



Impact of Islamic Banking on Energy Economics of Yemen: A Moderating Role of Government Policies and Regulations for Digitalization

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Abstract

The goal of this study was to investigate how Islamic banking has affected energy economy in Yemen, with a focus on the moderating function of governmental policies and regulations for digitalization. For this study, managers who work in the Islamic banking industry were the respondents, and a quantitative research methodology was used. The results of this study showed that the adoption of Islamic banking positively affects the affordability and sustainability of energy within Yemen's Islamic banking industry. Additionally, it has been discovered that economic growth, investment in renewable energy, and energy use all significantly influence the affordability and sustainability of energy. The findings further suggest the moderating function of governmental policies and regulations for digitalization in the interaction between Islamic banking and energy economics. These revelations add to the body of knowledge and have important ramifications for managers, legislators, and other stakeholders in the Islamic banking industry who are working on digitalization to promote energy sustainability in especially Yemen.

Introduction

Recently, international energy crises, unstable fossil fuel prices, and accountability in the natural environment have triggered an imperative to re-evaluate energy economies in developing countries (Belaïd, Al-Sarihi, & Al-Mestneer, 2023) including Yemen. The affordability of energy and its sustainability are now top priorities, and ease of access to affordable energy is indispensable for economic stability and social well-being. With an energy deficit and increasing energy prices, developing solutions that ensure economic expansion while safeguarding the environment (Aboagye, 2017) is incredibly important for Yemen. In this context, Islamic banking, which is based on the idea of ethical and socially responsible financing, could provide a promising avenue for transforming the energy sector (Muhmad, Muhamad, & Sulong, 2021) in Yemen. This study aims to shed light on how Islamic banking has the potential to bring energy affordability and sustainability in the country and how it can solve Yemen chain of energy problems.

The Islamic banking sector is based on principles that ban interest and encourage profit sharing, risk sharing and investing in projects that are not deemed ethically sound (Ben Jedidia, 2020). Due to these unique characteristics, they have more focused attention as the incremental growth mechanism for sustainable development, consistent with green financing. This sector has the potential to fund financially sustainable and environmentally friendly energy projects (Kunhibava, Ling, & Ruslan, 2018) in Yemen, a country where Islamic banking is

growing rapidly. Islamic banks are uniquely suited for investment in renewable energy, energy efficiency, and sustainable infrastructure under a common vision of ethical investments (Morea & Poggi, 2016). Through analyzing the role of Islamic banking in the energy sector of Yemen, this paper attempt to show how this alternative financing model can help both energy affordability and environmental sustainability. In this context, this research analyzes four variables (energy penetration, energy use, renewable energy investment and economic growth) the role of each of those variables' impact in energy price and energy sustainability markers. Access to energy services and the dissemination of those services, which we call energy penetration, is another important aspect of access to energy that could help alleviate concerns about affordability and availability in underserved regions (Sener & Fthenakis, 2014). They also analyze the consumption trends with energy and the transition related to renewable energy investments as one part of their effects in minimizing costs and pollution. Economic growth is the main driver of development, but growth also causes increased desire for energy since expanded systems of energy-extraction lead to expanded systems of activity, society must find balance between expansion and sustainability (Ma et al., 2023). This study senses the role of Islamic banking, as influenced by government policies for digitalization, along with the contextual resources mature for Yemen energy transition towards affording and sustainable energy economy based on these factors.

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The introduction of this study is timely and significant, as it responds to high interests in Islamic banking as an alternative mechanism for sustainable development, related to the challenges faced by the energy sector. The study provides a managerial view of Islamic banks' strategy and prioritization of energy financing by focusing on managers in the Islamic banking sector. By doing so, it contributes to the literature on Islamic banking as a means of enhancing energy accessibility and sustainability in developing countries. This study will therefore contribute to the financial-energy-policy interface by providing a detailed perspective on how Islamic banking and government regulation can work together to enhance Yemen energy economy.

Review of Literature

Islamic banking penetration could have important implications for energy affordability and sustainability (Banna & Alam, 2020). Islamic banks implement distinctive principles which are in line with ethical and socially responsible financing, resulting in preferential endorsement of projects involving social and environmental development. Islamic banks can help accelerate energy transition by providing capital for clean energy projects and by putting a wedge between investments that pollute our planet (Rahman et al., 2024). Moreover, the risk sharing nature of Islamic financing lowers the cost of borrowing and provides a huge opportunity for small to medium energy projects, which are critical for improving energy access in unserved areas (Bacha, Mirakhor, & Askari, 2015). Thus, improves the affordability of energy since such financing mechanisms mean less reliance on pricier, fossil-fuel-based, energy sources. Moreover, the ethical principles of the Islamic banking system promote investments in renewable energy sources which leads to sustainability. These banks would also promote resource optimism, matching complementary objectives for sustainable energy (Kalkavan & Eti, 2021). The penetration of Islamic banking, therefore, not only furthers economic growth by providing mechanisms for access to affordable energy, but also provides sustainability over time by helping incentivize cleaner energy solutions (Kasri et al., 2024).

Hypothesis 1: *Islamic banking penetration has impact on energy affordability & sustainability.*

Typically, when energy is spiking, energy prices are high because demand is greater than supply, so it becomes less affordable for consumers (Islam et al., 2023). Continuing reliance on fossil fuels also contributes to environmental degradation that trivializes the potential for sustainability. In this sense, when demand for energy meets sustainable supply, it can create a two-sided win for cost and sustainability outcomes (Tahiri Jouti, 2019). This requires us to use energy more efficiently and burden fossils less to balance the ecosystem. Energy use, when framed correctly, can actually be the cheapest, lowest-emission energy system that prioritizes

renewables deployment via policy or technology (Abdmouleh, Alammari, & Gastli, 2015). In addition, sustainable consumption practices, e.g., by using energy-efficient appliances or by using the brain, etc., decrease the total demand for energy services, which finally will lead to a lower energy resource price on the market (Malik et al., 2019). The carbon emission and resource use savings are massive from responsible consumption, which is why policy engagements that promote responsible consumption have significant environmental benefits as well (Irfany, Syam, & Haq, 2024). Therefore, following an energy efficiency based approach put the control power on energy costs and make sure to get access to energy avoidably cheap and keep on making environmental sustainability a reality.

Hypothesis 2: *Energy consumption has an impact on energy affordability & sustainability.*

Renewable energy sources, including solar, wind, and hydroelectric power, have experienced rapid development that has driven prices down, rendering the cleanest forms of energy highly competitive with conventional fossil fuels (Nasution & Shikur, 2023). This leads not only to more affordable energy due to the reduction in their price over the years, but also to lower price volatility, which is critical for many economies taking huge financing projects in advance. Investing in renewable energy systems is related to sustainability by reducing carbon emissions and other damages from extracting and using fossil fuels (Adams & Nsiah, 2019). Such investments also enhance energy security through diversification of the supply and reducing the dependence and risk from imported fossil fuel. Not to mention that renewable energy projects tend to employ locals and create jobs, driving economic growth that supports energy affordability for the long haul (Saidi & Omri, 2020). Policies that support renewable energy investments (e.g., tax credits, subsidies) are indispensable to speed up this transition process. These policy supports can demonstrate ways to help ease initial financial barriers and make continual access to renewable energy more viable for a broader spectrum of users (Eleftheriadis & Anagnostopoulou, 2015). Therefore, boosting investment in renewables improves the cost-efficiency and sustainability of energy systems and basically makes renewables the main element of a sustainable energy future.

Hypothesis 3: *Renewable energy investment has an impact on energy affordability & sustainability.*

Renewable energy has become big enough and cheap enough that some are beginning to see as being transformational to the affordability and sustainability of energy (Dincer, 2000). Technology for renewable energy solar, wind, and geothermal, among others has been improving over time as costs fall, creating new economically viable options. Investing in renewable energy helps to reduce dependence on fossil fuels, which are both subject to price volatility and environmentally

harmful (Panwar, Kaushik, & Kothari, 2011). Countries can make energy sustainable by ensuring stable energy costs with a transition to renewables, which in turn is going to provide energy on a long-term basis which is more affordable than the other conventional means, at the same time preserving environmental resources (Omer, 2008). Moreover, investments in renewable energy further eliminate greenhouse gases and pollution, complementing the sustainability efforts. Renewable energy infrastructure not only provides for more accessible and affordable energy but also becomes a driver of innovation through increased funding, serving as the footing for sustainable economic development (Tabrizian, 2019). Moreover, renewable energy is also tangible and there are governments and private sector which might invest in renewable energy, and so they are very advanced provide low-cost energy exploitation that are less vulnerable to the tender market (Ahmed et al., 2014). Thus, investment in renewable energy brings economic relief from energy cost and supports a sustainable future through minimized environmental degradation by energy production.

Hypothesis 4: *Economic growth has an impact on energy affordability & sustainability.*

Economic Growth Impact on energy affordability and sustainability while economic growth tends to increase the demand for energy, promotes higher energy prices, and puts strain on already stretched resources (Lee, Park, & Saunders, 2014). Quick economic growth in developing countries, in particular, might lead to boom within the industries, which might increase energy usage and in turn, the price of power (Singh & Ru, 2022). Though, we can also increase the availability of affordable energy due to economies of scale, innovation and better infrastructure all of which come from economic growth. Reducing emissions through economic growth and addressing affordability and sustainability by increasing energy efficiency and sustainable energy infrastructure builds in the right direction for both energy affordability and sustainability (Fu et al., 2021). Therefore, the effect of economic growth on energy accessibility and sustainability largely depends on the adopted growth model, which reinforces the importance of prioritizing sustainable growth approaches with digitalization that seeks to unify economic benefits with ecological preservation.

Hypothesis 5: *Government policies & regulations for digitalization have an impact on energy affordability & sustainability.*

Government policies associated with research and development in renewable energy technologies contribute to lower costs and greater access to energy in the long run (Evans, Strezov, & Evans, 2009). Furthermore, stronger government measures can improve energy security through diversifying fuels, lessening reliance on foreign energy sources, and protecting the economy from international energy market instability (Husain, Sohag, &

Wu, 2024). Moreover, these kinds of measures, government policies and regulations create the platform for near-term energy affordability and for long-term sustainability, framing citizen and industry policy for a cleaner and cheaper energy future.

Hypothesis 6: *Government policies & regulations for digitalization moderates the relationship between Islamic banking penetration and energy affordability & sustainability.*

Police and regulations are potentially the most important moderating factor between energy consumption as a dependent variable, and energy affordability and sustainability (Sun et al., 2021). Higher economic growth leads to higher energy consumption, which in turn can result in more expensive energy bills and pollution in economies that are heavily dependent on fossil fuels. The negative effects of this trend can be counteracted, nevertheless, by pursuing policies which promote energy efficiency and cleaner energy sources where appropriate, because these options promote responsible patterns of consumption and demand (Aydin & Brounen, 2019). Incentives such as energy saving appliances from government or fines on over-consumption due to high emissions will reduce total consumption which lowers prices and causes environmental damage. Furthermore, policies that require industries to integrate energy-saving practices move the economy structurally toward sustainability, relieving some of the demand pressure on natural resources (Sweeney et al., 2013). Optional policies like subsidizing renewable energy or incentivizing the smart grid makes energy more affordable to high users of it. This shows how government policies can temper the influence of energy usage, making increased consumption less expensive and less harmful to the environment (Wang & Taylor, 2014). Such regulatory moderation makes energy consumption and sustainable development goals balanced with both the economic and environmental priorities.

Hypothesis 7: *Government policies & regulations for digitalization moderates the relationship between energy consumption and energy affordability & sustainability.*

There is an importance of government policies and regulations, as they can significantly moderate the relationship between renewable energy investment and energy affordability and sustainability (Riley, 2014). This high set-up cost limits the proliferation of renewable energy projects due to significant financial barriers. Financial barriers to renewable energy often present significant challenges for investors, but government incentives such as tax breaks, grants, or renewable energy feed-in tariffs can effectively reduce these barriers by improving the economic case for investment (Sen & Ganguly, 2017). Such a transition would speed up the phase-out of fossil fuels, which ultimately reduces long-term energy costs and improves environmental sustainability. Finally, regulatory frameworks that enable grid modernization and foster the integration of

renewables reduce dependency on volatile fossil fuel markets and stabilize energy prices (Tang, Aruga, & Hu, 2023). They allow climate action objectives to literally ground by ensuring that clean energy can cover large footprints growing rapidly by moderating the cost dynamics of renewable investments. These are also, however, policies that shape demand for renewables that boost a healthy market and encourage innovations as well (Mentel et al., 2023). From the above, it is clear that the increasing use of government regulations is shaping renewable energy investments, ensuring such investments are both affordable and sustainable.

Hypothesis 8: *Government policies & regulations for digitalization moderates the relationship between renewable energy investment and energy affordability & sustainability.*

The link between economic growth and energy demand often increases energy prices and sharpens the long-run sustainability challenge. However, through focused policies, the government can steer economic growth into sustainable energy practices that facilitate affordable and environmentally sound expansion. Green technology policies such as grants for clean energy

research or subsidies for integrated energy-efficient capital can help dislodge the link between economic growth and unsustainable energy use (Khan et al., 2022). Regulatory incentives that compel different sectors to switch to cleaner technologies also reduce the change in building environment due to economic growth (Smulders, Bretschger, & Egli, 2011). Likewise, the expansion of clean energy sources through tax breaks or subsidies caused by renewable energy adaptation can reduce the cost of various forms of clean energy as the economy expands. Consequently, if economic growth is underpinned by green development policies, then it can contribute towards making energy more accessible and sustainable (Khaled, Ali, & Mohamed, 2021). Such reg windows provide the middle ground for growth whilst helping maintain the gains of an expanding economy without compromising energy affordability and the environment (Khan et al., 2022).

Hypothesis 9: *Government policies & regulations for digitalization moderates the relationship between economic growth and energy affordability & sustainability.*

The model of study is shown in Figure 1.

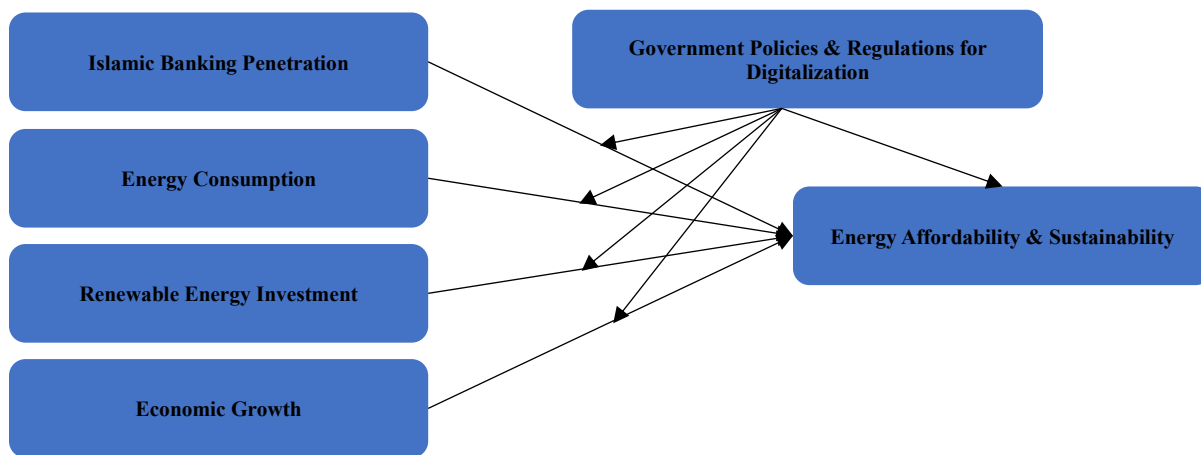


Figure 1: Framework of Study.

Methodology

This research has considered quantitative data for testing the relationships between the variables. The relationships developed in the conceptual model are tested by collecting data from the respondents. However, the Likert scale questionnaire is used for collecting data. The scale items for this research are taken from the existing studies that are based on credible contribution. Furthermore, these scale items were based on 7-points scale as it is reliable to test the variation in response. Firstly, the scale items for construct Islamic banking penetration were considered from the study Loonam and O'loughlin (2008) to determine its impact on energy affordability & sustainability. Secondly, the scale items for construct energy consumption were considered from the study Bavaresco et al. (2020) to determine its impact on energy affordability & sustainability.

Thirdly, the scale items for construct renewable energy investment were considered from the study Masini and Menichetti (2012) to determine its impact on energy affordability & sustainability. Accordingly, the scale items for construct economic growth were considered from the study Taiwo, Ayodeji and Yusuf (2012) to determine its impact on energy affordability & sustainability. Moreover, the scale items for construct government policies & regulations for digitalization were considered from the study Olson-Hazboun, Krannich and Robertson (2016) to determine its impact on energy affordability & sustainability. Finally, the scale items for energy affordability & sustainability are adapted from the research Kyprianou, Carlucci and Serghides (2022).

The respondents of this research were the managers of Islamic banking sector in Yemen. They were contacted physically to collect the data. The managers were asked to provide their response based on their opinion, observation and experience.

The data for this research is collected with cross-sectional method. This method is applied when data collection is required in any research. Furthermore, survey-based data collection is considered as a reliable way to collect the data to save the cost and time of research. The population of this research were the managers of Islamic banking sector in Yemen. Therefore, random sampling method is applied to collect data as the population was known. The questionnaire was printed to collect the data.

450 questionnaires were distributed to the respondents to collect the data. However, 337 responses were collected back. 271 respondents were men and 66 were women. Furthermore, all respondents were masters in their education. However, 77 respondents had more than 7 years of experience, 148 respondents have experience of more than 5 years, 45 respondents have experience more than 3 years, and 67

respondents have experience more than 1 years. Accordingly, they all were managers of Islamic banking sector in Yemen. The data collected of this research is analyzed with Smart PLS 4.

Data Analysis

The normality of distribution of data is checked at the initial stage. The data is tested for missing values, and the findings determined that there are no missing values in the data. Furthermore, the findings of skewness and kurtosis are determined to check the normality of data. Likewise, a kurtosis and skewness between -2 and +2 indicates a distribution that is normal (Royston, 1992). When both skewness and kurtosis are close to zero, the pattern of responses is considered a normal distribution. The findings reported in Table 1 confirmed that normality of data is achieved. Therefore, the data is reliable for further statistical analysis.

Table 1: Data Normality.

Items	No.	Missing	Mean	Standard Deviation	Excess Kurtosis	Skewness
IBP1	1	0	3.235	1.503	-0.429	0.105
IBP2	2	0	3.23	1.795	-0.531	0.473
IBP3	3	0	3.5	1.867	-0.773	0.319
IBP4	4	0	3.465	1.899	-0.772	0.403
IBP5	5	0	3.53	1.721	-0.444	0.324
EC1	6	0	3.483	1.815	-0.695	0.252
EC2	7	0	3.474	1.831	-0.869	0.177
EC3	8	0	3.643	1.852	-0.758	0.218
EC4	9	0	3.674	1.861	-0.734	0.329
EC5	10	0	3.652	1.927	-0.753	0.374
REI1	11	0	3.548	1.887	-0.705	0.4
REI2	12	0	3.552	1.84	-0.597	0.378
REI3	13	0	3.574	1.9	-0.769	0.347
REI4	14	0	3.443	1.775	-0.438	0.464
REI5	15	0	3.5	1.906	-0.901	0.233
REI6	16	0	3.443	1.807	-0.612	0.335
EG1	17	0	3.617	1.76	-0.568	0.302
EG2	18	0	3.043	1.477	-0.07	0.61
EG3	19	0	3.152	1.494	0.522	0.91
EG4	20	0	3.2	1.434	0.883	0.954
EG5	21	0	3.13	1.448	0.511	0.792
EG6	22	0	3.104	1.376	0.585	0.698
GPR1	23	0	3.178	1.5	0.362	0.727
GPR2	24	0	3.113	1.461	0.546	0.838
GPR3	25	0	3.004	1.41	-0.154	0.461
GPR4	26	0	3.161	1.359	0.508	0.688
GPR5	27	0	3.091	1.437	0.214	0.653
EAS1	28	0	3.074	1.48	0.247	0.715
EAS2	29	0	3.196	1.399	-0.091	0.558
EAS3	30	0	3.122	1.362	0.291	0.589
EAS4	31	0	3.017	1.338	-0.139	0.56
EAS5	32	0	3.122	1.3	0.391	0.645
WAS6	33	0	3.122	1.412	0.014	0.706

The findings of measurement model assessment are checked to determine the validity of individual items, convergent validity, and discriminant validity. The reliability of individual items is tested with factor loadings. The factor loadings > 0.60 (Shevlin & Miles, 1998) considered significant for reliability of items of any construct. This research reported that the factor is significantly above the recommended threshold. Therefore, the items used in this research have reliability at the individual level. Furthermore,

the findings of composite reliability and Cronbach alpha are checked to measure the internal consistency between the items of any construct. The internal consistency is achieved when both Cronbach alpha and composite reliability are more than 0.70 (Peterson & Kim, 2013). The data analyzed showed that the internal consistency of the data is achieved. Finally, the results of average variance extracted are determined to test the variance between the items loaded on a single construct. The results shows that there is more than 50% variance

between the items loaded on a single construct, that is acceptable (Alarcón, Sánchez, & De Olavide, 2015). The results are reported in Table 2. The significance of convergent validity is appropriate to go for further analysis of data.

Table 2: Convergent Validity.

Variables	Items	Factor Loadings	Cronbach's Alpha	Composite Reliability	Average Variance Extracted
Energy Affordability & Sustainability	EAS1	0.87	0.929	0.945	0.743
	EAS2	0.911			
	EAS3	0.874			
	EAS4	0.899			
	EAS5	0.905			
Energy Consumption	EC1	0.926	0.936	0.951	0.796
	EC2	0.911			
	EC3	0.892			
	EC4	0.904			
	EC5	0.916			
	EG1	0.688			
Economic Growth	EG2	0.872	0.948	0.96	0.827
	EG3	0.902			
	EG4	0.902			
	EG5	0.899			
	EG6	0.886			
	GPR1	0.921			
Government Policies & Regulations	GPR2	0.923	0.936	0.951	0.796
	GPR3	0.863			
	GPR4	0.881			
	GPR5	0.871			
	IBP1	0.9			
Islamic Banking Penetration	IBP2	0.904	0.94	0.954	0.807
	IBP3	0.912			
	IBP4	0.896			
	IBP5	0.879			
	REI1	0.903			
Renewable Energy Investment	REI2	0.882	0.951	0.961	0.804
	REI3	0.913			
	REI4	0.899			
	REI5	0.903			
	REI6	0.88			

The discriminant validity is tested to investigate multicollinearity issues in the research data. The discriminant validity is tested with findings of Heteritrait-Monotrait (HTMT) method. This method is widely used in social science research. The discriminant validity is achieved when the findings in HTMT

matrix are less than 0.85 (Henseler, Ringle, & Sarstedt, 2015). The findings of this research reported in Table 3 confirmed that the research data has significant discriminant validity. Therefore, there are no multiple collinearity issues in the data, and it can be used for further analysis.

Table 3: Discriminant Validity.

Variables	Economic Growth	Energy Affordability & Sustainability	Energy Consumption	Government Policies & Regulations	Islamic Banking Penetration	Renewable Energy Investment
Economic Growth						
Energy Affordability & Sustainability	0.792					
Energy Consumption	0.787	0.665				
Government Policies & Regulations	0.699	0.791	0.692			
Islamic Banking Penetration	0.822	0.715	0.699	0.736		
Renewable Energy Investment	0.778	0.653	0.691	0.673	0.698	

The findings of structural model assessment are used to test the relationships between variables. The relationships both direct

and moderating are tested with $t > 1.96$ threshold for structural equation modeling (Hair et al., 2007). According to the findings of hypothesis 1, Islamic banking penetration has impact on energy affordability & sustainability. Furthermore, hypothesis 2 confirmed that energy consumption has an impact on energy affordability & sustainability. Thirdly, hypothesis 3 findings renewable energy investment has an impact on energy

affordability & sustainability. Furthermore, hypothesis 4 outcomes established that economic growth has an impact on energy affordability & sustainability. Accordingly, hypothesis 5 confirmed that government policies & regulations for digitalization have an impact on energy affordability & sustainability. Direct relationships are reported in Table 4.

Table 4: Direct Relationships.

Relationship	Original Sample	Standard Deviation	T Statistics	P Values
Islamic Banking Penetration -> Energy Affordability & Sustainability	0.496	0.076	6.526	0.000
Energy Consumption -> Energy Affordability & Sustainability	0.204	0.026	7.846	0.000
Renewable Energy Investment -> Energy Affordability & Sustainability	0.107	0.021	5.095	0.000
Economic Growth -> Energy Affordability & Sustainability	0.549	0.074	7.423	0.000
Government Policies & Regulations -> Energy Affordability & Sustainability	0.432	0.07	6.141	0.000

Furthermore, the findings of moderating relationships are also tested with structural equation modeling method (see Table 5). The findings of hypothesis 6 confirmed that government policies & regulations moderates the relationship between Islamic banking penetration and energy affordability &

sustainability. This moderation is in positive direction, and a change in Islamic banking penetration is positively influenced by government policies & regulations to influence energy affordability & sustainability. The results of this hypothesis are graphically presented in Figure 2.

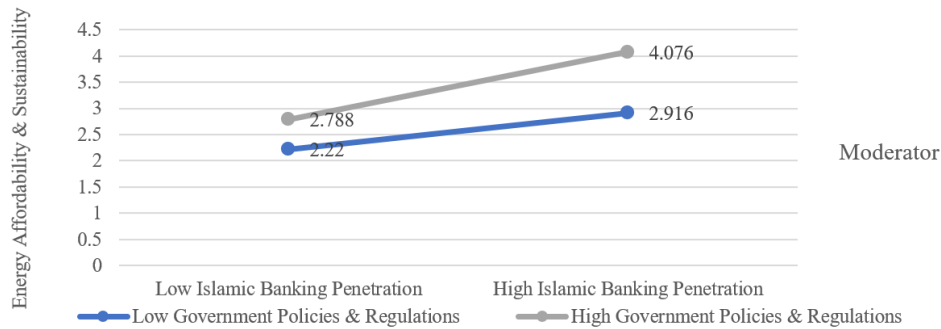


Figure 2: Moderating Effect 1 -> Energy Affordability & Sustainability.

Moreover, the findings of hypothesis 7 confirmed that government policies & regulations moderates the relationship between energy consumption and energy affordability & sustainability. This moderation is in positive direction, and a

change in energy consumption is positively influenced by government policies & regulations to influence energy affordability & sustainability. The results of this hypothesis are graphically presented in Figure 3.

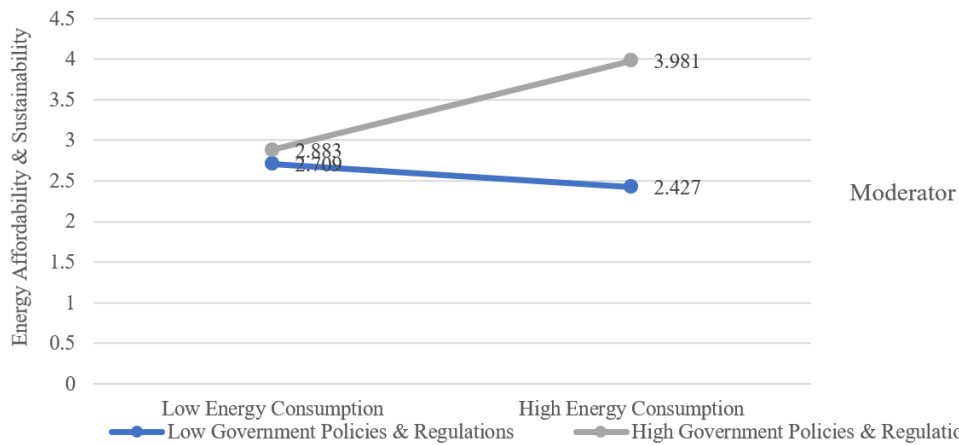


Figure 3: Moderating Effect 2 -> Energy Affordability & Sustainability.

Accordingly, the findings of hypothesis 8 confirmed that government policies & regulations moderates the relationship between renewable energy investment and energy affordability

& sustainability. This moderation is in a positive direction, and a change in renewable energy investment is positively influenced by government policies & regulations to influence

energy affordability & sustainability. The results of this hypothesis are graphically presented in Figure 4.

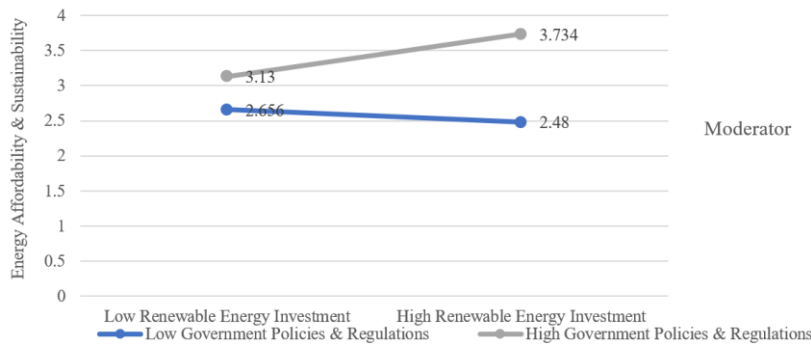


Figure 4: Moderating Effect 3 -> Energy Affordability & Sustainability.

Finally, the findings of hypothesis 9 confirmed that government policies & regulations moderates the relationship between economic growth and energy affordability & sustainability. This moderation is in a positive direction, and a change in

economic growth is positively influenced by government policies & regulations to influence energy affordability & sustainability. The results of this hypothesis are graphically presented in Figure 5.

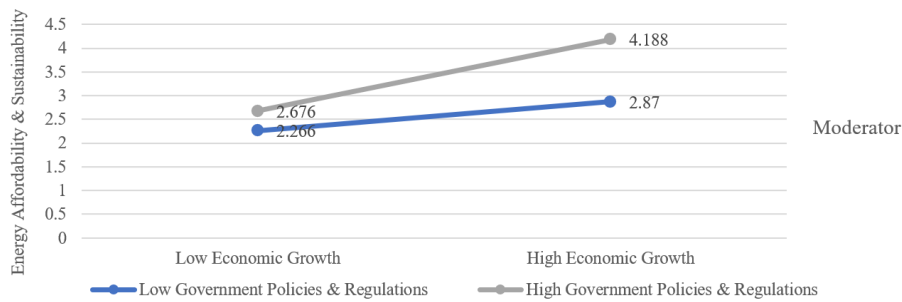


Figure 5: Moderating Effect 4 -> Energy Affordability & Sustainability.

Table 5: Moderating Relationships.

Relationship	Original Sample	Standard Deviation	T Statistics	P Values
Moderating Effect 1 -> Energy Affordability & Sustainability	0.148	0.071	2.071	0.039
Moderating Effect 2 -> Energy Affordability & Sustainability	0.345	0.092	3.751	0.000
Moderating Effect 3 -> Energy Affordability & Sustainability	0.195	0.094	2.073	0.039
Moderating Effect 4 -> Energy Affordability & Sustainability	0.227	0.041	5.536	0.000

In accordance, the effect size between the relationship was tested. An effect size is a value measuring the strength of the relationship between two variables in a population, or a sample-

based estimate of that quantity. The value of 0.02 is small, 0.15 is medium and 0.35 (Rosenthal, 1994) is large for f². The effect size of different relationships is reported in Table 6.

Table 6: Effect Size.

Variables	Energy Affordability & Sustainability
Economic Growth	0.293
Energy Consumption	0.205
Government Policies & Regulations	0.221
Islamic Banking Penetration	0.313
Renewable Energy Investment	0.192

Furthermore, this study has tested the model with coefficient determination, effect size and predictive relevance. The coefficient of determination or R squared method is the proportion of the variance in the dependent variable that is predicted from the independent variable. It indicates the level

of variation in the given data set. The value of R-Square 0.67 is substantial, 0.33 is moderate, and 0.19 is weak. According to results in Table 7, this research model achieved (Di Bucchianico, 2008) coefficient of determination.

Table 7: Coefficient of Determination.

Variables	R Square	R Square Adjusted
Energy Affordability & Sustainability	0.894	0.891

Q^2 is predictive relevance, measures whether a model has predictive relevance or not (> 0 is good). Further, Q^2 establishes the predictive relevance of the endogenous constructs. Q^2 values above zero indicate that your values are well

reconstructed and that the model has predictive relevance (Koban et al., 2012). The model of this research has strong predictive relevance based on the Q^2 findings reported in Table 8.

Table 8: Predictive Relevance.

Variables	SSO	SSE	$Q^2 (=1-SSE/SSO)$
Economic Growth	1380	1380	
Energy Affordability & Sustainability	1150	339.319	0.705
Energy Consumption	1150	1150	
Government Policies & Regulations	1150	1150	
Islamic Banking Penetration	1150	1150	
Renewable Energy Investment	1380	1380	

Discussion

According to the findings of this study, a widespread penetration of Islamic banking has a positive influence on energy and sustainability-related issues of affordability in Yemen, emphasizing the unique role of Islamic financial institutions in the solution of energy issues. The ethical financing principles and risk-sharing mechanisms of Islamic banking complement sustainable development objectives, as these banks are more likely to make socially responsible investments in areas such as renewable energy and energy-efficient projects (Morea & Poggi, 2016). Islamic banks also play a role in improving energy affordability as they allocate capital to projects focused on enhancing energy access and minimizing reliance on expensive fossil fuels (Fu et al., 2021). The study further reveals that energy use plays an important role in driving energy affordability and sustainability, while government policies and regulations significantly moderate this association. More energy used without adequate control is an increase in energy prices and environmental burdens (Kyprianou et al., 2022). This research, however, finds that the adverse effects of high energy consumption do get partially offset when the long-run energy consumption is paired with a robust governmental policy. In addition to this, regulatory frameworks that promote the use of clean and renewable energy technologies reduce energy costs overall, lowering dependence on non-renewable resources (Malik et al., 2019).

Also ranking high on the list of the main drivers of energy affordability and sustainability is renewable energy investment, which is being further amplified by government policies (Sun et al., 2021). Renewables, like solar and wind, also have lower marginal costs than most non-renewables and hence reduce the cost of the energy supply (Wang et al., 2020). Subsidies and tax incentives for renewable energy projects is government support that is crucial to feasibility. Government policies then help to moderate renewable energy investment and energy affordability link so that renewable energy solutions would become more accessible and sustainable (Azhgaliyeva, Kapoor, & Liu, 2020). It reiterates the need for a supportive policy to bring about the penetration of renewables at a rapid pace and make low-cost clean energy a reality for Yemen.

Economic development, a key driver for affordability and

sustainability of energy, also suffers from market failure (Ahmed et al., 2014). The results suggest that without government intervention, the longer-term trend of development will steer development in the opposite direction than required for sustainability. For example, economic growth typically leads to higher energy demand, which can result in rising energy prices and environmental damage unless it is managed appropriately (Dincer, 2000). Yet, if properly regulated, this economic growth can be used to facilitate green energy investments and projects. Such moderation effect of the government policies for digitalization indicates that when the directions of economic growth are guided through environmental gravitates, it can feast the investments in low-cost as well as sustainable energy systems to assure that the benefits of economic growth do not ecologies (Tabrizian, 2019).

It also highlights the significance of government policies and regulations for digitalization as a necessary moderator in all hypothesized links and calls for a conducive regulatory framework for stimulating sustainable energy practices (Riley, 2014). Effective government policies for digitalization process positive effect of energy-based affordability, sustainability, and economic growth, Islamic banking penetration, renewable energy investment and energy consumption (Malik et al., 2019). Through incentives for renewable energy development, emissions regulations, and encouragement of energy-saving measures, government action provides a supportive backdrop to sustainability initiatives (Kumar & Rathore, 2023). The significance of this moderating function not only cemented the positive impacts of the two factors on energy economy but also motivates Islamic banks along with other financial institutions to assist investments focusing on national sustainability objectives. These policies are essential to making sure that there are financial incentives aligned with being responsible stewards of the environment, enabling the necessary balance between energy affordability and sustainability (Wang et al., 2020).

Lastly, the results of this study can help to make the existing knowledge deeper by examining the role of Islamic banking moderated by government policies in enhancing energy accessibility and sustainability in Yemen. The combination of the ethical and socially responsible nature of Islamic banking with the directives of government policies in guiding

sustainable energy towards sustainable development outcomes makes Islamic banking a viable sector for providing sustainable energy finance (Azhgaliyeva et al., 2020). Islamic banking can help, but only if regulatory interventions make such borrowing worth lenders' time, and together they can make massive process happen to bring affordable and sustainable energy (Abdmouleh et al., 2015). These insights highlight important implications for policymakers and financial institutions and emphasize the opportunity of continued collaboration and policy innovation to effectively tackle the energy challenges in Yemen.

Theoretical Implications and Practical Implications

This study has important theoretical implications on the development of literature in sustainable energy economies through the perspective of Islamic banking in making energy affordable and sustainable. Energy finance, by itself, has been little studied, and certainly not carefully in light of the particularities of Islamic finance, which may be a superior implement of ethics and sustainability. This study expands the theoretical dimension in terms of research on sustainable finance by providing some evidence of how Islamic banking penetration affects energy economy and thus suggesting the potentials of alternative financing models in relation to sustainable development goals. Also, this research presents government policies for digitalization as a moderating variable in the correlation between energy consumption, renewable energy investment, economic growth and energy access and sustainability. It has become clear that such a lens draws attention to the role of regulatory frameworks in the ability of financial systems to deliver on sustainability. These results indicate the necessity of government intervention in enhancing the benefits of Islamic banking in terms of energy affordability, thus proposing that sustainable finance theories should account for regulatory environments. In addition, this research further supports the relevance of Islamic finance principles to sustainability challenges in the real world, serving as a theoretical backdrop for other studies to use Islamic banking activities as broader environmental and social levers.

This study, therefore, is expected to add significant practical knowledge for such policymakers, financial institutions, and energy sector community, interested in making energy more affordable and sustainable in Yemen and, by extension, in developing economy. The findings highlight the need for supportive policies and regulations by the government to promote sustainable energy with digitalization initiatives for policymakers, especially while associating with Islamic financial institutions. These practical implications highlight the need for policies to incentivize investments in renewable energy and energy efficiency while redirecting economic development towards green and sustainable development. Governments could use these strategies to ensure the availability of Islamic banking institutions that have the ethical traditions and principles of risk-sharing that could make a more

direct contribution to alleviating challenges of energy affordability, by creating a space for investment in sustainable projects. This study could provide managers and stakeholders of Islamic banking institutions with empirical insights on the feasibly viable business strategies toward sustainable energy. Through financing of renewable energy projects, loans for energy efficiency programs, or green infrastructure, Islamic banks can proactively support sustainable investment strategies while improving social and financial performance. This study also motivates synergy between policymakers and Islamic finance institutions to create specific financial products and services to serve energy-access and energy-affordability-targeted underserved communities. In essence, the study provides practical recommendations on how Islamic banking and regulatory framework can be utilized to build a green energy economy for sustainable economic growth along with digitalization support system for environmentally protected environment.

Limitations and Future Directions

A number of limitations of the present study provide opportunities for future research. First, the study is limited to the Islamic banking sector in Yemen which may affect the generalization of its findings to other areas having different regulatory environments, economic conditions, and cultural influences on Islamic finance. Future studies may broaden the perspective of this study by investigating other regions or compare the findings of different countries to explore the role of Islamic banking in broader environments. Second, the study is based on cross-sectional data; hence the effects of Islamic banking on energy accessibility and sustainability cannot be evaluated in the long-term. Future work could use longitudinal methods to examine change[comma] and investigate causal relationships[comma] allowing change in stimulus content or people to evoke questions about causality. At last, this study had a specific moderation variable, namely government policies, whereas future studies may take other moderating variables into account, such as technology progress or market progress variables, to provide a well-rounded understanding of the mechanisms of sustainable energy economies.

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CRedit Authorship Contribution Statement

Ibraheem Saleh Mokbel Alkoliby: conceptualization, data curation, formal analysis investigation, methodology. Mohammed Abdulbaset Al-Hakimi: Project administration, resources, software, supervision, validation, visualization, writing original draft, writing review & editing.

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The authors confirm the absence of any relevant financial

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Ethical Statement

Ethical standards were upheld, with no approval required as no biological or tissue samples were involved.

Data Availability Statement

The datasets can be obtained from the corresponding author upon request.

Artificial Intelligence/ Language Module Statement

The authors assume full responsibility for this work, completed without AI or LLM assistance.

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