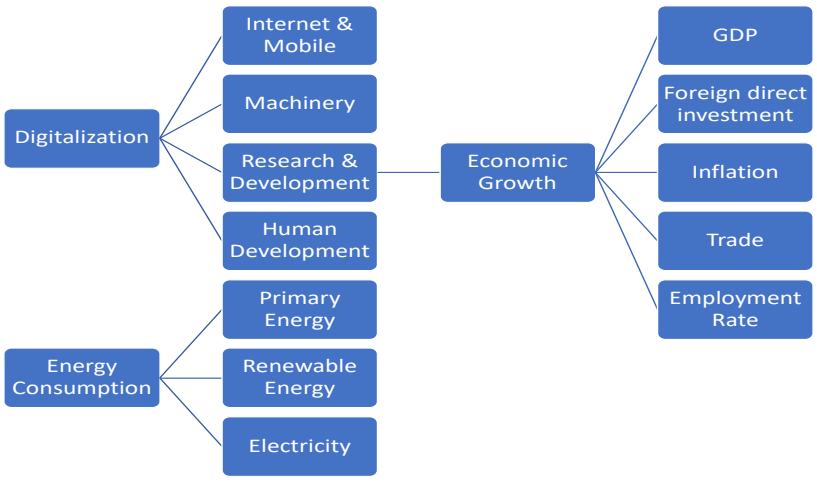


Figure 2 Research framework

### 3.3 Data Analysis

Many statistical techniques will be used in the Statistical Package for Social Sciences to analyze the data (SPSS) as descriptive and inferential statistics. Data will compute by means of descriptive statistics, including means, frequencies, modes, medians, and standard deviations. To simplify the data and identify any potential underlying causes that may have existed among the study's questions, inferences will be made using an alpha level of.05, which is employed in the majority of educational studies.

## 4. Statistical Analysis

The upcoming section will emphasize the important role of the econometric methods to examine the impact of Energy & Innovation on Economic Growth in Egypt. The study focuses on 32 years starting from 1990 till year 2021. In order for the accuracy and consistency of the observations, all of the variables were in percentage rates. Before going into details, the table below defines all of the examined variables in the model including the main dependent variable.

**Table 1: Dependent Variables Definitions**

| Variable Name | Definition | Source |
|---|---|---|
| GDP Growth rate % -The Dependent Variable | This define the economic growth of an economy. It measures the change that took place in the GDP (Gross Domestic Product) in a country over a certain period of time. This determine the economy's performance and health. | (Adithyan, 2024) |
| Industry Value Added % Of GDP | This indicates the output measurement of the private and public sector in an economy. This measurement deducts from the final output the costs of the intermediate inputs such as raw materials. | (Bureau of Economic Analysis, 2006) |
| Inflation Rate GDP Deflator % | It measures the changes in the price level in an economy over 1 year. | (Vishnava, 2024) |
| Internet Usage % of the population | This variable measures the percentage of people who accessed the internet over the previous 3 months through mobile, laptop, games machine and digital TV. | (World Bank, 2024) |
| FDI net Inflows % of GDP | The value of all the direct investments entering an economy by non-residents. | (World Bank, 2024) |
| Energy Depletion % of GNI | The ratio of the available stock of all the sources of energy to the remaining reserves over lifetime (estimated for 25 years). This indicator includes coal, natural gas and crude oil. | (World Bank, 2024) |
| Merchandise Trade% | The value of all the goods that are added or deducted from the stock of the resources by being imported or exported from an economy. | (UNESCWA, 2024) |
| Unemployment rate % | The percentage of all the people whom are unemployed divided by the labor force in a country. | (Bondarenko, 2024) |
| Urban Population % | The percentage of people whom are living in urban areas in a country. | (World Bank, 2024) |

## 4.1 Descriptive Statistics

Firstly, before running the model or any tests, the descriptive statistics need to be done. The main objective of such analysis is to examine the nature of all the variables throughout the years. Also, it shows whether there is an outlier or any deviations in any of the variables and examine the reasons behind it.

**Table 2: Variables Observations**

| DP_G% | INDV% | INF% | INT.U% | FDIInf % | EnergyDep % | MerchTrade % | UnEmp % | Urb. % |
|---|---|---|---|---|---|---|---|---|
| 362 | 33.345 | 10.328 | 19.073 | 2.292 | 6.505 | 29.768 | 10.131 | 2.04 |
| 422 | 32.977 | 9.904 | 13.205 | 1.481 | 6.377 | 27.223 | 9.600 | 2.06 |
| 156 | 39.890 | 29.518 | 72.060 | 9.349 | 14.680 | 45.822 | 13.15 | 2.25 |
| 126 | 27.406 | 0.919 | 0.000 | -0.205 | 2.069 | 18.825 | 7.840 | 1.84 |
| 556 | 3.339 | 6.187 | 21.768 | 2.257 | 2.838 | 7.280 | 1.610 | 0.13 |
| .088 | 0.210 | 1.000 | 1.029 | 1.936 | 0.635 | 0.464 | 0.494 | -0.0 |
| 359 | 2.282 | 4.280 | 3.107 | 6.165 | 3.410 | 2.172 | 2.077 | 1.58 |

The above table which explores the overall nature of the observations portrays the deviations that took place in some of the variables. Starting with the dependent variable which is the GDP growth rate, the average percentage of the economic growth in Egypt across the previous 32 years was 4.36% while the lowest growth rate Egypt faced was 1.126%. This shows the improvement that took place in the Egyptian economy across the years. Such improvement can be attributed to the several economic and social reforms that took place in Egypt in the previous year's such as the subsidy reform, improving healthcare education, reducing unemployment & expanding the infrastructure. Also, the structural reforms that aimed to enhance the private sector performance contributed heavily in levelling up the Egyptian economy performance (IMF, 2019). Moving on to the industry value added which is similarly in the factors that led to the GDP growth rate's enhancement.

Concerning the inflation rate which showed a deviation between the lowest value (0.919%) and the highest value

(29.5%), this can be explained through many reasons. The rise in the price level happened due to the rise in the food & energy prices worldwide along with the Egyptian currency depreciation that started since 2016 (African Economic Outlook, 2023).Another crucial reasons that led to higher price levels were the rise in fiscal deficit and rapid increase in the money supply (Khan & Miller, 2017). According to the above figure, there was a huge gap between the minimum internet usage rate and the maximum rate. This was mainly due to the urgent need for internet for remote learning and working especially after the Covid-19 pandemic. There are other usages for internet such as streaming activities and online shopping (Ahram Online, 2022).

Moving to the FDI inflows, it depicted a negative rate as a minimum rate while the maximum percentage was 9.35%. The FDI inflows in Egypt are concentrated in certain sectors such as the oil and gas industry, manufacturing, real estate and construction industries. The main reasons behind the improvement that took place in the direct inward investments entering Egypt were the low costs of labor while having skilled employees, huge domestic market due to the high population along with several reforms that encouraged the privatization (Llyods bank, 2024). Regarding the energy depletion which also showed some deviation between the maximum and minimum rate, this can be explained through several reasons. Usually, the energy sector in Egypt faces several obstacles like the huge population growth which rises the demand and the energy consumption while the resources are limited & scarce especially in the oil and natural gas. Also, the energy sector in Egypt is not very huge since due to the lack of private investments in it thus poor access to the latest technologies needed to produce and distribute the energy in Egypt (Energypedia, 2022).

Furthermore, merchandise trade improvement is caused by the rise in the investor confidence and enhancement in the business environment that caused the exports to increase along with the decline in the imports (Al-Alkhirah, 2024). Unfortunately, the unemployment rates in Egypt has rose due to the rise in the mismatch between the job supply and demand in the market in addition to the rise of informal or illegal jobs. Also,

the rise in the segregation between men and women led to the rise in the unemployment rates (Bihari, 2023). Lastly, the urban population rates rose across time due to the rise in the internal migration from rural to urban areas (UBRANET, 2019).

## 4.2 Correlation Analysis

This is very important to be examined before running the regression model in order to detect any sign of having high multi-collinearity between the main independent variables. The table below shows the correlation between all of the independent variables.

**Table 3: Correlation between independent variables**

| Correlation Probability | GDPG% | INDV% | INF% | INT.U% | FDIInf% | EnergyDEP% | Merch Trade% | Unemp% |
|---|---|---|---|---|---|---|---|---|
| GDPG% | 1.000 | | | | | | | |
| INDV% | -0.229 | 1.000 | | | | | | |
| INF% | -0.058 | 0.316* | 1.000 | | | | | |
| INT.U% | -0.119 | 0.452*** | 0.215 | 1.000 | | | | |
| FDIINF% | 0.617*** | 0.308* | 0.102 | 0.095 | 1.000 | | | |
| EnergyDEP% | 0.101 | 0.013 | 0.297* | -0.475*** | 0.317* | 1.000 | | |
| MerchTrade% | 0.200 | 0.657*** | 0.487*** | 0.229 | 0.703*** | 0.471*** | 1.000 | |
| Unemp% | -0.456*** | 0.560*** | 0.193 | 0.205 | -0.098 | -0.053 | 0.132 | 1.000 |
| Urban Pop% | -0.211 | -0.029 | -0.243 | -0.480*** | -0.283 | 0.196 | -0.238 | 0.178 |

Concerning the above table which depicted the level of multicollinearity between the independent variables, it stated the positive significant correlation between industry value added and the majority of the variables. First of all, there was a positive significant correlation between the industry value added and the internet usage with almost 45.2%. This correlation can be attributed to the recent investments in the ICT sector which

reached 3 Billion Dollars in 2020/2021. According to the ICT 2030 strategy, the Egyptian government already started to adopt several reforms, investments & offer trainings in such sector (Bissada, 2022). Moving on to the correlation between the industry value added and merchandise trade which was almost 66%, this can be due to the high reliance of the production on the traded and imported materials. Also, lots of the locally produced goods and services are traded and exported abroad. The main sectors that are traded are food and manufacturing (New Zealand Foreign Affairs and trade, 2021). In addition to, there was a positive significant correlation between unemployment rate and Industry value added. This can be due to the dependence on the machines and the foreign skilled labor as a result of the high skills mismatch in the Egyptian jobs market.

Moreover, Inflation rate had a positive significant correlation with the merchandise trade with an approximate 49%. This was mainly due to the consistent rise in the demand for goods of services resulting from the high population growth rates which is higher than the supply. Technically, this caused a huge shortage and led to rise in the demand of imported goods thus rise in the price level (Sharaf, 2023). Then, internet usage had a negative significant correlation with the energy depletion. The internet usage caused a definite reduction in the stock of energy resources available as the internet usage utilized and will always utilize huge amount of electricity (Kandil, 2023). Surprisingly, the negative correlation between the internet usage and the urban population can be explained through the gap between the rise of the urban population rates and the lack of the proper infrastructure in the ICT sector (Reda, 2018).

Moving on to the strong positive correlation between FDI inflows and merchandise trade which reached almost 70%, this is caused due to several reasons. The FDI inflows will have a positive impact on the country's exports due to the transfer of latest technologies and expansion of new products while offering training for the locally employed workers (Whiteaker, 2020). Last but not least, there was a positive significant relationship between the merchandise trade and energy depletion which is logical since

the trading in the inputs and raw materials utilizes huge amount of the energy resources.

## 4.3. Unit root test (Stationary test)

This test is essential to be analyzed before running the regression model since it shows the level of stationarity of all of the variables. This test depicts whether all or the majority of the variables suffered from high fluctuations or consistency in the values across the years. The methods that will be used in the stationarity test are as follows: Augmented Dickey Fuller Test and Philips Perron.

**Table 4: Stationarity level**

| Variables | ADF | | PP | |
|---|---|---|---|---|
| | Level | 1st difference | Level | 1st difference |
| GDP Growth rate (%) | | | | |
| None | -1.22 | -4.32*** | -1.22 | -8.22*** |
| Intercept | -3.68*** | -4.19*** | -3.29** | -8.06*** |
| Intercept and trend | -4.18** | -4.17** | -3.23* | -7.72*** |

| | | | | |
|---|---|---|---|---|
| None | -1.94* | -3.65*** | -1.53 | -3.44*** |
| Intercept | -3.21** | -3.59** | -2.16 | -3.36** |
| Intercept and Trend | -3.11 | -3.56* | -2.12 | -3.32* |
| Inflation rate (%) | | | | |
| None | -0.19 | -4.81*** | -1.86* | -8.36*** |
| Intercept | -3.34** | -4.70*** | -3.34** | -8.16*** |
| Intercept and Trend | -2.61 | -4.96*** | -3.31* | -8.03*** |
| Urban Population (%) | | | | |
| None | -0.40 | -3.86*** | -0.98 | -3.75*** |
| Intercept | -2.66* | -3.79*** | -2.30 | -3.66** |
| Intercept and Trend | -2.90 | -3.80** | -2.36 | -3.60** |
| Unemployment rate (%) | | | | |
| None | 0.84 | -3.73*** | -0.27 | -4.62*** |
| Intercept | -2.88* | -4.12*** | -2.16 | -4.54*** |
| Intercept and Trend | -4.32** | -3.65** | -2.10 | -4.48*** |
| Internet Usage (%) | | | | |
| None | 4.19 | 0.254 | 7.95 | -2.78*** |
| Intercept | 3.67 | -3.69*** | 6.77 | -3.69*** |
| Intercept and Trend | 0.77 | -5.23*** | 1.01 | -5.27*** |
| Energy Depletion (%) | | | | |
| None | -2.23** | -4.58*** | -2.25** | -5.86*** |
| Intercept | -3.24** | -4.62*** | -3.24** | -5.79*** |
| Intercept and Trend | -3.09 | -4.56*** | -3.13 | -5.65*** |
| Merchandise Trade (% of GDP) | | | | |
| None | -0.15 | -4.67*** | -0.42 | -4.28*** |
| Intercept | -2.15 | -4.58*** | -1.87 | -4.20*** |
| Intercept and Trend | -2.44 | -4.51*** | -1.87 | -4.06** |
| Industry Value added (% of GDP) | | | | |
| None | 0.179 | -4.06*** | 0.229 | -5.68*** |
| Intercept | -2.05 | -3.40*** | -2.09 | -5.52*** |

(* significant at 10%- ** significant at 5%- *** significant at 1%)
Source: Conducted by the researcher

Referring to the above figure, it measured the level of volatility and fluctuations in all of the variables including the dependent variable across the years at level and when the lagged effect is taken. To sum things up, all of the variables were significant at 1% at first difference. This means that all of the variables had huge ups and downs at level so taking the lagged effect is essential for achieving consistency and stationarity. Thus, taking the 1st difference in the regression model will achieve better unbiased results.

## 4.4. Regression Model

The following section will investigate to what extent the mentioned independent variables mainly the energy and technology in addition to other controlled variables affected the economic growth rate in Egypt. Hence, the econometric methods that will be used are as follows: OLS (Ordinary least Squares) & ARDL approach.

### OLS Model (Ordinary Least squares)

**Table 5: Simple Linear regression model**

| Variable | Coefficient |
|---|---|
| Energy Depletion% | -0.128 |
| FDI inflows % | 0.568*** |
| Industry Value Added% | -0.077 |
| Inflation Rate% | 0.043 |
| Internet Usage % | -0.008 |
| Merchandise Trade% | -0.031 |
| Unemployment rate% | -0.376** |
| Urban population% | 0.953 |
| C | 8.957 |
| R-squared | 0.6924 |
| Prob (F-Statistic) | 0.000195 |
| Durbin Watson | 2.12 |

(* significant at 10%- ** significant at 5%- *** significant at 1%)
Source: Conducted by the researcher

The above table resulted in having a positive significant impact of FDI inflows % on the GDP growth rate in Egypt across

the 32 years. When the FDI inflows increases by 1%, the GDP growth rate increases by 0.568%. This is reasonable since that the FDI and the inward direct investments in Egypt led to growth in the available job opportunities for the Egyptian labor workforce. In addition to, the rise in FDI inflows led to improvement in the level of infrastructure and the achievement of technology expansion (Abdelgany, 2020). Moving on to the unemployment rate which had an adverse impact on the economic growth rate of Egypt which was significant at 5%. As shown in the above table, when the Unemployment rate increases by 1%, the GDP growth rate decreased by 0.376%. The main reason behind the decline in the level of employment in Egypt was the huge dependence on the oil and gas sector for achieving growth. Accordingly, such sector is capital not labor intensive which hindered the growth of job opportunities. Apart from that, the tremendous rise in the informal labor market caused this rise in the unemployment leading to less contribution to the overall economic performance (DALY, 2021). Concerning the R-squared, it indicated that approximately 69% of the variations in the economic growth rate of Egypt is explained by the mentioned and selected independent variables. Moreover, the probability of f-statistic was significant at 1% which ensured the significance of the whole model. Last but not least, having the Durbin Watson equal to 2.1 indicated the non-existence of autocorrelation problem.

## ARDL Approach (Autoregressive Distributed Lag)

In this upcoming econometric approach, the impact of technology, energy and the other controlled variables on economic growth rate in Egypt will be estimated while taking into consideration the first difference or lagged effect for all of the variables.

**Table 6: Impact of variables on economic growth**

| Variable | Coefficient |
|---|---|
| Energy Depletion% | 0.108 |
| Energy Depletion% (-1) | -0.398*** |
| FDI inflows % | 0.475*** |
| Industry Value Added% | -0.152 |
| Inflation Rate% | 0.034 |
| Internet Usage % | -0.027* |
| Merchandise Trade% | -0.114* |
| Merchandise Trade%(-1) | 0.172*** |
| Unemployment rate% | -0.49*** |
| Unemployment rate%(-1) | 0.347* |
| Urban population% | 1.07 |
| C | 7.80 |
| R-squared | 0.884 |
| Prob (F-Statistic) | 0.000004 |
| Durbin Watson | 2.352 |

The ARDL results indicated that the lagged Energy depletion had a negative impact on the GDP growth rate in Egypt. This means that when the energy depletion increases by 1%, the GDP growth rate decreases by 0.398%. This means that the Egyptian community heavily relied on the utilization of non-renewable energy sources such as crude oil and natural gas. The reserves of natural gas even exceeded the oil reserves and due to this unforeseen rise in the domestic consumption, Egypt started to import more crude oil. This technically decreases the overall economic performance of the Egyptian economy (El-Deken, Farag, & Hamdy, 2011). Also, this caused more depletion of the existing resources hence leaving the environment harmed and polluted with more emissions. This leaves the environment degraded therefore this degradation will be costly to be solved. The FDI inflows had a significant positive effect on the Egyptian economic growth rate due to the same reasons mentioned before.

Concerning the internet usage, as the internet usage increases by 1%, the GDP growth rate decreases by 0.027%. The huge and the rise in the usage for all the internet servers caused lots of small medium enterprises to be encouraged to open their businesses online which are illegal and considered as informal sector.

Therefore, as these small medium enterprises rise in number the lower the overall economic performance of the Egyptian economic growth rate (wamda, 2013).

Furthermore, the lagged merchandise trade had a strong positive impact on the Egyptian economic growth rate. As the exporting of the raw materials and inputs such as: marble, cement and phosphate fertilizers rose in Egypt, this had a definite rise in the Egyptian economic growth (State Information Service, 2023). Regarding the unemployment rate which had a negative impact on the GDP growth rate in Egypt with a 1% significance level. This is mainly explained through the rise in the informal labor market which hugely expanded recently along with the mismatch between the skills needed and skills available in the labor market. The R-squared depicted that 88.4% of the Egyptian growth rate explained through all of the lagged independent variables. The Probability of f-statistic ensured the significance of the whole model and the Durbin Watson is close to 2 proving that there is no autocorrelation.

## 4.5. Diagnostic tests

**Long form and bounds test:** This test is an extension for the ARDL approach since that it measures the significance of the lagged variables and whether the variables were stationary more at level or at first-difference. This is an indication for the level of cointegration.

**Table 7: Long form and bounds test results.**

| F-Statistic | Significance level | I(0) – lower bound | I(1)-Upper bound |
|---|---|---|---|
| 8.471 | 10% | 1.85 | 2.85 |
| | 5% | 2.11 | 3.15 |

Source: Conducted by the researcher

**Heteroscedasticity test:** This test illustrates the level of scattered-ness in the spread of residuals or error term across the independent variables. This caused the variance of the error term to be unequal over the independent variables. It is very important

to test this since one of the simple linear regression model assumptions is to have a constant variance in the error term.

**Table 2: Heteroscedasticity test results.**

| F-Statistic | Probability |
|---|---|
| 0.8878 | 0.5736 |

Source: Conducted by the researcher

The upward results showed that since that the probability greater than 5%, this rejected the existence of a heteroscedasticity problem in the model.

**Normality test:** This test shows to what extent does the data and the observations selected are drawn from a normally distributed population.

**Table 9: Normality test results.**

| Jarque-Bera | Probability |
|---|---|
| 5.993 | 0.0499 |

Source: Conducted by the researcher

The results of the above table depicted that the selected data is not normally distributed since that the probability is less than 5%.

**Variance Inflation Factor (VIF) Test:** This is another test for multicollinearity after running the regression model. This measures the level of variance in all of the variance and if it is inflated to a large extent or not.

**Table 3: Variance inflation factor test results.**

| Variable | Coefficient Variance |
|---|---|
| C | 12.5388 |
| Energy Depletion% | 0.0118 |
| FDI Inflows % | 0.0172 |
| Industry Value added% | 0.0133 |
| Inflation% | 0.0015 |
| Internet Usage% | 0.0002 |
| Merchandise Trade% | 0.0047 |
| Unemployment% | 0.0232 |
| Urban Population% | 3.2033 |

Source: Conducted by the researcher

Referring to the results of the above VIF test, it can be concluded that there is no multicollinearity problem in the model since the above mentioned variables had a coefficient variance less than the range of 5 to 10.

**Serial Correlation Test:** This diagnostic test is very important to be examined since it measures the relationship between the observations for each of the independent variables across periods.

**Table 4: Serial Correlation test results.**

| F-Statistic | Probability |
|---|---|
| 0.4668 | 0.6333 |

Source: Conducted by the researcher

According to the above results, the serial correlation test neglected the existence of a serial correlation problem since that the probability is greater than 5%.

# 5. Results and Discussion

The upcoming section will evaluate the econometric results based on the estimated regression in done in the above section. Also, this section will emphasize the level of consistency between the literature review and previous studies and the regression results estimated in the model. Furthermore, this will conclude whether the energy and digitalization will have an impact on the economic growth in Egypt or not.

## 5.1 Data Analysis

| Hypotheses | Model | Supported/Not Supported |
|---|---|---|
| $H_{1:}$ The adoption and integration of digitalization in various sectors of the Egyptian economy will have a negative significant impact on economic growth. | ARDL Approach | Supported |
| $H_2$: The depletion of non-energy sources & energy consumption will cause adverse effects to economic growth in Egypt. | ARDL Approach | Supported |

## 5.2 Discussion of the findings

**Energy Depletion %:** The energy depletion rate which measures the stock of the current resources and minerals compared to the stock available for the upcoming generations capped at 25 years depicted an adverse effect on the Egyptian economic growth. Generally, there are several obstacles especially in the energy sector in Egypt which can explain such effect. The main reason is the tremendous rise in the population growth hence in the demand for the sources of energy. Accordingly, this led to energy shortages especially in the natural gas sector (Sharaf M. F., 2016). Another main reason is the high uncertainty in the exploration for new contracts in such sector. Furthermore, the higher the production and utilization of these non-renewable energy sources the lower the current value of the income in Egypt coming from energy depletion which reflected adversely on the country's economic growth. This can be reflected previously through the subsidies that were on the energy sector in Egypt (El-Deken, Farag, & Hamdy, 2011). Recently, several reforms and strategies are being adopted to expand and enhance the usage of the various renewable energy resources in order to achieve sustainability. Yet, not all of the reforms are yet fully implemented due to the infrastructure and fiscal challenges facing the economy. This drives more pressure on the utilization of the non-renewable energy sources which hinders the availability of the resources for the upcoming years resulting in more decline in the sources and economic growth.

**Internet usage %:** Usually and logically speaking, the internet usage has rose significantly in Egypt in the previous couple of years. Also, according to several recent studies, the role of ICT development in creating more job opportunities. This will automatically raise the investment opportunities which will therefore cause the economic growth to rise. On the other hand, in the case of Egypt, the level of digitalization which is measured through the internet usage rate did not cause an increase in the economic performance of Egypt. This can be due to several reasons. First of all, the role of digitalization needs to be oriented towards more productive activities. This means that the majority of the internet user in Egypt are mainly using internet for non-

productive activities such as scrolling on the social media platforms. Also, the expansion of the internet needs to be more efficient in the form of creating spillover effects. Also, creating and enhancing the expertise and know-how of internet usage efficiently to be used to innovate the production processes is not yet available in a huge manner in Egypt (Bakari & Tiba, 2020). Another aspect that needs to be considered when analyzing the effect of internet usage on economic growth is the lack of the investment policies implemented to detect and evaluate the quality of the ICT sector and digitalization. These policies are very crucial to be applicable since it enhances even the quality of workers working in such sector which will cause a positive spillover automatically on the Egyptian economy. Also, the poor focus of the channels that ICT investments can achieve more contribution to the economic growth of Egypt. The lack of enough access of ICT in the financial sector contributed to the negative impact of internet usage on economic growth (Mansour, 2022).

In addition, The results underscore the critical importance of prudent management of natural resources and strategic prioritization of digitalization efforts for sustainable economic growth in Egypt. The negative impact of energy depletion on economic performance highlights the urgency of transitioning towards a more diversified and renewable energy mix. Egypt must accelerate its investments in clean energy technologies, incentivize energy efficiency measures, and promote conservation efforts to ensure the long-term availability of energy resources for future generations.

Simultaneously, the findings related to internet usage reveal the potential pitfalls of haphazard digitalization endeavors. While the digital revolution presents vast opportunities for economic transformation, realizing its full benefits requires a deliberate and coordinated approach. Egypt must prioritize policies that channel digitalization towards productive activities, foster innovation ecosystems, and enhance digital literacy and skills development. Furthermore, strengthening the integration of information and communication technologies (ICTs) across vital economic sectors, such as finance and manufacturing, can unlock synergies

and amplify the positive impacts of digitalization on economic growth.

Ultimately, these results underscore the need for a holistic economic vision that harmonizes sustainable energy strategies with a robust digital transformation agenda. By proactively addressing the challenges of resource depletion and harnessing the potential of digitalization, Egypt can pave the way for a more resilient, inclusive, and prosperous economy – one that balances economic progress with environmental sustainability and technological advancement.

# 6. Conclusion

This thesis aimed at investigating the role of digitalization and energy on the economic growth in Egypt starting from 1990 till 2021. The role of digitalization was measured through the internet usage rates while energy sources was estimated through the energy depletion rate taking into consideration other macroeconomic controlling variables. These controlling variables included the following: trade, unemployment, FDI, urban population, inflation and industry value added. The results of the ARDL model indicated that there is a violation for the results of the previous studies. This meant that the energy depletion and internet usage throughout the selected time period did not contribute to the rise of the economic growth of Egypt.

## 6.1 Policy Recomendations

**Digitalization:** Recently specifically after the Covid-19 pandemic, the urge for digital transformation in Egypt was crucially needed. This is due to the major reliance on the internet and distance learning in all of the schools and universities in addition to people working remotely. Also, during this time period, Benya Raqmeya or known as Digital Future was established in 2020 which improved and enhanced the usage of the ICT sector for enterprises. It was a collaboration between the Federation of Chamber of commerce, the Ministry of public enterprise sector and several multinational corporations such as Microsoft, Dell and Cisco. In order for a recognizable digital transformation to be achieved in Egypt, this requires a forceful and dynamic digital ecosystem which includes high internet speed, availability of high digital skills in the employees, strong digital platforms, existence of enough digital and financial services and most importantly legal enforcement and regulatory environment for this sector.

Mainly, there are four main pillars that need to be integrated in order to transform Egypt into a digital economy. These pillars are as follows:

1. Technology: This mainly includes the level & quality of the infrastructure; to what extent will it be affordable, the amount of local content that will fill the market gap and need and the level of acceptance of the majority of the population to the digitalization platforms such as: AI, cloud computing and data analytics.

2. People: This pillar is extremely crucial as the human capital is a main driver for achieving this digital transformation. The development of the human capital can be enhanced through vocational training. This training will ensure improving the efficiency and productivity of all the employees using digitalization.

3. Governance: There must be several policies adapted such as: Ensuring the investor and business confidence regarding digitalization in terms of privacy and security concerns and enforcement of government regulations to incentivize this sector. Finally, the inclusion is very important and expanding to different segments of the population such as people with disabilities, different ages and genders.

4. Impact: This measures the effects driven by applying digitalization through different economic sectors such as: education, health manufacturing and many other sectors.

Therefore, the recommendations or the policies that needs to be considered in Egypt to expand the impact of digitalization in Egypt can be as follows:

1. **Establishment of a multi-sector digitalization economy:** in order to promote this transformation in the Egyptian economy, the country needs to combat red taping, reduce bureaucracy, consistency between the rules and regulations applied with the instant changes in the digitalization while monitoring this regularly. Reduction in the duplication of roles such as in consumer protection is very important point to be considered. Also, promoting the role of private sector enterprises in the development of such sector is essentially needed.

2. **Creating a strong legal environment for Digital transformation:** This is important in terms of applying flexible laws that align with the development and quick changes in the ICT sector while ensuring having an adequate safeguard for the protection the financial and cyber interests in Egypt. Also, modernize the outdated legislations such as the electronic signature and intellectual property rights. Also, having consistency with the worldwide mechanisms and standards in the cybersecurity and taxes is very important to prevent any tax evasion or labor exploitation. Furthermore, revising the taxation policies that can be applied on the digital payments while easing and facilitating the laws of digital financial services.

3. **Improvement of the ICT infrastructure:** Applying an efficient service through one-stop-shop for all the legal permits and licenses required is very important. Moreover, applying and expanding the 5G frequencies with an affordable price will ensure the internet speediness. Also, ensuring the usage of ICT integrated with the education and learning and many other sectors will be an efficient and cost effective idea.

4. **Improvement in the Egyptian Financial inclusion:** Giving incentives for the banks to cooperate with fintech startups will be very beneficial as well as advocating the spread of awareness towards financial inclusion across the community is very essential (Kamel, 2021).

**Energy:** According to several studies, the energy sector in Egypt has grown tremendously during the previous years due to the huge rise in the demand. This resulted from the growth in the Egyptian population. Since that the non-renewable sources of energy will not sustain with this consumption patterns in Egypt thus will face shortages in providing it, there is an urge for relying more on the renewable sources of energy. So, this started with the Egyptian government implementation of a strategy named as “Integrated and Sustainable Energy Strategy to 2035". The main aim of such

strategy is to diversify the usage of energy sources and at the same time have a sustainable energy supply. Such strategy forecasts that the energy sector will achieve sufficient utilization and production by 2030 maximum. On the contrary, there are still several recommendations and steps need to be considered in order to ensure the sustainability of the energy sector through promotion of renewable energy. Such recommendations include:

1. Spread the awareness towards the necessity of using renewable energy by offering rules and regulations promoting and encouraging the investments in such sector. This legislation is very important to be applied to promote the investments especially in the private sector. These laws can include providing with incentives through affordable loans with a low interest rate to invest in the renewable energy projects. In addition to this, another form of incentives for the private sector may include the reduction of taxes for firms in such sector to promote the usage of green technologies in this sector.
2. Offering subsidies to the renewable energy sector especially in the solar power providence. This can be learnt from Germany that subsidized the solar energy which increased the usage of solar roofs. Also, in Germany, the banking system offered and supported the usage of solar air conditioning. Another aspect that needs to be considered in this point is the green subsidies to encourage the pollution and carbon reduction (Ibrahiem, 2022).

The successful integration of digitalization and sustainable energy strategies can potentially unlock economic growth opportunities while mitigating environmental concerns in Egypt. To achieve this, the following policy recommendations can be derived from the studies:

Firstly, as highlighted by the World Bank (2021) study, Egypt needs to accelerate its digital transformation by enhancing service delivery, scaling out end-to-end digital government services, and improving ICT infrastructure and connectivity. This can be achieved through public-private partnerships and creating

a conducive regulatory environment that promotes investment and innovation in the digital economy.

Secondly, the studies by Aly.S & Salah.A (2022) and Elgohary (2022) emphasize the importance of leveraging digital transformation to achieve the environmental and social dimensions of sustainable development. Egypt should focus on developing and supporting digital initiatives that can reduce carbon emissions, improve resource efficiency, and enhance societal well-being.

Thirdly, as per the recommendations from Moussa & Tarek (2023), Egypt needs to prioritize capacity building, stakeholder collaboration, and the development of technological and organizational capabilities to foster a robust digital economy. This includes investing in digital skills training, promoting research and innovation, and strengthening the country's technology industries.

Fourthly, the study by IRENA (2018) highlights the need for a comprehensive set of rules, regulations, and implementation strategies to effectively promote the deployment of renewable energy sources and attract private investment in this sector. Egypt should continue to refine its policies and incentives to encourage the adoption of renewable energy technologies.

Fifthly, the study by Bélaïd & Rault (2021) suggests the importance of developing effective regulations and behavioral change strategies to encourage energy efficiency investments, particularly in the residential sector. Egypt can consider targeted policies, awareness campaigns, and incentives to promote energy-saving measures and eco-friendly behavior among households.

Finally, the analysis by Abdallah Mostafa & Selmey (2022) using Artificial Neural Networks (ANN) provides insights into the factors influencing Egypt's energy consumption. Based on their findings, Egypt should focus on managing trade openness, promoting sustainable economic growth, and addressing global energy price fluctuations to better control its energy demand.

By implementing these policy recommendations, derived from the studies in the literature review, Egypt can effectively leverage the potential of digitalization while ensuring sustainable energy consumption, ultimately supporting long-term economic growth and development.

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