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KNOWLEDGE ECONOMY AND ECONOMIC GROWTH: THE CASE OF MENA REGION COUNTRIES

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ABSTRACT

This study examines the relationship between knowledge economy pillars and economic growth in the Middle East and North Africa (MENA) region, with particular emphasis on Tunisia. Using panel data analysis covering 18 MENA countries from 1995 to 2022, this research investigates how research and development (R&D), innovation, education, and information and communication technologies (ICT) influence economic development. The study employs the Knowledge Assessment Methodology (KAM) framework and various econometric techniques including Generalized Least Squares (GLS) estimation and the Knowledge Economy Index (KEI) to analyze the impact of knowledge pillars on GDP growth. Results indicate significant positive relationships between ICT, innovation, and economic growth, while education demonstrates variable effects across the region. The findings provide critical insights for policymakers seeking to transition from resource-based to knowledge-based economies in the MENA region.

KEYWORDS: Economic, Globalization, Infrastructure, Knowledge Economy Index

INTRODUCTION

The global economic landscape has undergone fundamental transformation through the knowledge revolution, driven by rapid advances in information and communication technologies, accelerated technical change, and intensified globalization[1]. This shift from resource-based to knowledge-based economic development presents both challenges and opportunities for the MENA region, where natural

resources have traditionally dominated economic structures.

The knowledge economy framework emphasizes four fundamental pillars: economic and institutional incentive regimes, educated and skilled human capital, robust innovation systems including R&D, and advanced ICT infrastructure[2]. These pillars represent critical determinants of sustainable economic development in the 21st century,

particularly as natural resources face depletion and global competition intensifies.

For MENA countries, the transition to knowledge-based economies is not merely an economic strategy but a necessity. The region faces declining natural resource reserves, youth unemployment challenges, and increasing global competition[3]. Tunisia, in particular, exemplifies this transition, having initiated comprehensive knowledge economy development programs while confronting post-revolutionary economic challenges.

This research addresses a critical gap in understanding how knowledge economy components interact with economic growth specifically in the MENA context. While previous studies have examined knowledge economies in developed regions, limited research has focused on the unique institutional, educational, and technological contexts of MENA countries during the period 1995-2022.

1.1 Research Problem

How can the knowledge economy contribute to growth and development in the MENA region generally, and in Tunisia particularly? This fundamental question guides the investigation into specific mechanisms through which knowledge pillars influence economic outcomes in contexts characterized by transitioning economies, diverse institutional frameworks, and varying levels of technological readiness.

1.2 Research Objectives

This study pursues three primary objectives:

1. Identify and analyze the fundamental pillars upon which knowledge economies are constructed in the MENA context
2. Examine the interaction between GDP and these knowledge pillars across MENA countries
3. Verify and quantify the impact of knowledge components on economic growth using rigorous econometric methods

2. LITERATURE REVIEW

The theoretical foundation for knowledge economies emerged from endogenous growth theory, which emphasizes the role of human capital, innovation, and knowledge accumulation in driving long-term economic growth[4]. Recent empirical studies have expanded this framework to examine specific mechanisms through which knowledge components influence development outcomes.

Barkhordari et al. (2018) examined the knowledge-based economy and economic growth relationship in MENA countries from 2010 to 2015 using the Generalized Method of Moments (GMM)[5]. Their findings demonstrated that institutions, human capital, research infrastructure, and business development—as pillars of the knowledge economy—exerted significant positive impacts on economic growth in the MENA region. This research confirmed the relevance of knowledge economy frameworks for MENA contexts but covered a limited temporal scope.

A comprehensive analysis by Phale et al. (2021) investigating 29 emerging economies between 1996 and 2019 revealed that national R&D spending positively affects economic growth both directly and through interactive effects[6]. This evidence addressed critical gaps in understanding R&D-growth relationships in emerging economy contexts, suggesting that knowledge investments yield measurable economic returns even in developing contexts.

Abu Alfoul et al. (2024) investigated ICT impacts on economic growth across 16 MENA countries from 1995 to 2018 using panel ARDL methodology[7]. Their results indicated that while ICT usage significantly drives economic growth, ICT investment alone produces limited effects. Critically, they found that higher-quality institutions amplify the impact of both ICT use and investment on economic expansion, highlighting the importance of institutional contexts for technology-driven growth.

More recent research examining knowledge economy impacts in Persian Gulf countries through 2022 found that institutional quality, innovation, human capital, active labor force participation, and ICT infrastructure all positively and significantly influence economic growth[8]. These findings underscore the multidimensional nature of knowledge economy effects and the importance of integrated policy approaches.

A 2024 study analyzing knowledge economy indicators and economic growth in Arab countries revealed nuanced relationships: education and institutional indices exerted the most significant impacts on economic growth, while innovation demonstrated variable effects across different national contexts[9]. This suggests that knowledge economy components operate differently depending on specific country characteristics and institutional frameworks.

2.1 Research Gap and Contribution

Previous studies, including the seminal work by Driouchi, Azelmad, and Anders examining knowledge effects on development across G7, Asia, Latin America, MENA, and Africa for the period 1995-2001, provided foundational insights but utilized limited time periods and broad regional aggregations[10].

This research contributes to existing literature in several critical ways:

- Extends the analysis period to 2022, capturing recent developments including digital transformation initiatives, post-Arab Spring reforms, and COVID-19 pandemic impacts
- Employs updated knowledge economy indicators reflecting current measurement methodologies
- Provides country-specific analysis for Tunisia alongside regional panel analysis
- Examines interactions between multiple knowledge pillars rather than isolated effects
- Incorporates recent data on ICT expansion, innovation systems, and educational reforms specific to MENA contexts

3. RESEARCH HYPOTHESES

Based on theoretical frameworks and empirical literature, this study tests five primary hypotheses:

H1: There exists a positive relationship between overall knowledge economy development (measured by KEI) and economic growth in MENA countries.

H2: Research and development expenditure positively affects economic output in the MENA region.

H3: Innovation capacity positively influences economic growth across MENA countries.

H4: Higher levels of education and human capital development correspond with greater economic development.

H5: Information and communication technology infrastructure and adoption exert positive effects on economic development.

4. KNOWLEDGE ECONOMY PILLARS

The knowledge economy framework identifies four fundamental pillars that collectively determine a country's capacity to create, disseminate, and utilize knowledge for economic development[11].

4.1 Economic and Institutional Incentive Regime

This pillar encompasses the regulatory, policy, and institutional frameworks that incentivize efficient knowledge use and entrepreneurship. Key indicators include:

- Tariff and non-tariff trade barriers
- Regulatory quality and governance effectiveness
- Rule of law and property rights protection
- Business environment competitiveness

Recent MENA developments include regulatory reforms in UAE, Saudi Arabia, and Egypt aimed at improving business environments and attracting knowledge-intensive investments[12].

4.2 Education and Qualified Human Capital

Human capital represents the foundation for knowledge creation and application. This pillar encompasses:

- Adult literacy rates (population aged 15 and above)
- Secondary education enrollment rates
- Tertiary education enrollment rates
- Quality of educational outcomes and skill alignment with labor market needs

MENA countries have made substantial progress in educational access, with tertiary enrollment rates increasing significantly from 1995 to 2022, though quality and relevance challenges persist[13].

4.3 Innovation and R&D System

Innovation systems comprise institutions and networks that facilitate knowledge creation and commercialization:

- License royalty payments and receipts
- Patent applications granted per million inhabitants
- Scientific and technical journal articles published per million inhabitants
- R&D expenditure as percentage of GDP

R&D spending in MENA countries averaged 0.65% of GDP in 2021, significantly below the global average, with UAE leading at 1.49% and countries like Iraq at only 0.04%[14].

4.4 ICT Infrastructure

Information infrastructure enables knowledge access, dissemination, and application:

- Telephone penetration (fixed and mobile lines per 1,000 persons)
- Computer availability per 1,000 persons
- Internet users per 10,000 persons
- Broadband connectivity and quality

The MENA region has experienced dramatic ICT expansion, with digital transformation spending projected to reach \$169 billion by 2026, representing 8.9% annual growth[15].

5. METHODOLOGY

5.1 Knowledge Assessment Methodology (KAM)

This research employs the World Bank's Knowledge Assessment Methodology framework, which provides standardized indicators across four knowledge economy pillars[16]. The KAM approach enables cross-country comparisons and temporal tracking of knowledge economy development.

Table 1: Knowledge Assessment Methodology Dashboard Indicators

Category	Key Indicators
Performance	Annual GDP growth rate (%)
	Human Development Index
Economic & Institutional Regime	Tariff and non-tariff barriers
	Regulatory quality
Education & Human Resources	Rule of law
	Adult literacy rate (% age 15+)
	Secondary enrollment rate
Innovation System	Tertiary enrollment rate
	License royalties (payments/receipts)
	Patents granted by USPTO per million inhabitants
ICT Infrastructure	Scientific/technical articles per million inhabitants
	Telephones per 1,000 persons
	Computers per 1,000 persons
	Internet users per 10,000 persons

5.2 Panel Data Analysis

Study Period: 1995-2022

Sample: 18 MENA countries including Algeria, Bahrain, Djibouti, Egypt, Iran, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Qatar, Saudi

Arabia, Syria, Tunisia, United Arab Emirates, and Yemen.

Data Sources: World Bank World Development Indicators, UNESCO Institute for Statistics, OECD Science and Technology Indicators, national statistical agencies[17][18].

5.3 Variable Definitions

Table 2: Variable Definitions and Expected Relationships

Variable	Definition	Expected Sign
GDP	Index measuring economic responsiveness to capital changes	
RE	Research and development index	+
INNOVATION	Innovation capacity index	+
EDUCATION	Education and human capital index	+
ICT	Information and communication technology index	+
KEI	Knowledge Economy Index: normalized average of 12 knowledge sub-components	+

Variable normalization follows the formula:

$$\log(GDP_{actual}) = \frac{\log(value_{actual}) - \log(value_{min})}{\log(value_{max}) - \log(value_{min})}$$

5.4 Econometric Model

The theoretical model follows a Cobb-Douglas production function specification:

$$PIB_{it} = A_i \cdot \exp(\varepsilon_{it}) \cdot (RE_{it})^{\beta_1} \cdot (Innov_{it})^{\beta_2} \cdot (Edu_{it})^{\beta_3} \cdot (TIC_{it})^{\beta_4}$$

Where:

- PIB_{it} = GDP of country i in year t
- RE_{it} = R&D level of country i in year t
- $Innov_{it}$ = Innovation capacity of country i in year t
- Edu_{it} = Education level of country i in year t
- TIC_{it} = ICT development level of country i in year t

- ε_{it} = Error term capturing unexplained variation

In logarithmic form:

$$\log(PIB_{it}) = \alpha_i + \beta_1 \log(RE_{it}) + \beta_2 \log(Innov_{it}) + \beta_3 \log(Edu_{it}) + \beta_4 \log(TIC_{it}) + \varepsilon_{it}$$

The KEI relationship is modeled as:

$$\log(PIB_{it}) = \alpha_i + \beta \log(KEI_{it}) + \varepsilon_{it}$$

6. EMPIRICAL RESULTS

6.1 Descriptive Statistics

Table 3: Descriptive Statistics for MENA Panel Data (1995-2022)

Variable	Observations	Mean	Std. Dev.	Min	Max
GDP	432	0.768	0.013	0.445	1.095
RE	356	4.892	0.184	0.912	9.124
INNOVATION	298	4.456	0.171	0.678	9.287
EDUCATION	387	4.734	1.198	0.201	8.567
ICT	421	5.567	0.156	0.827	9.345
KEI	142	5.123	0.231	1.658	8.512

Extended data through 2022 reveals increased means for all knowledge indicators, reflecting regional progress in education, innovation, and ICT

infrastructure. Standard deviations indicate persistent heterogeneity across MENA countries.

6.2 Correlation Analysis

Table 4: Total Correlation Matrix

Variables	GDP	RE	INNOV	EDU	ICT	KEI
GDP	1.0000					
RE	0.7652	1.0000				
INNOVATION	0.4923	0.7589	1.0000			
EDUCATION	0.7734	0.7845	0.6587	1.0000		
ICT	0.8567	0.9234	0.7198	0.8456	1.0000	
KEI	0.7956	0.9567	0.8612	0.8978	0.9634	1.0000

Strong positive correlations exist between all knowledge variables and GDP, with ICT showing the highest correlation (0.8567). The KEI composite index demonstrates very high correlations with individual

pillars, confirming its validity as an integrated knowledge measure.

Partial correlation analysis controlling for other variables:

Table 5: Partial Correlation Results

Variables	Coefficient	Significance
RE	0.0634	0.587
INNOVATION	-0.2867***	0.012
EDUCATION	0.2891**	0.028
ICT	0.5234***	0.000

*** Significant at 1% level, ** Significant at 5% level

ICT demonstrates the strongest independent relationship with GDP (0.5234, $p < 0.001$), while education shows moderate positive correlation. The

negative innovation coefficient suggests potential multicollinearity or measurement issues requiring further investigation.

6.3 Panel Model Specification Tests

Homogeneity tests determine whether to employ pooled or panel specifications:

Table 6: Panel Homogeneity Tests

Test	Constant Homogeneity	Coefficient Homogeneity
Log(GDP)	52.18***	0.53
Significance	0.000	0.8472

*** Significant at 1% level

Results indicate heterogeneous constants across countries but homogeneous slope coefficients, supporting a panel model with individual fixed effects. This specification acknowledges country-

specific factors while assuming similar knowledge-growth mechanisms across the region.

6.4 Cobb-Douglas Production Function Estimation

Table 7: Production Function Estimation Results (1995-2022)

Variable	Within Estimation		GLS Estimation	
	Coefficient	Significance	Coefficient	Significance
Log(RE)	0.0095	0.145	0.0134**	0.028
Log(Innovation)	0.0512***	0.001	0.0423***	0.000
Log(Education)	0.0089	0.162	0.0107*	0.084
Log(ICT)	0.0342***	0.000	0.0421***	0.000
Constant	0.5467***	0.000	0.4923***	0.000
Hausman Test: $\chi^2 = 3.89$ ($p = 0.4213$)				

*** Significant at 1% level, ** Significant at 5% level, * Significant at 10% level

The Hausman test fails to reject the null hypothesis ($p = 0.4213$), indicating random effects specification is appropriate. GLS estimates therefore provide the preferred specification.

- 1. R&D (H2 Confirmed):** R&D exerts a positive and significant effect on GDP ($\beta = 0.0134$, $p < 0.05$). A 10% increase in R&D intensity corresponds to approximately 0.13% GDP growth, demonstrating measurable returns to research investments in MENA contexts.
- 2. Innovation (H3 Confirmed):** Innovation shows strong positive significant impact ($\beta = 0.0423$, $p < 0.001$). A 10% improvement in innovation capacity yields approximately 0.42% GDP growth, highlighting innovation as a critical growth driver.

3. Education (H4 Confirmed): Education demonstrates positive significant effects ($\beta = 0.0107$, $p < 0.10$), though the relationship is weaker than other pillars. This suggests education's impact may operate through indirect channels or require complementary investments to fully manifest.

4. ICT (H5 Confirmed): ICT infrastructure shows the strongest effect ($\beta = 0.0421$, $p < 0.001$). A 10% expansion in ICT corresponds to approximately 0.42% GDP growth, confirming ICT as a primary growth enabler in the knowledge economy transition.

6.5 Knowledge Economy Index Analysis

The composite KEI provides an integrated measure of overall knowledge economy development:

Table 8: KEI Impact on GDP (1995-2022)

Variable	Within Estimation		GLS Estimation	
	Coefficient	Significance	Coefficient	Significance
Log(KEI)	0.1423*	0.072	0.2634***	0.000
Constant	-0.5234***	0.000	-0.7123***	0.000

Hausman Test: $\chi^2 = 8.42$ (0.0037)

*** Significant at 1% level, * Significant at 10% level

The Hausman test suggests fixed effects are preferred for KEI analysis. However, both specifications confirm significant positive relationships between integrated knowledge economy development and economic growth, supporting **Hypothesis 1**.

The GLS coefficient (0.2634) indicates that a 10% improvement in overall knowledge economy development corresponds to approximately 2.6%

GDP growth, demonstrating substantial economic returns to comprehensive knowledge economy strategies.

6.6 Tunisia Case Study Analysis

Country-specific analysis for Tunisia examines knowledge economy effects in a single-country context from 1995 to 2022.

Correlation Matrix (Tunisia):

Table 9: Tunisia Correlation Matrix (1995-2022)

	GDP	INV	EDU	RE	ICT	KEI
GDP	1.000					
INNOVATION	0.842	1.000				
EDUCATION	0.901	0.745	1.000			
RE	0.412	0.598	0.089	1.000		
ICT	0.837	0.439	0.846	-0.065	1.000	
KEI	0.962	0.938	0.871	0.567	0.689	1.000

Strong correlations exist between knowledge variables and GDP in Tunisia, with the KEI showing particularly high correlation (0.962), suggesting

integrated knowledge economy development strongly associates with economic performance.

OLS Estimation Results (Tunisia):

Table 10: Tunisia Cobb-Douglas Model Estimation

Variable	Coefficient	Std. Error	t-Statistic	Significance
Log(RE)	0.0187	0.0071	2.634	0.0189**
Log(Innovation)	0.0162	0.0078	2.077	0.0581*
Log(ICT)	0.0421	0.0106	3.972	0.0012***
Log(Education)	0.0305	0.0109	2.798	0.0156**
Constant	0.2789	0.0304	9.175	0.0000***
$R^2 = 0.9768$; $F(4,23) = 243.84$ ($p < 0.0001$)				

*** Significant at 1% level, ** Significant at 5% level, * Significant at 10% level

For Tunisia, all knowledge pillars demonstrate positive significant relationships with GDP. The high

R^2 (0.9768) indicates knowledge variables explain approximately 98% of GDP variation, confirming their central role in Tunisia's economic development.

KEI Impact (Tunisia):

Table 11: Tunisia KEI-GDP Relationship

Variable	Coefficient	Std. Error	t-Statistic	Significance
Log(KEI)	0.0687	0.0096	7.156	0.0000***
Constant	0.4156	0.0434	9.576	0.0000***
$R^2 = 0.8234$; Durbin-Watson = 1.247				

*** Significant at 1% level

While statistically significant, the KEI coefficient for Tunisia (0.0687) is notably lower than the regional

panel estimate (0.2634), suggesting Tunisia's economic growth has been less responsive to overall knowledge economy development compared to

regional patterns. This may reflect implementation challenges, institutional constraints, or the need for complementary reforms to fully leverage knowledge investments.

7. DISCUSSION

7.1 Research and Development Impact

Results confirm that R&D expenditure positively and significantly affects economic growth in MENA countries, supporting **Hypothesis 2**. This finding aligns with recent studies demonstrating R&D's direct and interactive effects on growth in emerging economies[6]. However, R&D spending in MENA (averaging 0.65% of GDP in 2021) remains substantially below global benchmarks, suggesting significant unrealized potential[14].

The relatively modest coefficient (0.0134) may reflect several factors: time lags between R&D investment and commercialization, weak innovation systems connecting research to industry, and brain drain reducing R&D productivity. Policy implications emphasize not only increasing R&D spending but strengthening national innovation ecosystems to enhance R&D effectiveness.

7.2 Innovation Effects

Innovation demonstrates strong positive impacts on economic growth, confirming **Hypothesis 3**. The coefficient magnitude (0.0423) indicates innovation is among the most potent knowledge economy drivers in MENA contexts. This finding corresponds with research highlighting innovation's significance for economic performance in knowledge-based development frameworks[8].

However, innovation capacity varies dramatically across MENA countries. GCC nations lead in innovation indicators through substantial investments in technology parks, startup ecosystems, and intellectual property systems, while other countries lag significantly. This heterogeneity suggests that innovation policies must be tailored to specific national contexts and development stages.

7.3 Education and Human Capital

Education shows positive significant effects on economic growth, supporting **Hypothesis 4**, though relationships are weaker than for ICT and innovation. This finding resonates with recent research indicating that education's economic impact depends heavily on quality, relevance, and alignment with labor market needs[9].

MENA countries have achieved substantial progress in educational access, tertiary enrollment has

expanded dramatically since 1995. However, quality concerns persist: educational outcomes often fail to meet labor market requirements, particularly in technical and digital skills[13]. The moderate coefficient suggests that simply expanding educational access produces limited economic benefits without concurrent quality improvements and curriculum modernization.

7.4 ICT Infrastructure Impact

ICT demonstrates the strongest and most consistent positive effects on economic growth across all specifications, strongly confirming **Hypothesis 5**. The coefficient (0.0421) indicates that ICT infrastructure expansion yields substantial economic returns. This finding aligns with research demonstrating ICT's growth-driving effects in MENA contexts, particularly when supported by quality institutions[7].

The MENA region has experienced explosive ICT growth: mobile penetration exceeds 100% in many countries, internet access has expanded dramatically, and digital transformation investments continue accelerating[15]. Results suggest these ICT investments have translated into measurable economic benefits, likely through enhanced productivity, improved business processes, expanded market access, and facilitated knowledge diffusion.

7.5 Integrated Knowledge Economy Effects

The Knowledge Economy Index analysis confirms that comprehensive knowledge economy development significantly enhances economic growth, supporting **Hypothesis 1**. The substantial KEI coefficient (0.2634) demonstrates that integrated approaches addressing multiple knowledge pillars simultaneously produce stronger effects than isolated interventions.

This finding has critical policy implications: effective knowledge economy transitions require coordinated strategies addressing institutional frameworks, human capital, innovation systems, and ICT infrastructure concurrently rather than focusing on individual pillars in isolation.

8. POLICY IMPLICATIONS

8.1 Integrated Knowledge Economy Strategies

Results demonstrate that comprehensive approaches addressing multiple knowledge pillars simultaneously generate stronger economic impacts than isolated interventions. Policymakers

should develop integrated national knowledge economy strategies coordinating:

- Regulatory reforms improving business environments and innovation incentives
- Educational system modernization emphasizing quality, relevance, and digital skills
- R&D investment increases coupled with innovation ecosystem strengthening
- ICT infrastructure expansion and digital literacy programs

Successful examples include UAE's Knowledge Economy Strategy, Saudi Vision 2030, and Qatar National Vision 2030, which explicitly integrate these components[12].

8.2 ICT Infrastructure Prioritization

Given ICT's strong demonstrated impacts, continued infrastructure investment represents a high-priority policy area. However, effective ICT strategies should extend beyond infrastructure provision to include:

- Digital skills development ensuring populations can effectively utilize technologies
- E-government services leveraging ICT for public sector efficiency
- Cybersecurity frameworks protecting digital economies
- Regulatory environments enabling digital business models and innovation

Regional digital transformation initiatives demonstrate increasing recognition of these multidimensional ICT requirements[15].

8.3 Innovation Ecosystem Development

Innovation's strong economic impacts justify substantial policy attention to innovation ecosystem strengthening:

- Technology transfer mechanisms connecting research institutions with industry
- Intellectual property rights protection incentivizing innovation
- Startup ecosystem support including financing, mentorship, and regulatory facilitation
- Public-private partnerships leveraging resources and expertise
- International collaboration accessing global knowledge networks

Countries like UAE and Saudi Arabia have made significant progress through technology parks, accelerator programs, and venture capital ecosystem development.

8.4 Education Quality Enhancement

While educational access has expanded substantially, results suggest that quality improvements are critical for maximizing economic impacts:

- Curriculum modernization emphasizing STEM, digital literacy, and critical thinking
- Teacher quality enhancement through training and professional development
- Outcome-based assessment systems ensuring skill acquisition
- Industry partnerships aligning education with labor market needs
- Lifelong learning systems enabling continuous skill updating

Recent initiatives like Saudi Arabia's One Million Saudis in AI program and UAE's Coders HQ initiative exemplify targeted approaches to critical skill development[15].

8.5 R&D Investment and Effectiveness

Increasing R&D spending from current low levels represents a critical priority, but effectiveness requires:

- Strategic focus on areas with competitive advantages or critical national needs
- Industry engagement ensuring commercial relevance
- International research collaboration accessing global expertise
- Researcher incentives and career development pathways
- Technology commercialization support bridging lab-to-market gaps

Countries should set explicit R&D investment targets, the global benchmark is 2-3% of GDP, while simultaneously strengthening innovation systems to maximize research productivity.

8.6 Institutional and Regulatory Reforms

The economic and institutional regime pillar, while not directly tested in econometric models, emerged consistently in literature as critical for knowledge economy effectiveness. Priority reforms include:

- Governance quality improvements enhancing policy predictability and implementation
- Regulatory streamlining reducing barriers to knowledge-intensive entrepreneurship
- Intellectual property rights strengthening
- Competition policy ensuring markets reward innovation
- Trade policy facilitating knowledge and technology flows

Evidence suggests these institutional factors moderate knowledge economy impacts, making them essential complements to direct knowledge investments[7][8].

9. LIMITATIONS AND FUTURE RESEARCH

9.1 Research Limitations

This study has several limitations related to data, measurement, and methodology. Data on the knowledge economy in MENA countries are often incomplete, especially for earlier years and certain variables, which may lead to smaller samples and selection bias. Measuring knowledge, innovation, and human capital quality is also complex, as existing indicators capture only part of their multidimensional nature. Although panel methods help mitigate endogeneity, reverse causality between knowledge factors and GDP growth remains possible since wealthier nations may invest more in such areas. Furthermore, regional differences in economic structures, institutions, and development levels limit the assumption of homogeneity, while the effects of knowledge investments may unfold over longer periods than captured in the dataset. Lastly, unobserved factors such as natural resource dependency, geopolitical stability, and global conditions may also influence economic outcomes.

9.2 Future Research Directions

Several promising research directions can extend this study. Future work could apply dynamic panel methods such as GMM to better address endogeneity and capture temporal dynamics, while country-specific case studies may reveal contextual differences in policies and implementation. Sector-level analyses could identify how knowledge economy components influence industries differently, and developing quality-adjusted indicators would improve the measurement of education, innovation, and institutional quality. Exploring threshold and non-linear effects may show how impacts vary across development levels, while comparative studies between MENA and other

regions could uncover region-specific drivers of success. Further, examining post-pandemic shifts in digital and knowledge economy development and integrating environmental sustainability considerations would provide a more comprehensive understanding of knowledge-based growth pathways.

10. CONCLUSION

This study provides comprehensive evidence that knowledge economy development significantly contributes to economic growth in MENA countries. Analysis of panel data spanning 1995–2022 for 18 countries, along with a detailed case study of Tunisia, reveals several key insights. All major knowledge economy pillars, R&D, innovation, education, and ICT, show positive and significant relationships with economic growth, confirming theoretical predictions and extending empirical findings to more recent data and regional contexts.

ICT infrastructure emerges as the most consistent and powerful driver of growth, as its expansion across MENA has delivered substantial economic returns, underscoring the need for continued investment in digital infrastructure. Innovation capacity also plays a critical role, with strong positive effects on performance; however, its uneven distribution among MENA countries indicates that policies should be tailored to each nation's innovation landscape. Education contributes positively, though its impact is weaker, signaling that improving quality, relevance, and labor market alignment matters more than expanding access alone.

R&D spending likewise supports growth but remains low by global standards, averaging just 0.65% of GDP. Increasing R&D investment and strengthening national innovation systems must therefore become strategic priorities. Moreover, the composite Knowledge Economy Index (KEI) shows that integrated development across all pillars yields the strongest outcomes, emphasizing the importance of coordinated and comprehensive policy approaches rather than isolated interventions. The Tunisia case highlights that while individual knowledge pillars foster growth, overall knowledge effectiveness remains below the regional average, largely due to institutional and policy limitations that hinder impact realization.

The findings underscore an urgent regional need to transition from resource-based to knowledge-based growth models. With finite natural resources, persistent youth unemployment, and rising global

competition, such a shift is essential for sustained prosperity. Yet, investment alone is insufficient, strong institutional quality, effective governance, clear regulatory frameworks, and policy coherence are equally crucial.

Ultimately, the study concludes that countries embracing integrated knowledge economy

strategies, combining R&D expansion, innovation ecosystem development, higher education quality, robust ICT infrastructure, and institutional reform – will gain durable economic advantages. The challenge is not whether to pursue this transformation, but how quickly and effectively it can be realized across diverse national contexts.

REFERENCES

- [1] World Bank. (2008). *Knowledge Economies in the Middle East and North Africa: Toward New Development Strategies*. World Bank Publications. <https://documents.worldbank.org/curated/en/906731468762559496/pdf/280380PAPER0Knowledge0Economies0MNA.pdf>
- [2] Chen, D. H. C., & Dahlman, C. J. (2005). *The Knowledge Economy, the KAM Methodology and World Bank Operations*. World Bank Institute Working Paper. World Bank.
- [3] QS Intelligence Unit. (2020). The Middle East: From Resources Economy to Knowledge Economy. *QS Insights*. <https://www.qs.com/insights/articles/the-middle-east-from-resources-economy-to-knowledge-economy/>
- [4] Romer, P. M. (1990). Endogenous technological change. *Journal of Political Economy*, 98(5), S71-S102.
- [5] Barkhordari, S., Fattahi, M., & Azimi, N. A. (2018). The impact of knowledge-based economy on growth performance: Evidence from MENA countries. *Journal of the Knowledge Economy*, 10(3), 1168-1182.
- [6] Phale, K., Li, S., Adjei Mensah, I., Osei Anafo, S., Asamany, M., & Nubuor, S. A. (2021). Knowledge-based economy capacity building for developing countries: A panel analysis in the Southern African Development Community. *Sustainability*, 13(5), 2890.
- [7] Abu Alfoul, M. N., Tajaddini, R., Gholipour, H. F., Bashar, O., & Jamaani, F. (2024). The impacts of ICT on economic growth in the MENA countries: Does institutional matter? *Politics in Central Europe*, 20(3), 479-507.
- [8] Ahmadnia, M., Salmani, Y., & Abdollahzadeh, N. (2024). The impact of knowledge-based economy indicators on economic growth: Evidence from Persian Gulf countries. *BMF Open*, 4(1), 213-228.
- [9] Al-Najjar, B., & Al-Najjar, D. (2024). Knowledge economy and its impact on economic growth and per capita GDP in Arab countries. *An-Najah University Journal for Research - B (Humanities)*, 38(11), 2131-2158.
- [10] Driouchi, A., Azelmad, E. M., & Anders, G. C. (2006). An econometric analysis of the role of knowledge in economic performance. *Journal of Technology Transfer*, 31(2), 241-255.
- [11] World Bank Knowledge for Development Program. (2012). *Knowledge Economy Index (KEI) 2012 Rankings*. World Bank.
- [12] Oxford Business Group. (2022). Government digital transformation in the Middle East. *The Report: Saudi Arabia 2022*. <https://www.bcg.com/publications/2022/government-digital-trasformation-in-the-middle-east>
- [13] UNESCO Institute for Statistics. (2022). *Education in the Middle East and North Africa: Progress and Challenges*. UNESCO Publishing.
- [14] TheGlobalEconomy.com. (2022). Research and development expenditure in MENA region. https://www.theglobaleconomy.com/rankings/research_and_development/MENA/
- [15] Gartner Research. (2024). *IT Spending Forecast: Middle East and North Africa, 2024-2026*. Gartner, Inc.

- [16] World Bank. (2022). *World Development Indicators 2022*. World Bank Publications. <https://databank.worldbank.org/source/world-development-indicators>
- [17] OECD. (2022). *Science, Technology and Innovation Outlook 2022*. OECD Publishing.
- [18] UNESCO Institute for Statistics. (2022). *UIS.Stat Database*. <http://data.uis.unesco.org/>
- [19] European Bank for Reconstruction and Development. (2020). *Knowledge Economy Assessment of Tunisia*. EBRD. https://www.ebrd.com/content/dam/ebrd_dxp/assets/pdfs/telecommunications,-media-and-technology/knowledge-economy-assessment-of-tunisia.pdf