

Assessing the Knowledge-Based Economy: Metrics and Analytical Approaches

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Abstract:

This paper aims to investigate the assessment of indicators used to quantify the knowledge economy, adopting an inductive methodology that examines its theoretical underpinnings, key requirements, and obstacles that hinder. It also emphasizes the main metrics employed to evaluate the performance of the knowledge economy. The findings highlight several critical aspects, particularly the contribution of the knowledge economy to the development of human capital through continuous education and skill enhancement, while stressing the importance for governments to establish a supportive environment that recognizes knowledge as a crucial resource for production and a fundamental driver of long-term economic growth and competitiveness.

Keywords: Economy based on knowledge; metrics for the knowledge economy; European index of knowledge economy; Arab index of knowledge economy; World Bank's knowledge economy ranking.

Jel Classification Codes: O33, O35, O47

1. INTRODUCTION

Amid the profound transformations brought about by globalization, the global economy has shifted towards a new model shaped by advances in technology, information, and communication. Within this framework, the notion of the “knowledge economy” has gained prominence, reflecting a qualitative transformation in the way economic development is understood. Unlike traditional models that relied heavily on natural resources or industrial output, the knowledge economy is primarily built upon the creation and use of knowledge and information, aligning with the digital era where technological innovation drives economic activity.

Historically, agriculture and industry served as the backbone of economic growth. Yet, with the rise of modern technologies—particularly information and communication technologies—the basis of economic strength has moved from physical production to the ability to generate, access, and disseminate knowledge. In this sense, innovation, ideas, and information have become decisive factors shaping a nation’s competitiveness in global markets. As a result, economic power has transitioned from control over resources to control over creativity and innovation.

This transformation signifies a paradigm shift from centuries-old economic thinking that measured strength by resource abundance or production volume. In today’s context, competitiveness depends less on sheer output and more on the speed of adopting technological change and nurturing innovative ideas. The prevailing rule is no longer “survival of the strongest,” but rather “survival of the fastest” in adapting to digital progress. Thus, knowledge and information technology replace capital. To evaluate and measure the knowledge economy, a set of indicators must be available. In order to comprehensively understand and address the various aspects of the topic, the following key research question can be posed: Which indicators should be employed to measure the advancement of the knowledge economy?

Significance of the Study:

The significance of this study stems from its focus on delving into the concept of the knowledge economy, a transformative shift in the global economic landscape. By examining the various indicators that are used to assess and measure the effectiveness of this new economic model, the study aims to shed light on how nations can better understand and track their progress in this rapidly evolving domain. Furthermore, it highlights the critical importance of accurate and comprehensive measurement, as such data serves not only as a benchmark for evaluating the success of knowledge-based economies but also as a guide for policymakers and leaders to make informed decisions that foster innovation, competitiveness, and sustainable development in a knowledge-driven world

Objectives of the Study:

To comprehensively address and understand all aspects of the topic, the study employs a descriptive approach. This methodology enables a detailed examination of the theoretical foundations of the knowledge economy, exploring its core principles and unique characteristics. Additionally, it allows for an in-depth analysis of the essential conditions and requirements needed to establish and sustain a knowledge-based economy, including the necessary infrastructure and supportive policies. Moreover, this approach facilitates the identification of key indicators used to assess the development and effectiveness of the knowledge economy, ensuring a thorough exploration and understanding of the topic from multiple perspectives.

Research Methodology:

In order to fully explore and understand the various dimensions of the topic, this study utilizes a descriptive approach. This method is particularly effective for providing a clear and detailed examination of the theoretical foundations of the knowledge economy, including its core principles and defining characteristics. Additionally, it allows for a deep dive into the necessary components and conditions that must be in place to successfully establish and sustain a knowledge-driven economy. By using this approach, the study also identifies the key indicators that are used to assess the performance and progress of the knowledge economy, thus offering a comprehensive analysis of the subject from multiple angles.

2. THE NATURE OF THE KNOWLEDGE ECONOMY

The knowledge economy is of significant importance today due to its unique characteristics that differentiate it from traditional economic models. Unlike the conventional economy, which depends on physical resources and manufacturing, the knowledge economy focuses on the creation, distribution, and application of knowledge as the primary driver of growth and development. This shift emphasizes intellectual capital, innovation, and technology, which in turn fosters greater efficiency, competitiveness, and sustainable progress across various sectors. The knowledge economy not only improves economic performance but also enhances the quality of life by providing new opportunities for learning, collaboration, and advancement.

2.1 The Concept of the Knowledge Economy

The term knowledge economy has been given several definitions, among them:

- The Asia-Pacific Economic Cooperation (APEC) defines the knowledge economy as: An economy primarily based on the production, dissemination, and use of knowledge as the main driver of development, generating wealth and employment across all economic sectors (Maked & Yahiaoui, 2014, p. 10).
- The Organization for Economic Cooperation and Development (OECD) defines it as: A type of economy based on the production, distribution, and utilization of knowledge and information (Mothari, 2023, p. 123).
- The United Nations Development Programme (UNDP) views the knowledge economy as a system centered on generating, sharing, and effectively applying knowledge across all dimensions of social life—economic, political, civic, and personal. Its primary aim is the ongoing enhancement of human well-being, which necessitates both the development of human capabilities and their equitable utilization (Maked & Yahiaoui, 2014, p. 10) .

The economist Fritz Machlup defines it as:

- An economy based on knowledge in which the labor force in knowledge-producing sectors surpasses that of other economic sectors (Mothari, 2023, p. 132).
- It is also described as an advanced economic model characterized by the extensive use of information technology and internet networks in various aspects of economic activity, especially in e-commerce, relying heavily on knowledge, creativity, and innovation (Farid & Abdel Aali, 2018, p. 160).
- The technological aspect, particularly with regard to information and communication technology (ICT), also forms a core part of the definition of the knowledge economy (Bouricha, 2022, p. 598).
- It can also be described as an economic system where knowledge constitutes the main source of added value, acting as a fundamental element in production, marketing, and expansion. Its growth is closely linked to the progress of information and communication technologies, which represent the core driver of its evolution .

The following table presents a comparison between the conventional economy and the knowledge-based economy.

Table 1. The difference between the knowledge economy and the traditional economy

Characteristics	Knowledge economy	Traditional economy
Economic phenomenon	It does not suffer from the problem of scarcity and there is abundance and diversity in resources.	Suffering from scarcity problem
Scope of competition	Universality	Local
Basis of wealth	Technical knowledge, creativity, intelligence, information, human capital	land, labor, physical capital
Measure of economic efficiency	The extent to which the organization owns knowledge and human capital and its speed of innovation, outpacing competitors.	Productivity of factors of production
The driving force of growth	Innovation, knowledge	labor, capital
Primary interest in projects	Satisfying evolving consumer desires through continuous product development and focus on quality.	Achieving the highest possible level of profits by controlling price levels without focusing on the consumer
The importance of research and innovation	High	Low and medium
The nature of the relationship with other projects	Alliances and mergers	Competitive relations and limited cooperation
Required education and skills	High skills and lifelong learning	Specific skills depending on the nature of the work

Source : (Boukhari, 2021, pp. 259-260)

2.2 Characteristics of the Knowledge Economy

The knowledge economy is characterized by a set of distinctive features that differentiate it from traditional economic models. These can be summarized as follows (Mehri & Farid, 2018, p. 294):

-Globalization: The labor market is no longer confined within national borders. European countries, for example, became a major economic power by surpassing geographical and political boundaries through the European Union. Similarly, the internet has created a borderless economy, allowing emerging nations to compete with industrial giants in accessing consumers and securing a share of global markets. This transformation goes beyond spatial limits to include time, as work has increasingly shifted to a continuous 24-hour cycle.

Customer-oriented adaptation: Competitive advantage in the knowledge economy no longer rests solely on mass production, large-scale marketing, distribution, or standardized policies. Instead, success relies on recognizing the individuality of each consumer, which requires the provision of high-quality products and services tailored to specific needs and preferences.

-Scarcity of skilled human capital: With current economic growth, many positions remain unfilled, particularly in information technology. In the United States, for instance, nearly 15% of IT-related jobs are vacant. Businesses face challenges in finding the right mix of skills,

making it necessary to open labor markets so that expertise unavailable in one country can be sourced from another through digital networks.

-Consumer empowerment: Intense competition, trade liberalization, widespread internet access, and multiple distribution channels have shifted decision-making power to consumers. Understanding consumer behavior and preferences has therefore become essential, with customer service emerging as a key differentiator for firms in the modern economy.

-E-commerce expansion: The increasing number of internet users has reinforced the role of e-commerce, whether in business-to-business (B2B) or business-to-consumer (B2C) transactions. Projections indicate that global e-commerce volumes will exceed one trillion dollars in the near future. As traditional sales and services are gradually replaced by online platforms, employment patterns are shifting toward jobs requiring advanced IT skills.

-Need for lifelong learning: The demand for adult education is expected to rise significantly, with continuous training and education becoming fundamental requirements to maintain individuals' productivity and employability.

-The "one-company" model: Future enterprises are expected to operate with a lean structure, relying on a limited number of employees and core departments, while outsourcing most other functions. This trend also includes remote work, where employees can perform tasks from home while remaining digitally connected to their organizations.

2.3 The Importance of the Knowledge Economy

The significance of the knowledge economy can be highlighted through the following points (Khriouach & Ben Omar, 2019, p. 336):

-Scientific and practical knowledge, which lies at the core of the knowledge economy, has become the primary foundation for the creation, growth, and accumulation of wealth—an idea historically linked to the origins of economics and its pursuit of understanding wealth generation.

-It contributes to improving performance, enhancing productivity, reducing production costs, and upgrading product quality through the application of advanced technological tools and methods embedded in the knowledge economy.

-The advanced techniques and outputs of the knowledge economy play a key role in boosting production and national income, generating business activities, revenues, and profits, while also creating income streams for individuals whose activities are connected to these sectors—whether directly or indirectly. This is especially evident in industries such as electronics, precision equipment, computer hardware, software development, and machinery production.

-It supports job creation, particularly in areas where advanced technologies are utilized. Although this raises debates, the reality is that the knowledge economy continues to generate a growing and diverse range of employment opportunities. These opportunities, however, are largely available to individuals with high-level scientific and practical skills aligned with technological requirements, while opportunities for those lacking such competencies tend to decline.

2.4 The Mechanisms of the Knowledge Economy

The advancement of nations and communities depends largely on activating the processes of acquiring, assimilating, producing, and applying knowledge in various aspects of life. These processes can be outlined as follows (Hri, 2016, p. 128):

-Human resource mechanisms: A cornerstone of the knowledge economy is the development of a highly skilled workforce. This requires training individuals and equipping them with advanced expertise, as the quality of human capital is the essential driver of creativity, innovation, and both technological and intellectual achievements.

-Investment mechanisms: A significant portion of resources must be allocated to activities that enable the absorption, creation, and dissemination of knowledge across all economic sectors. This includes investment in infrastructure, modern equipment, and software, all of which facilitate the generation and practical use of knowledge.

-Mechanisms for fostering a knowledge culture: The knowledge economy flourishes in an environment that values creativity, research, and technological advancement. It grows stronger within structured systems of knowledge management, supported by information and communication technologies at the local, regional, and global levels, which serve as a fundamental backbone.

-Mechanisms for stimulating creativity and innovation: Continuous renewal of the knowledge economy relies on cultivating a culture that encourages invention and creative thinking. Strengthening these mechanisms is essential, as recognizing and rewarding innovators enhances their contribution. Pioneers in science and research, therefore, gain both material and moral recognition, reflecting the broader societal and institutional appreciation of their efforts. This underscores the increasing added value of knowledge, technology, and their applications, along with their profound impact on human life and social development.

3. Requirements and Challenges of Achieving the Knowledge Economy

the knowledge economy to achieve its objectives, a set of essential foundations and requirements must be provided. However, despite their availability, the knowledge economy still faces several challenges that hinder full integration.

3.1 Pillars of the Knowledge Economy

The knowledge economy is based on four essential pillars, which are (Boulekdoura, 2018, p. 372):

-First Pillar: This includes a set of variables grouped under three main components:

Tariff Barriers: These relate to the presence or absence of customs tariffs, which serve as a measure of the level of competition within the market.

Quality of Regulation: This reflects the policies governing market dynamics, including attempts to control prices, inadequate supervision of banks, and strict rules applied to international trade and business development.

-Rule of Law: This refers to the degree of confidence investors and citizens have in the legal system, including the handling of criminal cases, violence-related offenses, the effectiveness of the judiciary, and the enforceability of contracts.

Second Pillar: Education and Human Resources

This factor is assessed based on variables such as enrollment rates at different educational stages, adult literacy levels, and the overall cultural level of society. It also takes into account the quality of education across all stages, the availability of skilled human resources, and the level of training they receive.

-Third Pillar: Innovation and Renewal Innovation forms the foundation of competitiveness. Since innovation relies largely on research and development, this pillar is measured by variables such as the number of researchers per million inhabitants, patents registered by researchers, scientific publications in pure and applied sciences, the volume of investments in R&D by both public and private sectors, and the availability of financial support for start-up projects developed within national technology incubators.

-Fourth Pillar: Information and Communication Infrastructure Information and communication infrastructure forms the solid foundation upon which knowledge-based economic activities grow. The components of this pillar include information and communication tools such as traditional and mobile telephones, the number of personal

computers available in the national environment—which serve as indicators of the extent to which information technology is used for internet access and field applications—as well as the types of information technologies prevalent within the national environment that contribute to the optimal investment in the flow of information. Additionally, the level of availability of e-government services and the amount of expenditure dedicated to ICT infrastructure are also taken into account.

3.1 Requirements of the Knowledge Economy

For the knowledge economy to prosper and become a solid foundation for sustainable development, several essential requirements must be fulfilled (Ben Youb & Tebaibia, 2017, p. 90).

-Developing human capital: The cornerstone of the knowledge economy is a well-prepared and highly skilled workforce. This requires continuous investment in training, education, and professional development to ensure that individuals possess advanced scientific and practical competencies. At the same time, the state must provide a supportive environment where knowledge is recognized and utilized as a central factor of production, equal in importance to traditional resources such as land, labor, and capital.

-Enhancing research and problem-solving skills: A knowledge-driven society depends on individuals' ability to think critically, analyze information, and connect ideas in order to identify and solve complex challenges. Building such capabilities means encouraging creativity, decision-making, and analytical reasoning from the earliest stages of education. By strengthening these intellectual skills, societies create citizens who are not only consumers of knowledge but also active contributors to scientific and technological progress.

-Restructuring public expenditure: Achieving success in a knowledge economy requires governments to rethink their fiscal priorities. A decisive increase in spending on education and research is vital, extending from primary schooling through higher education and advanced training programs. Rationalizing and guiding public expenditure toward strengthening the knowledge base ensures that resources are effectively directed to improve learning outcomes, support innovation, and foster long-term economic resilience.

-Expanding access to ICT infrastructure: Information and communication technologies form the backbone of the knowledge economy. Ensuring the widespread availability of modern digital tools and providing individuals with seamless access—regardless of time or location—is crucial for knowledge generation, exchange, and application. A strong ICT infrastructure also reduces inequality by bridging geographical and social gaps, while simultaneously enabling participation in global economic and innovation networks.

-In summary, the success of the knowledge economy depends on a comprehensive framework that integrates human development, advanced research skills, strategic public investment, and robust technological infrastructure. When these conditions are met, societies are better positioned to harness knowledge as the primary engine of growth, competitiveness, and sustainable development.

3.2 Challenges of Integrating into the Knowledge Economy

Despite the efforts made by governments across the world, it is impossible to ignore the seriousness of the obstacles hindering their transformation into a knowledge-based economy. These challenges include (Bourouissa & Oudayfiya, 2022, pp. 227–228):

-Lack of integration between research and industry, and brain drain: The weak integration between research institutions and the industrial sector can be attributed to several factors. The limited diversification of the industrial fabric does not support the development of a strong scientific or industrial interface. Moreover, the lack of effective policy frameworks for science and technology reduces the ability to align research with the needs of the productive

sector. As a result, opportunities to transfer knowledge generated by universities and research institutions into companies remain limited. Another factor is the average level of researchers in scientific and technological fields, often due to academic training gaps.

In addition, brain drain and the inability of countries to retain skilled talent represent a significant loss of expertise.

-Lack of incentives: One of the most pressing issues preventing transformation into a knowledge-based economy is the absence of incentives for creating knowledge, along with challenges in knowledge distribution and accessibility. Developing countries, in particular, struggle with knowledge production due to its high costs, which require sufficient financial resources to support knowledge creation.

-Imbalance between knowledge production and absorption: There is a delicate balance between external knowledge production and its absorption. The lower the level of knowledge production, the greater the need for efficient absorption. In most cases, absorption capacity must be much higher than the capacity to produce knowledge.

-Low quality of education: Measuring education solely by the number of schooling years, while neglecting the qualitative differences in knowledge outcomes, is not entirely accurate. Such neglect may lead to overlooking the very essence of education, which is meant to achieve meaningful learning outcomes

-Exclusion of Innovators: The exclusion of innovators by the existing political system leads to excessive concentration of power and decision-making in the central government, resulting in the marginalization of initiatives in other fields. Even local authorities are not free to launch new projects and operations.

-The Development of Knowledge Privatization (Intellectual Property as a Contradictory Tool and a Double-Edged Sword): This element can be considered a genuine strategy for many actors in the knowledge society, generating a strong incentive effect that could enhance innovation conditions in the long term. On the other hand, in its darker side, this right is subject to some radical criticism and questioning, which in particular leads to the excessive privatization of knowledge.

-The Problem of Weak ICT Infrastructure and the Difficulty of Its Dissemination: Access to, use of, dissemination, and facilitation of information and communication technology must be ensured in countries in order to promote the development of the knowledge economy. This includes improving the quantity and quality of equipment, facilities, and infrastructure related to these technologies, establishing a solid regulatory environment for ICT, and intensifying training programs and courses for individuals to enhance digital skills. This would create opportunities to accelerate the integration of ICT into the knowledge economy, thereby improving economic competitiveness through products and services with competitive advantages that qualify them to enter global markets.

4. Indicators for Measuring the Knowledge Economy

To measure the knowledge economy, a clear methodology for evaluation and assessment must be followed, along with the availability of a set of indicators that are commonly used for this purpose.

4.1 Methodology for Evaluating and Measuring the Knowledge Economy

The World Bank's initiative "Knowledge for Development" represents one of the most influential frameworks that linked the role of knowledge with the dynamics of economic and social development. This initiative highlighted that the fundamental divide between advanced and less developed countries does not primarily stem from differences in income or financial resources, but rather from disparities in the ability to generate, acquire, and utilize knowledge effectively. In other words, the essence of underdevelopment lies in weak knowledge systems

rather than insufficient wealth. Building on this insight, the World Bank designed the Knowledge Assessment Methodology (KAM) as a comprehensive tool for measuring the knowledge economy and identifying the structural reforms required to achieve sustainable progress. This methodology stresses that establishing a knowledge-based economy necessitates rethinking overall development strategies, where knowledge, creativity, and innovation should constitute the cornerstone of economic policies. The framework relies on four interconnected pillars (Aouar & Krouche, 2021):

-Human Capital: Human resources form the nucleus of the knowledge economy. They are represented in the skills, qualifications, creativity, and competencies possessed by individuals, which allow them to engage effectively in economic and social life. These capabilities are not static but can be expanded through sustained investment in quality education, healthcare, continuous training, and professional development. In doing so, societies create a highly skilled labor force capable of producing, disseminating, and applying knowledge to drive growth and competitiveness.

-Innovation: A robust national innovation system encompasses universities, research institutes, laboratories, technology parks, consulting firms, and industries that collaborate to develop and diffuse new technologies. Effective innovation requires linking local research with global knowledge flows, encouraging adaptation of advanced technologies to national contexts, and providing supportive policies and infrastructure. For developing economies, nurturing innovation is particularly vital, as it creates new opportunities, encourages entrepreneurship, and builds technological independence. Governments therefore need to design incentives that reward innovative activity, support intellectual property rights, and reduce barriers for innovators and entrepreneurs.

-Information and Communication Technology (ICT): ICT acts as the backbone of the knowledge economy, providing the infrastructure that enables the creation, exchange, and dissemination of knowledge on a large scale. Its importance lies in reducing transaction costs, overcoming geographical barriers, and integrating economies into global markets. Over the past decades, ICT has become not only a facilitator of economic growth but also a key driver of innovation, education, and governance reform. Ensuring widespread access to affordable ICT tools and services remains an essential requirement for empowering individuals, businesses, and institutions to fully participate in the knowledge economy.

-Economic and Institutional Regime: The broader institutional and economic environment represents the enabling foundation of a knowledge-based system. It includes transparent governance, efficient legal and regulatory frameworks, stable macroeconomic conditions, and incentives that encourage investment in knowledge creation and use. To be effective, this framework must promote fair competition, protect intellectual property rights, and facilitate integration into global markets. Reducing protectionist barriers and encouraging openness to trade and international cooperation are crucial steps to foster innovation, attract foreign investment, and stimulate a competitive knowledge-driven economy.

Through these interdependent pillars, the methodology demonstrates that the transition toward a knowledge-based economy is not merely a technical or technological process, but rather a comprehensive development project requiring coordinated policies, sustained investments, and institutional reforms that place knowledge at the heart of growth strategies.

Table 02. Some indicators adopted in measuring the knowledge economy according to the knowledge evaluation methodology.

Education and human capita	Innovation system
adult literacy rate Secondary education enrollment rate	Number of researchers in research and development sectors Number of patents
University enrollment rate	Number of published scientific articles
Information and communication technology	Economic and institutional system
Number of telephones per 1000 people Number of computers per 1000 people Internet usage rate	Customs and non-customs taxes Organizational quality Trade openness

Source : (World Bank, 2017, p. 29)

4.2. The Importance of Measurement in the Knowledge Economy

The significance of measuring the knowledge economy arises from the increasing complexity of evaluating economic activity within the context of the new economy, which is characterized by rapid transformation and constant innovation driven by the digital revolution. This ongoing shift introduces qualitative improvements, novel innovations, and fresh methods for exchanging and delivering products and services through the multiplicity of communication channels. Establishing accurate tools for measuring the knowledge economy is therefore of great importance, as it provides the foundation for conducting empirical studies capable of addressing the challenges that hinder development. In this regard, most indicators are derived from statistical data, which, due to their quantitative and objective nature, offer valuable insights for researchers and policymakers alike. Consequently, such measurements play a critical role in guiding countries aspiring to build a knowledge-based economy, enabling them to strengthen their global competitiveness in an increasingly knowledge-driven marketplace while simultaneously improving their growth performance (Boukhari, 2021, p. 260).

4.3 Steps for Calculating Knowledge Economy Indicators

Economic indicators generally provide a condensed view of how an economic system performs. However, when it comes to assessing the efficiency of a knowledge-based economy, the task becomes far more complex. This is largely due to institutional and methodological challenges that hinder the proper accounting of intellectual capital. Knowledge, unlike traditional inputs, is not easily measurable or quantifiable, which means that most available indicators of knowledge capital growth are indirect and often only capture partial aspects of its true value.

4.3.1 Measuring Knowledge

Knowledge, unlike traditional production inputs, cannot be assessed through classical production models that usually allow for predicting the effect of additional inputs. For instance, increasing the amount of steel used in manufacturing predictably leads to a proportional rise in automobile production, in line with the established production functions. In contrast, the introduction of new knowledge operates differently: rather than merely increasing output, it fundamentally reshapes the underlying production models, giving rise to innovative products, novel production methods, and entirely new opportunities:

-Measuring Scientific Contributions (Inputs): In the context of the knowledge economy, a primary focus remains on the generation of knowledge and the production of meaningful scientific contributions. This evaluation relies on several indicators, including:

-Research and Development Expenditures: These reflect the scale of resources allocated to expanding the knowledge base and advancing scientific outputs. Indicators related to researchers also provide insights into the scope of problems addressed and the scientific efforts required to generate new knowledge.

-Number of Engineers and Technicians: This refers to the pool of scientifically and technically qualified professionals, categorized according to academic degrees and professional training. It includes graduates from technical universities as well as vocational and professional institutes.

-Patents: As formalized representations of ideas, patents constitute some of the most direct indicators of scientific and technological creativity. Most countries maintain national systems for registering patents within centralized databases that cover a wide spectrum of technological fields, including inventions, innovations, and inventor information.

-Technology-Related Balance of Payments: This measures the international flow of technological knowledge through licensing fees, technology purchases, and other direct payments. Such activities can be classified according to organizational power, funding source, or field of application. Particular emphasis is often placed on R\&D expenditures and human resource allocations as key input indicators.

-Measuring Knowledge Stocks and Flows: Estimating the stock of innovations can be achieved by analyzing data on patent exclusivity and utilization periods, as well as monitoring R\&D employment and the growth of researchers across disciplines. More challenging, however, is measuring knowledge flows or the economic value of knowledge entering the production cycle within a given period. Typically, two indicators are used:

-Diffusion of Embedded Knowledge: Reflected in production processes, machinery, materials, and components incorporating new technologies.

-Diffusion of Disembodied Knowledge: Represented by technical expertise, patents, licenses, and specialized skills.

-Measuring Knowledge Networks: Implicit knowledge flows—such as those generated through teaching, discussions, reasoning, observations, and collaborative problem-solving—cannot be effectively captured through conventional indicators. This necessitates the development of new measures to track the processes of invention and knowledge dissemination among individuals, institutions, and economic actors. A core element of this involves evaluating national innovation systems, particularly their capacity to disseminate knowledge within and across countries and to establish linkages among diverse stakeholders.

Surveys on innovation are frequently employed for this purpose, enabling at least partial mapping of national innovation systems and their ability to diffuse knowledge across economies. Two main types of flows are typically analyzed:

-The transfer of knowledge between universities, public research bodies, and industries.

-The dissemination of fundamental scientific knowledge exchanged among researchers in a marketplace that connects suppliers with end-users.

4.3.2 The Strong Rise of ICT as a Vehicle for Knowledge

The knowledge economy is fundamentally dependent on the dissemination and investment of information, in addition to its generation, of course. The success of companies and institutions depends greatly on their effectiveness in collecting knowledge and using it to raise productivity and generate new goods and services. The economy has become led by a hierarchical series of knowledge networks in which information changes at a rapid rate. There are many types of knowledge networks, such as university networks, research centers, networks of information institutions such as libraries, publishing houses, documentation centers, and networks of various industries. This is what made the society that does not care

about networking knowledge institutions a society that is behind the global economic bandwagon. The knowledge economy is emerging and developing using methods that depend on information technology and seeks to manage information efficiently so that knowledge-based industries become the basis of the economic sector.

4.3.3 The role of communications and information networks

Several types of information technology impacts knowledge creation can be distinguished, as follows:

- The creation of a vast amount of information that could lead to a true revolution.
- Information and communication technology can solve the problem of spatial proximity in knowledge exchange and fruitful collaboration, even if many obstacles remain. Distance education and learning, as well as collaboration between geographically distant individuals and groups, have become widely used and effective applications.
- ICT is itself a set of tools for increasingly effective science production, enabling a powerful surge in creative interaction. It also opens up new possibilities for processing using modern technologies characterized by extensive databases, which in itself represents a powerful system for advancing science.

4.3.4 information technology

The term information technology refers to a set of elements and capabilities used to collect, store and disseminate data and information using computer and communications technology at high speed and efficiency to create everything that would help in the development of societies.

4.4 The Most Important Indicators for Measuring the Knowledge Economy

Several sets of indicators are used to measure the knowledge economy:

4.4.1 European Knowledge Economy Indicators

The European Bank for Reconstruction and Development (EBRD) established standards for measuring knowledge economy development through its Knowledge Economy Index. Covering 46 countries (38 of which are EBRD members and 8 OECD comparators), the new index includes 38 indicators grouped into four pillars (Ould Amer & Yousfi, 2023, p. 341):

-Innovation institutions: covering factors such as economic openness, business environment, and governance.

-Innovation skills: general and specialized skills necessary for innovation.

Innovation system: inputs and outputs of the innovation system, as well as related legacies and conditions.

ICT infrastructure: measuring availability, accessibility, and advancement of ICT.

4.4.2 Arab Knowledge Economy Index

The UN Development Programme (UNDP) and the Mohammed bin Rashid Al Maktoum Foundation launched the Arab Knowledge Index in 2015, updated in 2016 to better reflect the knowledge landscape in Arab countries. The indicators align with international standards while accounting for Arab regional specificities. The initiative aims to clarify the position of Arab knowledge and its challenges (Bougamoum & Kenida, 2018, p. 128) .

4.4.3 World Bank Knowledge Economy Index (KEI)

The World Bank Institute supports countries aspiring to build knowledge economies by assessing 140 countries. The 2008 KEI framework is based on four key pillars:

- Economic incentives and institutional regime Innovation
- Education and human resources
- Information and communication technologies (ICT)

These pillars are broken down into around 80 variables. Countries can use these indicators to guide their transition to a knowledge economy, based on a scale from 0 to 10. Two composite indicators emerge:

-Knowledge Index (KI): measuring overall knowledge performance.

-Knowledge Economy Index (KEI): measuring the economy's knowledge-based capacity.

Strengthening these four pillars increases the quantity and quality of knowledge available to the economy. The KEI measures a country's ability to generate, adopt, and disseminate knowledge, reflecting its overall potential for knowledge development (Qarni Abdelghani, 2020, pp. 70-79) .

5. CONCLUSION

This research paper aimed to study the indicators for measuring the knowledge economy, given its great importance in our present time. The paper reached a number of findings, the most prominent of which are:

The knowledge economy is essentially based on the production, dissemination, and utilization of knowledge as a fundamental driver of development, wealth creation, and employment across all economic sectors.

The knowledge economy is characterized by a set of features that distinguish it from other economies, such as the scarcity of human skills and competencies, and the ability to adapt to individual needs and demands.

The knowledge economy contributes to creating job opportunities in fields where advanced technologies are applied. These opportunities are broad, diverse, and continually increasing.

Information and communication infrastructure represents the solid foundation upon which knowledge-based economic activities grow.

Providing access to information and communication technologies (ICTs) at any time and place, as well as allocating investments in innovation and scientific research, are among the most critical requirements for achieving a knowledge economy.

One of the major challenges facing integration into the knowledge economy is the weakness of ICT infrastructure and the difficulty of its diffusion.

Measuring the knowledge economy requires adopting a specific evaluation methodology based on key principles such as human capital, innovation, information and communication technology, and the economic and institutional system.

Based on the results obtained, the following recommendations can be made:

-It is necessary to give significant importance to the knowledge economy by allocating investments to research, development, and innovation.

-Developing ICT infrastructure.

-Addressing the challenges that hinder the knowledge economy.

-Providing incentives in the fields of research, development, and innovation.

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