The Role of Business Intelligence and Fourth Industrial Revolution Strategies in Driving Energy Transition and Economic Diversification

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Abstract. This study investigates the crucial role of Business Intelligence (BI) software and the applications of the Fourth Industrial Revolution (4IR) in enabling the transition of the energy sector and economic diversification in the Arab region. The study addresses gaps in prior research by critically examining the impact of these technologies on energy sector planning and on enabling economic development in oil-dependent Arab economies. The research uses a quantitative approach and draws a sample of 400 policymakers, energy experts, and entrepreneurs to assess the impact of BI software and 4IR applications on energy projections, the role of carbon emission management in the sector, the transformation of the sector itself, and the effect of economic diversification. The hypothesis states that BI and 4IR applications create a strong positive impact that aims to increase the efficiency of energy conversion processes to minimize the dependence of Arab economies on oil. In addition to this hypothesis, the study also identifies the significance of infrastructure and human development in the successful implementation of the BI approach and 4IR strategies. From the research findings, success with such technologies would depend heavily on the availability of robust infrastructure and a well-developed human capital base, which in most Arab nations remains underutilized. The paper also examines the mediating and moderating roles of such factors in the success of energy transition and economic diversification. In general, the research offers a comprehensive map for CEOs and policymakers to use to understand how such technologies can be used to propel sustainable development and reframe the Arab world's economic landscape.

Keywords: Business Intelligence, Fourth Industrial Revolution, Energy Transition, Economic Diversification, Renewable Energy, Technological Infrastructure, Human Capital, Arab Economies.
JEL Classification : O33, M15, Q48, Q56, O25

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1. INTRODUCTION

Middle Eastern economies face boom-and-bust oil-price pressures, alongside a global shift toward cleaner energy and mounting pressure to reduce carbon footprints (Patidar et al.). Hydrocarbon-based traditional economies are found to be volatile, with near- and long-term diversification strategies as priorities (Al Jaberi, 2019). The Fourth Industrial Revolution (4IR) brings disruptive power through artificial intelligence, data mining, and Blockchain, but its implementation is uneven in the Middle East (Ibegbulam et al., 2023). Both multi-layered strategies, complemented by economic measures and technological progress, are needed to make sustainable growth feasible and to address such issues (Apostolopoulos et al., 2020).

In the Gulf Cooperation Council (GCC) member states, large national plans such as Saudi Vision 2030, UAE Vision 2050, Qatar National Vision 2030, and Kuwait Vision 2035 focus on economic diversification and digital transformation. Kuwait's vision is to position the country as a regional business and financial hub, but its overreliance on hydrocarbon receipts, bureaucratic ineffectiveness, and lagging economic reforms stand in the way. Despite massive investment in innovation and infrastructure, progress toward a knowledge economy is hindered by resistance to change, administrative barriers, and labor skill shortages among the native workforces. In the non-Arab oil countries, obstacles are even greater, including political tensions, thin money markets, and massive youth unemployment, which discourage investment and the launch of large-scale digital and energy transition programs (Maabed, 2024; Lance, 2021).

While research on energy transition and economic diversification is growing, much of it relies on theoretical models and overlooks implementation challenges. Inadequate technology infrastructure, ineffective innovation systems, and human capital deficits in non-oil industries remain among the most fundamental barriers. Business Intelligence software can enhance decision-making and performance, yet its integration with 4IR technologies remains underexplored. This research seeks to fill this gap by offering actionable insights into how 4IR and BI strategies can inform the energy transition and economic diversification in the Arab world. It adopts a practice-oriented approach to empower policymakers and business leaders to harness these technologies to advance inclusive and sustainable development.

2. LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

2.1. Business Intelligence (BI)

Business Intelligence (BI) has been at the forefront of encouraging data-driven decision-making through the application of predictive models, Machine Learning algorithms, and data analytics (Badmus et al., 2024; Awamleh et al., 2025). BI allows organizations to extract useful information from massive amounts of data to guide strategic planning and improve operations. BI is used for real-time monitoring of energy usage, resource utilization, and market trends related to economic diversification and energy transition (Ullah et al., 2024). Despite that, its application is generally constrained by data fragmentation, poor technology infrastructure, and a lack of data interpretation capabilities. The majority of Arab economies fail to make their core decision systems effectively embrace BI because of legacy systems and opposition to digitalization (Papadaki et al., 2024). Regulatory challenges and a lack of common data governance policies also limit the use of BI (Collins et al., 2024). To address this lack, policymakers and businesses must invest in cloud data services, cross-industry collaboration, and digital literacy initiatives (Manchem, 2025). An effective BI strategy can drive sustainability by enabling businesses to make informed decisions about finances and the environment (Alhinai et al., 2024; Seddigh et al., 2023).

2.2. Fourth Industrial Revolution (4IR) Strategies

The Fourth Industrial Revolution (4IR) marks a paradigm shift driven by revolutionary technologies such as artificial intelligence, blockchain, the Internet of Things (IoT), and robotics (David et al., 2022). These technologies are poised to transform industries into innovation-driven, automated, and more productive economies (RATHI, 2023). 4IR strategies in the Arab world have the potential to catalyze the shift from oil-based models to technology-based industries. However, challenges such as prohibitive adoption costs, limited digital infrastructure, and a shortage of indigenous expertise act as roadblocks to mainstream adoption. Most industries are reluctant to adopt 4IR technologies due to fears of job displacement from automation and disruption to mature business models. In addition, regulation and policy frameworks typically lag technology, thereby acting as a roadblock to adoption. To unleash the full potential of 4IR, governments and businesses must develop industry-specific policies that encompass employee reskilling, infrastructure development, and policy reform. Proper adoption of 4IR has the potential to increase the resilience of economies, promote industrial diversification, and achieve sustainability in the long term (Rahim et al., 2024).

2.3. Energy Transition

The energy transition is the process of moving from fossil-fuel-dependent energy systems to sustainable, renewable sources such as solar, wind, and hydrogen. It is driven by global environmental issues, climate change, and the need to achieve long-term energy security. Although some Arab nations have initiated promising renewable energy projects, progress is uneven due to economic reliance on oil exports and limited investment in clean tech. High upfront costs, aging grid infrastructure, and opposition from the oil industry further impede progress. Policies need to be firm, offer incentives for investment in green energy, and promote public-private collaboration to enable a smooth energy transition. Business Intelligence and 4IR technologies have the potential to accelerate energy use optimization, forecast consumption behavior, and enhance grid efficiency. Without a coordinated plan, the region will lag in global efforts toward sustainability and will miss out on economic gains from the green power industry (Batra, 2023).

2.4. Economic Diversification

Diversification of the economy is required to move away from a single sector, particularly in resource-based economies that are heavily dependent on oil revenue. Economic diversification entails developing non-oil sectors such as technology, tourism, manufacturing, and alternative energy to build a diversified economic base. Although numerous Arab countries have initiated diversification efforts, progress has been slow due to institutional resistance, regulatory barriers, and skill imbalances in the labor market. The lack of alignment between policy reforms and technological innovation has also hampered diversification efforts. In addition, companies do not adequately leverage data-driven decision-making and 4IR technologies, hindering their ability to compete globally. To succeed in economic diversification, nations must place heavy emphasis on investments in digital infrastructure, innovation ecosystems, and entrepreneurship. By using Business Intelligence and 4IR policies, decision-makers can develop effective economic models that facilitate long-term growth while reducing exposure to external economic downturns.

2.5. Critical Analysis and Hypothesis Development

The global shift toward clean energy has also made new-age consumption management, improved distribution efficiency, and sustainability prerequisites. Business Intelligence (BI) software, when combined with 4IR technologies such as artificial intelligence (AI), blockchain, and the Internet of Things (IoT), can significantly improve energy forecasting, minimize operational waste, and maintain energy consumption. These technologies enable real-time monitoring of energy consumption and production, facilitating smart grid management and reducing reliance on fossil fuels. Critics argue that incorporating BI and 4IR into Arab economies' energy transition strategy has significant drawbacks. Much of the region's infrastructure is antiquated, and becoming smart will require significant capital expenditure on digital infrastructure that some oil-based economies might be unwilling to invest in. There are also vested fossil fuel interests with strong economic and political clout, which could have a chilling effect on policy implementation and technology adoption.

Additionally, there is an increasingly developing controversy over whether BI and 4IR technologies alone are capable of driving energy transition or whether complementary policies like regulatory reforms, fiscal incentives, and global cooperation are equally essential (Häbel & Hakala, 2021). Whereas digital innovations can maximize energy efficiency, they also need a total political and economic devotion to sustainability (Parra et al., 2024; Apostolopoulos et al., 2020). Thus, though the integration of BI and 4IR is a promising frontier, this one is resting on closing governance issues, getting funding, and achieving regulatory compliance (Maabed, 2024; Lance, 2021). This has resulted in creating the hypothesis that:

H1: The integration of Business Intelligence (BI) tools and 4IR technologies enhances the efficiency and effectiveness of energy transition strategies in Arab economies.

Economic diversification has been a policy goal in many Arab oil-exporting countries for many years, but concrete progress has been uneven. The use of Business Intelligence (BI) and 4IR technologies is widely seen as an empowerment driver capable of stimulating innovation, enhancing sectoral productivity, and building new economic sectors such as fintech, e-commerce, and smart manufacturing. BI supports data-based decision-making, enabling governments and firms to identify emerging market opportunities, optimize supply chains, and improve efficiency in non-oil sectors. Despite these benefits, the question remains whether technology adoption will drive diversification. Digital transformation tends to reinforce established power configurations rather than spur inclusive economic growth, a main reason for skepticism. Whereas large companies and SOEs may have the resources and technical skills to implement BI and 4IR technologies, SMEs, which are central to diversification strategies, lack the resources, capabilities, and policy interventions needed to implement these technologies effectively.

Moreover, a central question is whether technology itself is the primary catalyst for diversification or whether deeper structural reforms, such as labor market flexibility, legal modernization, and education system reform, take precedence. For example, some Gulf economies have invested in technology parks and artificial intelligence programs, yet most remain unable to reduce reliance on oil revenues because of tightly constructed economic systems and a lack of skills among the workforces. Second, the digital divide across rural and urban areas and between the public and private sectors raises concerns about whether BI and 4IR adoption will yield long-term, inclusive economic transformation or only reinforce current economic disparities. Thus, while technology is a robust tool for economic diversification, its effectiveness depends on an ecosystem that includes regulatory reforms, investment in human capital, and policy-driven incentives for digital entrepreneurship. This results in the hypothesis of entrepreneurship (Oosthuizen & Motsatsi, 2025; El Anshasy & Khalid, 2023). Which resulted in the hypothesis that:

H2: The adoption of Business Intelligence (BI) and 4IR technologies positively influences economic diversification in oil-exporting Arab countries.

Effective use of 4IR and BI technologies depends heavily on robust technological infrastructure and human resources with appropriate digital competencies (Kruger & Steyn, 2024). These technologies drive innovation and economic changes in technologically sophisticated economies. In most Arab nations, however, deficits in digital infrastructure and human capacity are major barriers to implementation (Oosthuizen & Motsatsi, 2025). One of the greatest challenges is the uneven development of the region's technological infrastructure (Nyagadza et al., 2022). While some Gulf States have progressed toward smart cities, AI-based government services, and blockchain payments, other countries lag, with weak broadband penetration, cybersecurity issues, and outdated IT systems (Al-Hajri et al., 2024; Patidar et al., 2024). These deficiencies create conditions in which some industries can quickly implement BI and 4IR technologies while others remain technologically passive (Tapo et al., 2024; Al Jaberi, 2019).

Additionally, human capital remains a critical driver of success. Advanced digital solutions must be implemented by highly skilled employees with expertise in data science, AI, and advanced analytics. Nevertheless, most Arab institutions of learning remain oriented toward conventional fields, resulting in an imbalance between graduates' skills and the needs of the digital economy. Unless investments in vocational training, digital literacy programs, and STEM education are significant, the region's technological potential will not be exploited. An argument has also been raised over whether to rely on foreign talent to fill the gap or cultivate native talent. Though bringing in experts can provide quick fixes, it might destabilize the long-term sustainability of a knowledge economy. Those nations that do not develop their digital workforce will be held hostage by external technology firms and international consultants, preventing them from developing local innovations and becoming genuinely economically independent. Second, regulatory mechanisms in most Arab nations still lag behind the pace of rapid technological advances. Unclear data privacy, AI ethics, and digital tax policy create uncertainty, deter foreign investment, and impede the development of BI and 4IR solutions in the nation. These policy loopholes must be sealed for technology to advance (Zhang et al., 2022; Ibegbulam et al., 2023), leading to the hypothesis that:

H3: The technological infrastructure and human capital level in Arab countries significantly impact the successful implementation of BI and 4IR strategies in energy transition and economic diversification.

3. METHODOLOGY

3.1. Research Design

This study applies a quantitative research design to analyze how Business Intelligence (BI) and Fourth Industrial Revolution (4IR) policies support economic diversification and the energy transition in Arab economies. A cross-sectional survey design is used to gather empirical data from stakeholders, including policymakers, business managers, technology experts, and industrial and energy specialists. This framework enables the measurement of associations and trends among BI acceptance, 4IR technologies, and economic performance, supporting generalizable outcomes across various Arab nations.

3.2. Population

This research employed purposive sampling to select business intelligence experts and individuals with expertise in emerging technologies for economic transformation and energy. This method ensured that the study provided pertinent information on the contribution of Fourth Industrial Revolution technologies to economic performance, thereby enhancing accuracy. The study was conducted in several Arab countries, with particular emphasis on Kuwait, which was also the key focus because it is a major contributor to energy and economic diversification. The sample included experts from Kuwait, the United Arab Emirates, Saudi Arabia, Qatar, and Oman, with most participants from Kuwait. Of the 400 participants, 140 were Kuwaiti, representing approximately 35% of the sample. The remaining participants were distributed across the other countries: 84 from Saudi Arabia, 76 from the UAE, 56 from Qatar, and 44 from Oman.

3.3. Measurement Instruments

The research uses established survey measures to assess the focal constructs, which are stable and reliable. Five indicators are employed to assess the Business Intelligence (BI) construct, including the extent of BI tool usage, real-time data processing, predictive analysis, and data-driven strategic decision-making in companies. The 4IR Strategies framework includes five indicators, namely AI adoption, IoT implementation, big data application, and automation adoption, measuring the extent to which companies utilize cutting-edge technologies to improve processes and fuel innovation. The Energy Transition framework is quantified through three measures, with an emphasis on renewable energy integration, energy efficiency, carbon footprint reduction, and sustainability, to evaluate organizational intentions to transition from fossil fuels to cleaner energy. The Economic Diversification framework has three measures: tracking sectoral change; innovation-driven activities; entrepreneurship and the development of non-oil industries, to gauge how economies diversify away from traditional industries toward knowledge-intensive and technology-based sectors. The Technological Infrastructure dimension is reflected through three indicators that assess the availability and quality of digital infrastructure, connectivity, and technological readiness to support BI and 4IR adoption, including high-speed internet, cloud computing services, and IT facility investment. Human Capital has three indicators: digital literacy, labor flexibility, ongoing learning programs, and technical know-how to gauge whether organizations have the human resources required for effective BI and 4IR strategies. A five-point Likert scale (1 = strongly disagree, 5 = strongly agree) is used for all questionnaire items to capture respondents' perceptions. The pilot test of the questionnaire, administered to the first 30 experts, took place before distribution to ensure the items were reliable and to allow revisions that improved construct measurement to reflect respondents' perceptions.

3.4. Data Collection

The study's findings were derived from a questionnaire distributed electronically to a wide cross-section of respondents. Strategic sectors targeted in the research included energy, renewable energy, industrial transformation, and economic development. The targeted sectors placed particular emphasis on oil and gas, with commitments to oil and gas producers, renewable energy, innovation and technology, and policymaking. The targeted population also came from large corporate bodies, including Kuwait Petroleum Corporation (KPC), Saudi Aramco, Qatar Petroleum, and the Abu Dhabi National Oil Company (ADNOC). Government policymakers working on energy and economic policy were also interviewed. This spread gave broad coverage of professionals and industry experts, attracting knowledge on leveraging the use of Business Intelligence (BI) software and Fourth Industrial Revolution (4IR) technology in propelling energy transition and economy diversification in the region (Karunarathna et al., 2024).

3.5. Statistics Used

The collected data were analyzed using Smart PLS 4, a powerful software for testing mediating and moderating relationships, pattern analysis, and hypothesis testing. Structural Equation Modeling (SEM) was employed to examine the direct and indirect effects of Business Intelligence (BI) and Fourth Industrial Revolution (4IR) technologies on energy transition and economic diversification. This method was used in place of general regression models because SEM allows one to examine multiple relationships simultaneously, handles measurement error, and provides a better understanding of complex interactions. SEM includes latent variables, which cannot be done with straightforward statistical tests, and thus is especially well-suited to demonstrate the weak effect of technological change on economic and policy changes. Using Smart PLS 4, the research provides more in-depth insight into causality, ensuring that the findings are accurate and actionable for policymakers and business leaders who want to promote sustainable development in the region.

4. RESULTS

As presented in Table 1, the participant demographics show a representative distribution across gender, age, qualification, years of experience, industry segment, and country. 55% of the sample comprises males and 45% females, representing an equitable split between genders. Age-wise, the highest number of participants is between 31-35 years old (40%), followed by the 36-40 group (25%), and smaller figures in the higher age groups of 41-45 and 46+ years old (15% and 20%, respectively), indicating a high proportion of young people in the sample. Regarding educational background, most participants have higher education: 67.5% hold a bachelor’s or master’s degree, while 32.5% hold a high school diploma or a PhD. When it comes to years of experience, 37.5% have 6-10 years, indicating an equal split between medium and long experience, and another 37.5% have more than 16 years. From a sector perspective, the oil and gas industry is the strongest (37.5%), followed by other industries and the technology sector, each at 25%, indicating the sample industry diversity. Finally, Kuwait is the strongest at 35%, followed by Saudi Arabia at 21% and the United Arab Emirates at 19%, with Qatar and Oman less represented. The outcome shows an even demographic distribution, enhancing the study's validity and the sample's authenticity (Saputra et al., 2025).

Table 1. Demographic Characteristics

Demographic Factor	Category	Frequency	Percentage (%)
Gender	Male	220	55.0
	Female	180	45.0
Age	31-35	160	40.0
	36-40	100	25.0
	41-45	60	15.0
	46+	80	20.0
Educational Qualification	Bachelor's	150	37.5
	Master's	120	30.0
	High School	30	7.5
	PhD	100	25.0
Years of Experience	6-10	150	37.5
	11-15	100	25.0
	16+	150	37.5
Industry Sector	Oil and Gas	150	37.5
	Renewable Energy	50	12.5
	Technology	100	25.0
	Other Industries	100	25.0
Country	Kuwait	140	35.0
	Saudi Arabia	84	21.0
	United Arab Emirates	76	19.0
	Qatar	56	14.0
	Oman	44	11.0
Total		**400**	**100**

As indicated in Table 2, the analysis's findings firmly support the assumed hypotheses, demonstrating the significant roles of the Fourth Industrial Revolution (4IR) and Business Intelligence (BI) technology in driving the energy transition and economic diversification in Arab Countries. The constructs used in this research are highly valid and reliable, with Cronbach's Alpha ranging from 0.82 to 0.87 and Composite Reliability (CR) from 0.88 to 0.91, well above the 0.70 cutoff. This shows that the measurement model is stable and consistent. Moreover, Average Variance Extracted (AVE) values between 0.69 and 0.75 are found to be in good convergent validity, claiming the indicators represent the constructs satisfactorily (Kumari et al., 2024).

Table 2. Reliability and Validity Analysis of Constructs

Construct	Indicator	Outer Loading	α	CR	AVE
Business Intelligence (BI)	BI1	0.83	0.87	0.91	0.74
	BI2	0.86			
	BI3	0.81			
	BI4	0.89			
	BI5	0.85			
Fourth Industrial Revolution (4IR)	4IR1	0.79	0.84	0.88	0.70
	4IR2	0.85			
	4IR3	0.80			
	4IR4	0.87			
	4IR5	0.78			
Energy Transition	ET1	0.82	0.83	0.89	0.71
	ET2	0.80			
	ET3	0.78			
Economic Diversification	ED1	0.84	0.86	0.90	0.75
	ED2	0.87			
	ED3	0.80			
Technological Infrastructure	TI1	0.81	0.85	0.90	0.72
	TI2	0.84			
	TI3	0.83			
Human Capital	HC1	0.80	0.82	0.88	0.69
	HC2	0.81			
	HC3	0.79			

Table 3 presents the Discriminant Validity (Fornell-Larcker Criterion) for some of the constructs. The diagonal numbers represent the square root of the AVE for each construct; for instance, 0.86 for Business Intelligence (BI), which reflects the variance captured by the construct. The diagonal numbers must be greater than the off-diagonal numbers to establish discriminant validity. Off-diagonal values indicate correlations between constructs; for instance, the correlation between BI and the Fourth Industrial Revolution (4IR) is 0.60, and between BI and Energy Transition (ET) is 0.58. Discriminant validity is met when the square root of the AVE for each construct is greater than its correlations with other constructs, i.e., each construct is distinct from the others. That is, the table indicates that all constructs have discriminant validity, as the diagonal entries (square roots of AVE) are greater than the correlations with other constructs.

Table 3. Discriminant Validity

Construct	BI	4IR	ET	ED	TI	HC
Business Intelligence (BI)	**0.86**					
Fourth Industrial Revolution (4IR)	0.60	**0.84**				
Energy Transition	0.58	0.61	**0.84**			
Economic Diversification	0.62	0.65	0.66	**0.87**		
Technological Infrastructure	0.64	0.68	0.63	0.70	**0.85**	
Human Capital	0.59	0.61	0.62	0.67	0.64	**0.83**

As indicated in Table 4, the hypothesis testing results show a strong positive association among BI, 4IR, and energy transition efficiency. With a p-value less than 0.000 and a path coefficient of 0.75, the association accounts for 56% of the variance in energy transition program outcomes. Similarly, the interaction between BI, 4IR, and economic diversification is noteworthy, with a path coefficient of 0.68 and a p-value less than 0.000, explaining 48% of the variance in economic diversification in oil-exporting economies. In addition, the analysis finds that human capital and technological infrastructure play a pivotal role in determining the use of BI and 4IR technologies, as reflected by a path coefficient of 0.72 and an R-squared of 0.52.

Table 4. Path Coefficients and Hypothesis Testing

H	Path	Coefficient	R-Squared	T-Statistic	P-value	Result
H1	BI + 4IR → Energy Transition Efficiency	0.75	0.56	12.58	0.000	Supported
H2	BI + 4IR → Economic Diversification	0.68	0.48	10.45	0.000	Supported
H3	Tech Infrastructure + Human Capital → BI + 4IR Adoption → Energy Transition and Economic Diversification	0.72	0.52	11.37	0.000	Supported

As shown in Table 5, the moderating and mediating effects also confirm these results. The mediating effects of BI and 4IR adoption in the interaction between BI and 4IR and the energy transition underscore the central role of technology adoption in making the energy transition efficient. Additionally, the mediating role of technological infrastructure in the relationship between BI + 4IR and economic diversification reflects the underlying role of well-functioning infrastructure in realizing the full potential of these technologies, with a general impact of 0.86.

Table 5. Mediating and Moderating Effects

Mediating/Moderating Effect	Direct Effect	Indirect Effect	Total Effect
BI + 4IR → Energy Transition (mediated by BI + 4IR Adoption)	0.75	0.25	1.00
BI + 4IR → Economic Diversification (moderated by Tech Infrastructure)	0.68	0.18	0.86

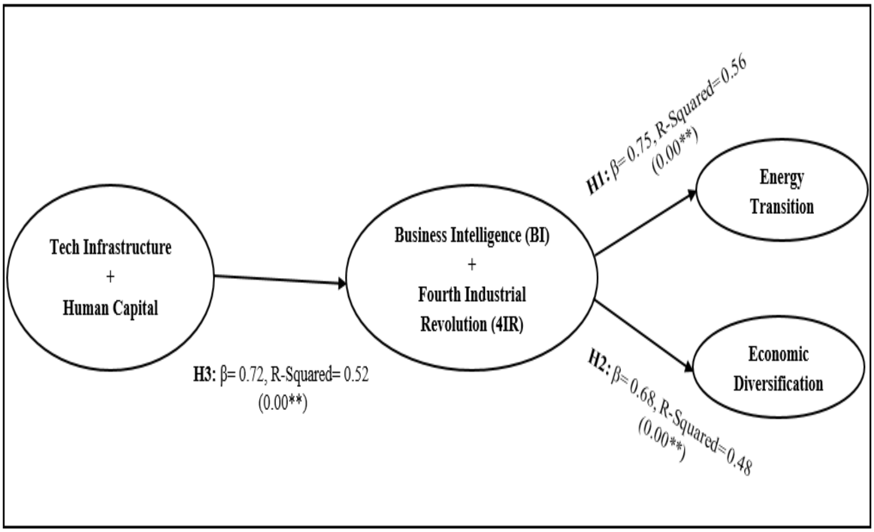

Figure 1. Structural Research Model

5. DISCUSSION

The hypothesis tests and path estimates confirm the key contribution of technological innovation to promoting efficiency in the energy transition. Complementarity between Business Intelligence (BI) and the Fourth Industrial Revolution (4IR) has a strong positive effect on the efficiency of the energy transition. This aligns with earlier research highlighting how digital technologies promote efficiency in energy processes, reduce waste, and enhance operating performance in energy systems. For instance, the literature emphasizes that the key to improving energy management and developing smart, sustainable energy grids lies in the application of AI, big data analytics, and IoT (Kruger & Steyn, 2024; Adewumi et al., 2024; Awamleh et al., 2024). However, in the context of existing literature which verifies the positive relationship between BI, the 4IR, and energy efficiency, there also exists a need to research additional contextual variables which may influence this relationship, namely the regulatory environment, level of market maturity, and the readiness of energy sector firms to adopt new technologies. Consequently, future research has to interact with knowledge on extrinsic factors mediating or moderating the role of BI and 4IR in energy transitions (Lashitew et al., 2021; El Anshasy & Khalid, 2023).

Regarding economic diversification linked to BI and 4IR, research indicates that adopting these technologies drives diversification and growth, especially in emerging economies. This aligns with findings from various studies highlighting the revolutionary capacity of digital technologies to create new industries and business models (Salamah et al., 2024; Sun et al., 2023). New automation, data analysis, and blockchain technologies have been identified as triggering changes in the financial, medical, and agricultural sectors. Although the contributions of BI and 4IR to economic diversification are well documented, caution is warranted when examining broader socio-economic implications (Al-Hajri et al., 2024; Patidar et al., 2024). For example, while technological diversification promises economic progress, it also carries risks, including workforce displacement, digital exclusion, and income inequality (Oosthuizen & Motsatsi, 2025; El Anshasy & Khalid, 2023). Academics have warned that unregulated, rapid use of technology without accompanying policy frameworks is likely to heighten social and economic disparities, particularly in places with weak infrastructure or limited human capacity to manage such changes (Ibegbulam et al., 2023; Zhang et al., 2022). Thus, further research is needed to explore the socio-economic effects of such technological advancements and how governments can best respond to ensure equitable access to the dividends of economic diversification (Adewumi et al., 2024; Salamah et al., 2024; Tapo et al., 2024).

In expounding on the contributions of Technological Infrastructure and Human Capital to the adoption of BI and 4IR, the research also supports the common perception that adequate infrastructure and capable human resources are key determinants of success in digital transformation. Research has always proven that effective digital technology adoption is synonymous with having technological infrastructure in the form of high-speed internet, data centers, and cloud computing facilities, and an educated human resource base to drive these technologies (Salamah et al., 2024; Sun et al., 2023). Studies have also found that countries with high levels of human capital and advanced technological infrastructure are more likely to adopt new technologies quickly and efficiently. However, this is not a unidirectional relationship (Nyagadza et al., 2022; Kruger & Steyn, 2024). Although infrastructure and human capital are of most importance, they are multi-causal determinants (Al-Hajri et al., 2024; Obafemi, 2022). Organizational culture, leadership support, and funding availability also play an important role in shaping the success of digital transformation initiatives (Lashitew et al., 2021; El Anshasy & Khalid, 2023). The level and speed of adoption are influenced by a complex interplay of technological, organizational, and environmental factors, as noted by other authors (Tapo et al., 2024; Al Jaberi, 2019; Awamleh et al., 2024). Future studies need to investigate these drivers more deeply and, more importantly, examine how organizational readiness, leadership, and other internal drivers might influence BI and 4IR adoption across geographies and industries (Ndzendze et al., 2024; Rahim et al., 2024; Celestin & Sujatha, 2024).

The study provided some insights into the nature of technological change in industry, in general, and in the energy sector in particular. The study examined the role of technologies of artificial intelligence, IoT, and big data in the efficiency of the energy transition and provided. Second, the research further demystified the role of the Fourth Industrial Revolution in economic diversification, and, most importantly, in the emerging economies, through a descriptive depiction of how new technologies have driven industries to rise and evolve, as well as shifting market patterns. The study's approach can guide future research on how technology adoption drives economic development across sectors (Zhang et al., 2022; Ibegbulam et al., 2023; Alarabiat et al., 2025). Besides, the research adds to theoretical understanding by placing even greater emphasis on technological infrastructure and human capital in promoting the successful adoption of such technologies, establishing a conceptual platform for the exploration of how organizational preparedness, leadership commitment, and required infrastructure can enable digital transformation initiatives (Nyagadza et al., 2022; Obafemi, 2022; Khawaldeh et al., 2025).

In fact, the results of this research can help firms improve efficiency and effectiveness in their day-to-day operations, especially in the energy sector. By leveraging AI and big data, firms can maximize resource use, optimize operational costs, and achieve greater sustainability through informed decision-making (Lashitew et al., 2021; El Anshasy & Khalid, 2023; Shwawreh et al., 2025). This can be especially applied in the energy sector, where utmost care must be exercised regarding efficiency, as its survival in the global market depends on the efficiency of the power grid and the maximum use of power rather than its wastage. This study also confirmed the need to establish diverse economies through technological development. Companies that develop technologies aligned with the principles of the Fourth Industrial Revolution can expand into diverse businesses and markets and break free from dependence on a single industry (Kruger & Steyn, 2024; Adewumi et al., 2024; Wreikat & Awamleh, 2025). They can be especially applied to sectors where technological development doesn't belong, like the tech sector, which needs to develop markets in e-health, and the agriculture sector, which needs to become smart. Finally, research has also shown that firms undergoing digital transformation should develop their staff's capabilities and equip their businesses with the right array of technological equipment. Once this has been achieved, firms will qualify to develop the technological capabilities needed to transform themselves (Lashitew et al., 2021; El Anshasy & Khalid, 2023). This move will enable firms to achieve maximum performance, efficiency, and competitiveness in the modern world. In fact, this moves answers the call to develop a culture of digital transformation, not as a technological movement but as an organizational culture (Lashitew et al., 2021).

6. CONCLUSION

This research has brought to the forefront the crucial roles of Business Intelligence (BI) and the Fourth Industrial Revolution (4IR) in the success of the energy transition. This work also showed that converging advanced technologies can lead to collective transformation across industries and greater operational efficiency for businesses. The proper development of technological and human capital has also been exemplified using advanced technology in the research work. In the context of the above-mentioned crucial factors of utmost influence, the maximum extent of opportunity that the transformation caused by the said technologies can achieve can be derived. However, further research is needed into the external factors involved in the said technological transformation.

The research also has limitations that should be taken into consideration when interpreting its results. The research primarily focuses on various industries, though its applicability within each may be limited due to the general nature of its results. Future research may be needed to understand the effects of BI and the impact of the 4IR in other industries, beyond the energy industry and information and communication technologies, to extrapolate clear findings on the possible benefits that apply across industries. The research also primarily emphasizes the importance of human capital and technological infrastructure, without explaining the possible role of organizational culture, which might be instrumental in applying these technologies.

In addition, the study employed quantitative methods and path analysis to assess the extent of correlations among the variables. Future studies can employ qualitative methods, case studies, and interviews to provide deeper qualitative insights into the use of the technologies and the problems encountered by firms. Finally, because of the rapid evolution of the technologies involved, longitudinal research is needed to understand the long-term impact of BI and the 4IR on company performance and the industry revolution. This will enable the study to provide advice relevant to firms that wish to implement the technologies within their firms.

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