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Higher Education Spending and Sustainable Development Dynamics in Iraq

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Abstract

General Background: Higher education is widely recognized as a strategic pillar for achieving sustainable development, particularly in developing and post-conflict economies. **Specific Background:** In Iraq, structural instability, regional disparities, and digital inequality raise questions about how higher education financing and digital infrastructure relate to sustainable development trajectories. **Knowledge Gap:** Limited empirical studies integrate asymmetric time-series modeling with spatial econometric analysis to capture both temporal and geographic disparities in Iraq. **Aims:** This study examines the dynamic and spatial relationships between higher education expenditure, internet penetration, macroeconomic variables, and sustainable development indicators during 2003–2024 using NARDL and spatial panel models. **Results:** Findings reveal asymmetric responses, where reductions in education spending correspond to larger developmental setbacks than gains associated with increases, alongside significant spatial spillovers across governorates. Governance quality and unemployment mediate these relationships. **Novelty:** The study integrates nonlinear dynamic modeling with spatial econometrics to reveal cumulative and geographically clustered development patterns. **Implications:** Stable education financing, digital inclusion strategies, and regionally differentiated policies are essential for balanced and sustained development planning in Iraq.

Highlights:

- Education budget reductions correspond to deeper long-run developmental declines.
- Strong spatial spillovers link governorate-level education and development patterns.
- Governance quality and unemployment shape cumulative development dynamics.

Keywords:

Higher Education, Sustainable Development, NARDL Model, Spatial Econometrics, Digital Divide

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Introduction

University education is the key to sustainable development. It also helps in fostering human capital since individuals are provided with the knowledge and skills they need to adjust themselves with the changes that are inherent in the knowledge economy and even with the emerging demands of the modern society. [1]. In Iraq, which is undergoing complex economic and social transformations, the need for a systematic assessment of the role of higher education in promoting sustainable development pathways is increasing, particularly in light of financing and infrastructure challenges, regional disparities and the widening digital divide [2]. This assessment is doubly important with the relative improvement in education indicators and commitment to the SDGs recorded in official reports, and the rise of some Iraqi universities in specialized international classifications [3], despite the persistence of structural obstacles related to policy effectiveness, funding stability, and governance efficiency [4]. This research is based on the central premise that the impact of higher education on sustainable development in Iraq is characterized by temporal asymmetry and spatial heterogeneity, and that macroeconomic dynamics -such as unemployment, inflation and capital formation -interact with higher education variables - such as university spending and the spread of the Internet -in a nonlinear manner. To experimentally test this hypothesis, the research adopts a dual approach: dynamic quantitative analysis using annual time data for the period 2003-2024 via the nonlinear distributed autoregression model (NARDL) to capture asymmetric short- and long-term effects; and spatial analysis employing spatial regression models, based on spatial weight matrices to measure neighborhood effects and monitor disparities between governorates.

This study aims at giving a fair approximation of the magnitude, nature, and quality of the connection among higher education and sustainable development as well as coming up with viable recommendations on the basis of quantitative and spatial facts that would help in maximizing or justice in investment in higher education, eliminating the digital divide and improving the advancement of the educational and research framework in Iraq.

Although the higher education role is fundamentally critical in sustaining sustainable development pathways, Iraq is plagued with structural and economic facing problems that curb the application of this role. The main limitations are scarcity of funds, infrastructural inequalities, spatial differences, widening digital divide, and macroeconomic factors as unemployment and inflation. Accordingly, there is a need for an in-depth scientific study that clarifies the nature of the relationship between higher education and sustainable development through a time-dynamic analysis supported by a spatial analysis that monitors disparities between governorates during the period 2003–2024.

The importance of this research stems from:

- Provide an accurate and comprehensive scientific estimate of the impact of higher education on sustainable development in Iraq, temporally and spatially.
- identification of disparities in the immediate and long-term impacts on macroeconomic indicators of education variables (Internet penetration, university spending).
- supplying decision-makers with useful suggestions to enhance the impact of higher education on development by encouraging investments, reducing the digital divide, and improving the effectiveness of research and educational infrastructure

Research Questions

- What kind of dynamic relationship exists between some indicators of sustainable development in Iraq from 2003 to 2024 and higher education indicators?
- Is asymmetry between positive and negative shocks in education variables a defining feature of this relationship??
- What is the magnitude and significance of spatial and neighborhood influences in explaining developmental disparities between governorates?
- What policies are most effective for maximizing the impact of higher education in light of temporal and spatial outcomes?

Research hypotheses:

- H1: There is a long-term relationship between indicators of higher education and sustainable development in Iraq.
- H2: The impact of university spending shocks and internet penetration is asymmetric between high and low, short and long term.
- H3: Spatial influences have a significant role in explaining disparities between governorates, and their inclusion improves the relevance of models.
- H4: Macroeconomic performance (growth, unemployment, inflation, capital formation) mediates the relationship between higher education and development.

Method

1. Research Methodology

- An analytical quantitative approach to measuring the dynamic temporal relationship using NARDL.
- A spatial approach that employs spatial regression models (Spatial Lag, Spatial Error) to capture the effects of neighborhood and spatial solidarity.

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1. Nature of the data

- Annual data for 2003–2024.
- Key variables: Higher education spending, Internet penetration, real GDP per capita, unemployment, inflation, and capital formation.
- Sources: Iraqi Ministry of Higher Education and Scientific Research, World Bank, official government publications.

1. Data collection tools

- Structured time series and numerical indicators, revised to ensure consistency, verifying completeness and measurement quality to enable accurate and transparent estimation of temporal and spatial models.

1. Economic model and quantitative analysis

- Apply NARDL with decomposition of key variables into positive and negative compounds to capture asymmetry.
- Initial tests: single root tests (ADF/PP), boundary testing (Bounds Test) to check for co-integration, residual and structural stability diagnostics (CUSUM/CUSUMSQ).

1. Spatial Analysis.

- Construct spatial weight matrices (marginal contact or inverse distance), and test Moran I for spatial correlation.
- Estimate Spatial Lag and Spatial Error models, examining suitability and proximity links, and deconstructing direct and indirect impacts.

Result and Discussion

A. Previous Studies:

The relationship between higher education and economic development is central to modern economic and educational literature, going beyond the role of universities as educational institutions to being engines of innovation, stations for knowledge transfer, and attractors of regional and structural growth. Global studies confirm that returns on investment in higher education are not limited to individual benefit, but extend to deep social, spatial and institutional returns. A nodal review of [5] showed that private and social returns to higher education remain high, especially in developing countries, with a growing surplus of long-term social returns, supporting the vision of education as a public enterprise rather than an individual investment. This view rises to the level of endogenous growth theory, which holds that knowledge-not traditional capital-is In that respect, the Aghion et al. (2009) contribution proves that higher education does not only impact directly on economic growth, but also through the enhancement of innovation and R&D possibilities that universities usually cultivate. We find empirical support of the fact that universities do produce spatial spillovers in that a single institution increases the local incomes by imparting skills, attracting investments, and generating indirect employment opportunities. In the first worldwide survey of university impact, Valero and Van Reenen (2019) found out that in regions with strong universities, the local revenue grows by 10-15 per cent over decades, which is due to cognitive and skill flows, the location of which is not constrained by campus facilities. Following the widespread onset of digital transformation, technological infrastructure has emerged as an inevitable supplement of these forces. The World Bank (2019) has emphasized the fact that the system of education that is effective in terms of information and communication technology (ICT) attracts significantly greater returns to productivity in comparison to the traditional ones because the Internet access opens the global resources, boosts research cooperation, and reduces the cost of learning and training. However, quantitative achievement is not high enough to trigger off growth; quality of learning is the critical factor. In depth analyses of the international data in two studies, Hanushek and Woessmann (2012, 2015) proved the point that indicators of the quality of education show a greater deviation to economic growth in comparison to enrollment and completion rates, and that qualitative human capital is the substantive difference-maker, whereas the number of certificates is the quantity difference-maker. The analysis argues in line with the institutional economics model because it argues that corruption, a weak rule of law, and poor governance, which Acemoglu and Robinson (2012) note as prominent features of developing countries, inhibit the turnover of investments in education into economic returns, despite the presence of sufficient financial and human assets. With the Iraqian situation, the sources indicate a clear divide between aspirations and the actual situation. As noted in the report prepared by the United Nations Development Programme (UNDP, 2023), Iraq is facing significant educational disparities, strong geographical differences between governorates in the country, and a serious digital barrier, which is compromising its ability to enhance inclusive and resilient development. World Bank reports (2020, 2022) record significant shortfalls in financing, poor governance, poor learning results, and extreme lack of the educational and technical infrastructure, especially in conflict-related areas. According to UNESCO reports (UNESCO, 20212024), higher-education access and IT integration policies have been increasing gradually, but the organisation nevertheless still indicates continued gender and regional disparities, and poor connections between higher learning institutions and the labour market. These data can be supported by the information published by the Ministry of Higher Education and Scientific Research in Iraq (2024), which shows that there are tangible improvements in SDG-related performance rates and, in particular, in the area of research and innovation, but at the same time, this state of Affairs is not enough to make universities true drivers of structural change. Regional studies are an essential source for understanding local dynamics, especially in the absence of disaggregated data on Iraq in some global sources. Nevertheless, the work of AlSamarraiet al. [19] (different, World Bank MENA) and the United Nations Economic and Social Commission for Western Asia (ESCWA) [20] accurate diagnoses on inequalities in education funding and resource efficiency, and digital transformation disparities among Arab countries, allowing inductive inference on the Iraqi context.

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The Organisation for Economic Co-operation and Development (OECD, Education at a Glance) also provides a benchmarking framework, although Iraq is not included in all indicators, which helps assess Iraq's performance within its broader regional context [21]. These dynamics cannot be understood without incorporating advanced spatial and economic dimensions. The unequal distribution of universities and digital infrastructure generates spatial disparities in returns, which justifies the use of spatial economy tools. LeSage and Pace [22] and Elhorst [23] are the primary references for spatial regression models (SAR, SEM, SDM), which allow for the measurement of direct and indirect (streamlined) effects of education on development. Moran's I and LM tests introduced by Anselin [24] [25] are also used to detect spatial dependency in remnants of models, which enhances the credibility of the results. Given the nature of economic and political shocks in Iraq, there is a need for non-linear models that take into account the differentiated effects of positive and negative shocks, which is provided by the NARDL model developed by Shin et al. [26], based on the bounds testing approach of Pesaran et al. [27], allows for the identification of nuances in long-term and short-term adaptation when exposure conditions change (such as increased versus decreased spending). In the context of digital transformation, Czernich et al. [28] show a strong causal relationship between broadband penetration and economic growth, while Billon et al. [29] argue that ICT serves as a complement to human capital, not a substitute for it, and produces expansive spatial impacts beyond the confines of educational institutions.. Other researches like Marginson [30] caution on the risks of marketisation of universities where profitability can cut down their function as a social facility in the best interest of the society a very real danger amid the climate of rising pressures of funding. Lastly, the policy of matching the results of education to the labour market is also one of the key weak areas. As shown by Arab Barometer and International Labour Organization (ILO, Iraq) [31] data the rate of unemployment among graduates is also large as a result of skills mismatch with the requirements of the market and the lack of the appropriate career orientation mechanisms. This indicates that the achievements of higher education are gauged not just by the number of degrees given or the enrolment of students but also by how the learner is empowered to play a significant role in the contemporary economy which fully aligns with the capability approach proposed by Sen [32] and Nussbaum [33], who emphasize on the able freedom and the capacity to take action instead of just concerning the inputs in education.

B. The first topic: Theoretical framework

R&D also plays a pivotal role, a systematic creative activity aimed at expanding the knowledge base and innovating new applications, measured by indicators such as research expenditure, number of researchers, number of patents and scientific publications [38][39]. Innovation arises through systematic interactions between universities, businesses, and government, and is the application of a new or significantly improved product, process, marketing, or organizational method [40] [41]. The Brundtland Commission has defined sustainable development as: "development that meets the needs of the present without compromising the ability of future generations to meet their own needs", and is applied in practice across the three dimensions: economic, social, and environmental [42] [1]. Green skills and green jobs, competencies that enable individuals and institutions to support the transition towards a low-carbon, resource-efficient economy, are also key pillars of sustainable environmental development [43]. Governance and institutional quality are defined as the effectiveness of formal rules and their enforcement mechanisms (e.g. transparency, rule of law, quality regulation), which constitute incentives for investment in education and innovation [44]. The TFP is a crucial measure of the indirect impact of education and research on the economy, as it reflects technological progress and efficient use of inputs [45]. Knowledge flows, which are the positive external influences that result when knowledge generated on the one hand (such as the university) increases the productivity of others through cooperation, dissemination, or mobility, also play a pivotal role in deepening spatial influences [46] [47]. Finally, employability, which is the ability of graduates to obtain and retain suitable jobs, measured by the compatibility of skills with the labor market, employment rates, and the wage gap, is a critical indicator of the success of higher education in achieving development goals [35] [48].

1. Introduction This framework aims to build an integrated analytical model that explains the mechanisms through which higher education can contribute to achieving economically, socially and environmentally sustainable development, provided that an effective institutional and governance environment is in place. 1.2 Basic concepts Higher education is defined as post-secondary education provided by universities and academic institutions, and includes three basic tasks: teaching, scientific research, and community service, and is the main source for the production of advanced human capital and applied knowledge that drives development [34] [35]. This concept is closely related to the concept of human capital, which means the knowledge, skills and health embodied in the individual, which increases his productivity and remuneration. At the macro level, its accumulation is one of the key drivers of sustainable economic growth [36] [37].
2. Framed economic theories of the relationship between higher education and sustainable development Human Capital Theory (Becker; Mincer)

This school of thought indicates that university education increases the productivity by increasing skills and knowledge, which subsequently increases salary and the attribution of an economy at large. This influence is based on the three axes of intergenerational effects, intergenerational social returns (external and fluid influences), and private returns (per capita income).

C. Self-Growth Theory (Romer; Aghion, Howitt).

According to this theory, the creation of knowledge, research, and development which are usually located in university institutions are the main cause of long-term growth. The available empirical data on university-industry ties, amount of patents, and standard of research are the key to making a macro factor more productive and driving the structural change in the economy.

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D. Capacity Approach (Sen; Nussbaum)

This framework aims at empowering people via higher education, which enhances the expanded substantive freedoms, as well as capabilities, including decision-making power, good health, and civic participation. This would support the Sustainable Development Goals (SDGs) in the context of not just economic development such as SDG4 (quality education), SDG8 (decent work), SDG9 (industry and innovation), SDG10 (reduced inequality), and SDG16 (peace, justice, and strong institutions).

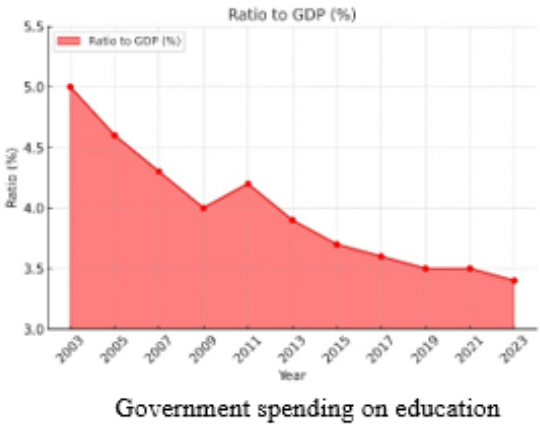
States that the effects of higher education depend on the quality of national institutions, such as good governance, their adherence to the rule of law, and the fight against corruption. The transformation of the inputs to education into actual economic outputs in a weak institution situation might fail, and thus the returns to the desired outcome could be reduced.

G. The impacts of geographic concentration

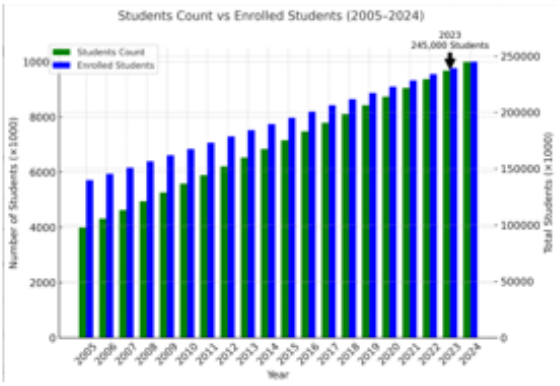
The spatial dispersion of knowledge as well as the dynamics of center-margin relations are explained by the Spatial Economics and New Theory of Economic Geography (Fujita, Krugman, Venables) resulting in spatial differences to higher education returns. Spatial regression models like SAR and SARAR, which include spatial and environmental factors are supportive of these dynamics.

Digital Transformation and Network Effects Digital infrastructure (such as the spread of the Internet) complements higher education by enabling e-learning, research collaboration, and linking the labor market to graduates. Evidence suggests that there are nonlinear interactions and critical thresholds (justifying the use of NARDL models to analyze differentiated effects between positive and negative shocks).

Labour Market Matching and Structural Transformation The output of universities must be aligned with the demands of the labour market; otherwise the mismatch may manifest itself in the form of graduate unemployment. Macro variables (such as unemployment rate and inflation) are mediators and drivers of the education-development nexus. The second topic: Quantitative and spatial analysis of data 2.1 Economic and social data In this section, we review the data and indicators used in analyzing the contributions of higher education to the achievement of the Sustainable Development Goals in Iraq during the period from 2003 to 2023. These indicators reflect the different dimensions with which higher education interacts, in economic, social and spatial terms. The data indicate a gradual decline in government spending on higher education as a percentage of GDP, falling from about 5.1% in 2003 to 3.5% in 2023, reflecting the instability of funding and the effects of economic and political crises. However, the number of higher education students has witnessed a remarkable growth, from 150,000 students in 2003 to 245,000 students in 2023, and the number of faculty members has increased from 5,000 to 9,500, which indicates a quantitative expansion in the system, despite the challenges in quality and resources and as shown in Figure 1 and Table 1



Government spending on education



Evolution of student and faculty numbers

Figure 1.

Table 1

Year	Expenditure onStudents Number education, % GDP		Number of graduatesIn Higher Education (bachelor's and master's	
2003	5.1	150000	70,000	5,000
2010	4.4	180,000	90,000	7,200
2015	4 o-o	200,000	110,000	8,500
2020	3.7	220,000	120,000	9,000
2023	3.5	245,000	125,000	9,500

Table 1.

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. Real GDP per capita has fluctuated considerably, peaking at a steady $4,100 in 2010 and then falling back to $4,180 in 2024, with a contraction recorded in 2023, reflecting the economy's reliance on oil and weak diversification. Although the average unemployment rate improved from 30% in 2003 to 17% in 2024, the youth unemployment rate remains high, reflecting mismatches between education outcomes and market needs.

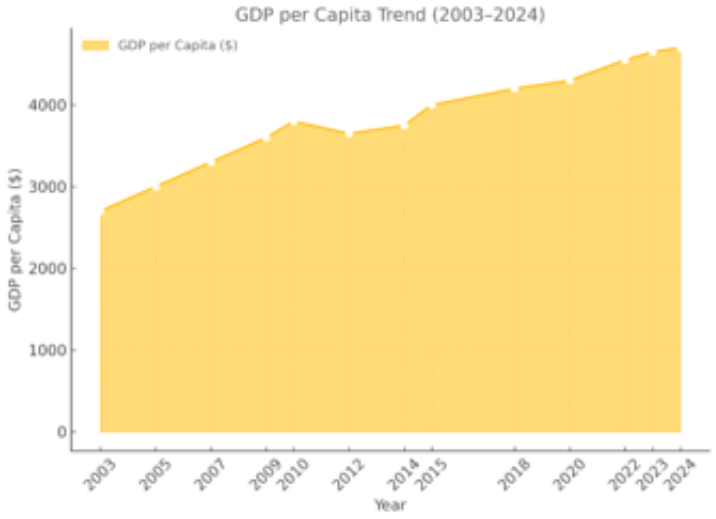

Figure 2. GDP per Capita

One of the most prominent transformations in Iraq is the significant digital transition, with Internet penetration rising from 2.5% of the population in 2003 to more than 72% in 2023, indicating infrastructure development, but still geographically uneven, and often limited in rural or conflictaffected areas.

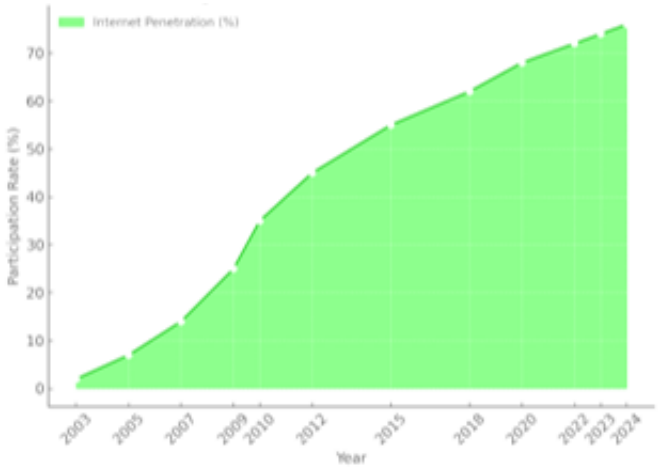

Figure 3. Internet penetration and digital transformation

Year	Internet penetration (% of population)	Governance Index (values from 0 to 100)
2003	2.5	45
2010	18.0	50
2015	40.0	53
2020	65.0	55
2023	72.3	58

Table 2. Indicators of the Digital Divide (Internet penetration) and the Quality of Governance (2003-2023)
Source: [15], [16], [49], [50].

Year	Non-oil economic growth (%)	General unemployment rate	Youth unemployment	CO2 Emission Intensity (Ton/GDP)	Energy Productivity (GDP/Toe)
2003	3.5	16.0	30.0	0.85	3200
2010	4.0	15.2	28.0	0.83	3400
2015	3.8	14.8	25.5	0.80	3550

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2020	3.1	15.0	27.0	0.78	3600
2023	9.2	16.5	29.5	0.76	3650

Table 3. Indicators of sustainable development and economic development (2003-2023)
Source: [15], [16], [31], [43], [51].

Year	Economic Growth Rate (%)	GDP per capita, USD
2003	3.5	3,200
2010	4.0	4,100
2015	3.8	4,600
2020	3.1	5,100
2023	-1.5	4,180

Table 4. **Real GDP per capita and the growth of real GDP in Iraq (2003)**
Source: [15], [16], [52].

2.2 Spatial and developmental indicators

The geographical differences between governorates are acute as indicated by the spatial and developmental indicators. Across urban governorates (Baghdad, Najaf and Karbala) are more universally accessed in universities, communications infrastructure and health and education services with rural governorates (Anbar, Salahuddin and Diyala) being affected by the conflict and suffering from acute shortages of the same on top of the development gap. There is also an evident imbalance in access to electricity, water, and roads, which check the inequality of digital education and learning opportunities in infrastructure analysis. The rate of urbanization also increased as a result of the increasing urbanization rate of 58 per cent to 70 per cent between the year 2003 and 2023, but there was no equal distribution of resources. Rather it increased pressure on the large cities and marginalized outlying regions.

As for health and the environment, the indicators indicate a gradual improvement in the intensity of carbon dioxide emissions, but they are still high compared to international standards. The percentage of recycled waste does not exceed 5%, and the number of doctors per 10,000 people is still below the required level, which reflects a weakness in basic services that affect the quality of life and environmental sustainability, as shown in Figure 4.

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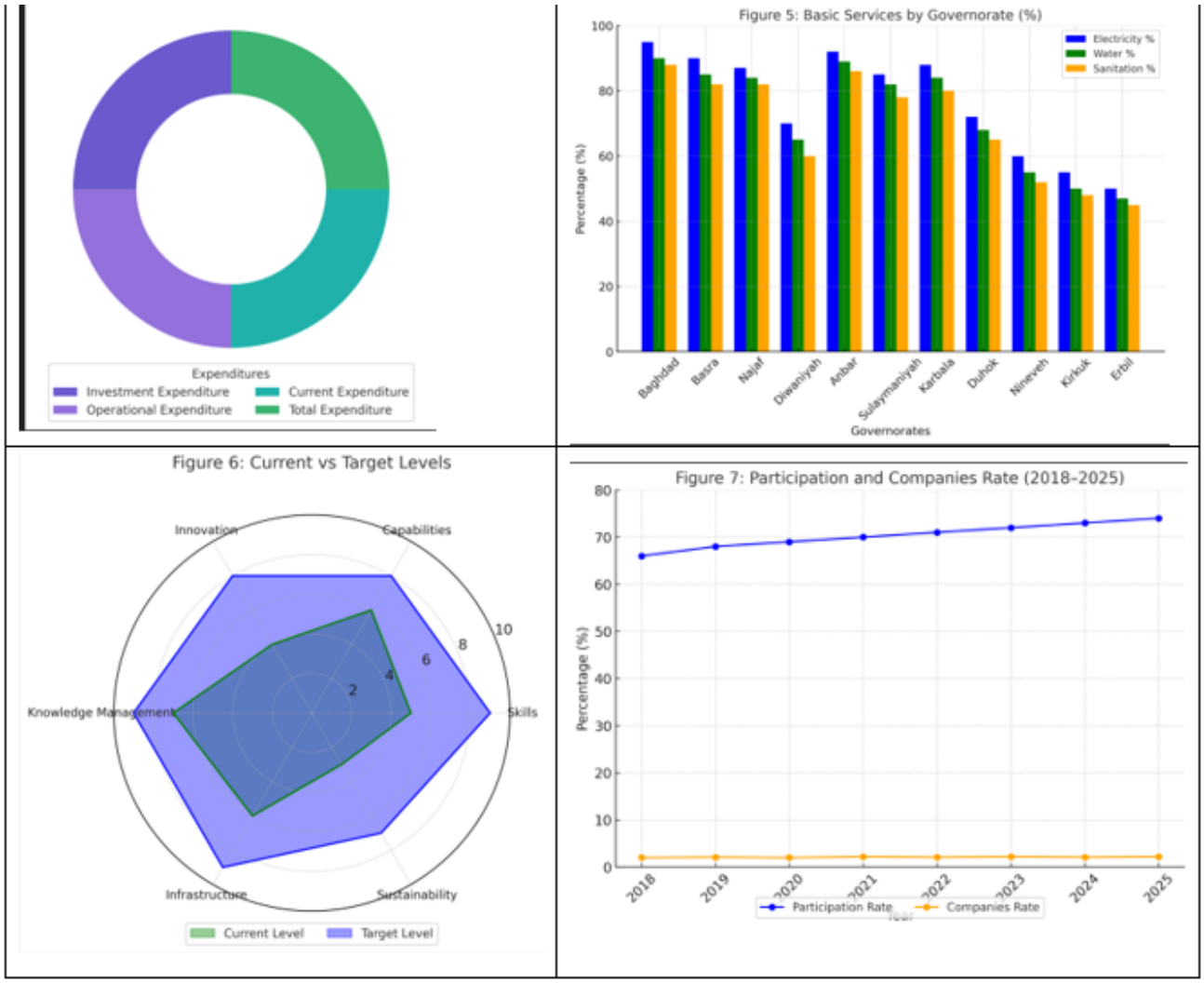

Figure 4.

This chapter aims to measure the asymmetric impacts of higher education and digital infrastructure on sustainable development indicators, taking into account the spatial and temporal dimension. The analysis is based on annual data for 18 Iraqi governorates for the period (2005-2023), and uses advanced econometric tools including the NARDL model, spatial models (SLM, SEM, SDM), and the dynamic model of the spatial panel estimated by the System GMM method.

2.2 Statistical description of the data (2005–2023)

Variable	Average	Standard Deviation	Minimum limit	Maximum Limit
SDG	58.3	12.7	32.1	81.5
HE_exp (% of output)	1,8	0.6	0.9	3.2
Archives	45.2	18.3	12.4	78.9
UNEMP	14.6	4.8	7.2	26.5
Governance	42.1	9.4	25.3	60.8
GDP_PC (USD)	5,200	1,800	2,900	8,700

Table 5.

3. Pre-estimation tests

3.1 Unit Root Tests

The ADF andPP tests were applied to all variables. The results are in.

- Significant variation in development indicators between governorates (such as: Erbil and Baghdad versus Muthanna and Nineveh).
- High unemployment rates in the southern and western governorates.

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- Expenditure on higher education was concentrated in the central governorates.
- The original variables are unstable at the 5% level.
- All variables became stable at the first distinctions (X), allowing for the use of the NARDL model.

3.2 Determining the Optimum Gap Length

Using the AIC and BIC criteria, the optimal gap length was determined as follows:

Variable	(SDG)	q (HE_exp)	r (digital_gap)		s (other variables)
Optimal Length	2	1	1	1	

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