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Abstract

Construction is the world's largest energy-consuming sector, producing energy inefficiency, therefore they may serve as a prospective target with the greatest potential to achieve the shared aim of sustainable development. Nonetheless, excessive construction energy use negatively influences the environment, including air pollution, the greenhouse effect, the urban heat island effect, and others, all of which can be detrimental to human health and social economy growth. Fossil-based energy is the primary source of environmental pollution. However, fossil fuels account for 84.7% of global energy use. Renewable and nuclear energy sources account for 5% and 4% of total primary energy consumption, respectively.

The construction industry must make a significant transition to a sustainable energy future. According to Anyanwu, O. C., & Kur, K. K. (2024). , "sustainable energy paths" should be based on principles such as effective resource conservation and environmental protection, social acceptability, low risks and contributions to reducing international conflicts, and equitable collaborations with developing countries. The sector's adoption of such a system would almost definitely necessitate a reduction in its reliance on oil and other fossil fuels, a reduction in CO_2 emissions, interventions to reduce social costs, proper attention to material choice, and a shift toward green or renewable energy.

Keywords: green energy؛ climate change؛ GCC؛ manufacturing sector؛ OLS model

1. Introduction:

The construction sector is a large consumer of nonrenewable energy and a contributor to greenhouse gas emissions; to achieve net-zero carbon emissions by 2050, it is imperative to address the significant environmental impact of the construction sector, which currently accounts for 36% of global energy consumption and 39% of worldwide CO_2 emissions. Reducing these emissions requires a multifaceted approach, including stringent government policies, advanced tools for carbon emission analysis and calculation, and the adoption of sustainable materials. This discussion will explore the evolution of green construction, the role of carbon emissions, regulatory frameworks, modeling techniques, life cycle assessments, and the use of eco-friendly materials such as biochar, bioplastics, agricultural waste, animal wool, fly ash, and self-healing concrete. Notably, research indicates that the construction phase alone contributes 20-50% of the total carbon emissions throughout a building's life cycle.

Valuing the construction business and appraising its value to the economy is a challenging but necessary undertaking. Highlighting the importance of construction to the economy is critical to ensure that it is a top priority on government agendas. This applies to all countries, including the UK, and is especially important for newly developed and developing countries. It can provide a foundation for development by creating a conducive environment for alternative industries to thrive. Additionally, it can serve as a starting point for achieving energy efficiency and sustainability.

The construction industry in the Gulf Cooperation Council (GCC) is anticipated to increase at an average annual rate of 3.5–4% in 2023–2024, outpacing the growth of the overall economy during this time of rapid expansion. European Union External Action Service. This positive forecast " The surge in energy export revenues has provided a significant boost to available project financing, while Gulf Cooperation Council (GCC) countries continue to advance their long-term development strategies across both energy and non-energy sectors.," according to research on the topic from The Economist Intelligence. The construction industry and its supply chains will receive further assistance from other projects related to residential and commercial real estate, fundamental infrastructure (transportation, electricity, and water systems), and industrial developments (light and heavy manufacturing). Statistical Review of World Energy (2020).

1.1. Research Problem

The main problem of the study lies in measuring the extent of the use of green energy in construction work and its impact on supporting the construction sector and its contribution to the economy. According to this problem, the following questions can be concluded:

• To what extent does green energy contribute to the construction sector, applying to GCC countries and China?

• Has the use of green energy in the construction sector increased economic value added, applying to GCC countries and China?

1.2. Significance of the Research

The significance of the study stems from estimating the impact of green energy in supporting the manufacturing value add to GDP in GCC countries comparing with China during the period (2000-2023) the study is also concerned with monitoring the difficulties and problems that faced the application of using green energy in GCC, which contributes to providing solutions and proposals for these problems.

1.3. Research Objectives.

The main objective of this research is to examine the impact of using green energy on the manufacturing value add to GDP in GCC countries comparing with China, especially aims to achieve the following objectives:

a) Evaluation of green energy use.

b) Environmental impact assessment.

c) Identify considerations for green energy use.

d) Evaluate implementation strategies and challenges.

e) Provide recommendations for future policy and research.

1.4. Research Hypotheses.

- The use of green energy has a significant impact on the added value of the construction sector in GCC countries.
- The use of green energy has a significant impact on the added value of the construction sector in China.

1.5. Research Methodology.

This research employs a dual analytical framework to examine green energy's influence on the construction sector:

1.5.1. Panel data Methodology

- Coverage: GCC member states
- period: 2000-2023

1.5.2. Time series Methodology

- Coverage: China's construction sector
- period: 2000-2023

1.5.3. Model Specification

This dual-method approach enables comprehensive evaluation of renewable energy integration across different economic contexts and governance systems. The panel analysis reveals regional patterns in GCC states, while the time series examination tracks China's progressive transition toward sustainable construction practices.

$$\boldsymbol{MFVit} = \boldsymbol{\alpha_0} + \boldsymbol{\beta_1 CO2_{it}} + \boldsymbol{\beta_2 REC_{it}} + \boldsymbol{\beta_3 FEC_{it}} + \boldsymbol{\beta_4 EEF_{it}} + \boldsymbol{\beta_5 GCF_{it}} + \boldsymbol{\beta_6 GDP_{it}} + \boldsymbol{\beta_7 INF_{it}} + \boldsymbol{\beta_8 NGC_{it}} + \boldsymbol{\mu_{it}}$$

Where MFV is Manufacturing, value added the dependent variable, CO2 is CO2 emissions from manufacturing industries and construction (% of total fuel combustion), REC is Renewable energy consumption (% of total final energy consumption), FEC Fossil fuel energy consumption (% of total), EEF is Total energy supply per unit of GDP, (energy efficiency), GCF is Gross capital formation (current

US$), GDP is GDP (current US$), INF is Inflation, consumer prices (annual %), NGS is Natural gas supply

1.6. Study Structure

The study is structured with an introduction that addresses the research problem, its significance, objectives, and hypotheses. It includes a literature review to provide context and background. The theoretical framework examines the impact of green energy use in the construction-related manufacturing sector on GDP. The study also includes an analysis of the evolution of the manufacturing sector for construction in the GCC and China from 2000 to 2023. Furthermore, the study uses an econometric model to estimate the impact of green energy use on GDP in the GCC and China from 2000 to 2023. The study concludes with references.

2. Literature reviews

2.1. Cheng, D., Shi, X., & Yu, J. (2021). This study addresses this gap by analyzing the impact of the Three Gorges Project (TGP)—the world's largest hydropower facility—on manufacturing firms in China's host province. The study found that the TGP significantly enhances firm productivity, with results that are both statistically robust and economically meaningful. Further analysis identifies three underlying mechanisms: improved energy access spurs investment in productive assets, lower energy costs enable firms to expand output, competition effects: Market dynamics drive efficiency gains.

2.2. Yaya Li, et al. (2023). This study utilizes a cross-sectional autoregressive distributed lag (CS-ARDL) methodology to analyze a panel dataset of 17 manufacturing sectors across 42 economies from 2000 to 2014, focusing on the impact of green manufacturing technology innovation (GMTI) on energy intensity (EI). The results reveal several key findings: (1) GMTI leads to a reduction in EI, with robustness tests confirming the consistency of these results. (2) The reduction in EI due to GMTI is significant in both the short and long terms, with the long-term effects being more pronounced.

2.3. Zeng, Q., et al (2024). This study investigates how green energy influences economic prosperity, green economic recovery, and long-term sustainability. Using data from 33 industrialized and developing countries from 1991 to 2022, the research evaluates the relationship between green energy, sustainable economic growth, and post-crisis green recovery. Key findings reveal that both population growth and GDP per capita significantly shape sustainable development.

2.4. Anyanwu, O. C., & Kur, K. K. (2024). This study examines the relationship between energy consumption and industrial sector performance across 32 Sub-Saharan African countries from 2002 to 2019. To assess long-term effects, the research employs advanced econometric techniques, including Fully Modified Ordinary Least Squares (FMOLS), Pooled Mean Group (PMG), and Generalized Linear Model (GLM). The study emphases that, Energy consumption (both renewable and fossil fuels) has a positive impact on industrial performance

2.5. Dirma, V., et al. (2024). 334The study refutes claims that transitioning to renewable energy slows economic progress. It highlights the importance of adopting these resources for lowering greenhouse gas emissions, improving air quality, and ensuring sustainable development in the European Union. Ultimately, findings indicate that renewable energy sources (RES) do not obstruct long-term economic growth; rather, they promote it through technological innovation, job creation, and attracting substantial investments, thereby contributing to environmental protection and energy stability.

2.6. Qiao Zeng, et al. (2024). This study investigates the effects of green energy on economic prosperity, green economic recovery, and sustainability over the long term. It analyzes data from 33 industrialized and developing countries from 1991 to 2022, focusing on green energy, sustainable economic growth, and green recovery strategies. The analysis employs methodologies including Pooled Ordinary Least Squares (OLS), the Fixed Effects Model (FEM), and the Random Effects Model (REM). Findings indicate that both population growth and gross domestic product per capita play significant roles in promoting sustainable development.

3. Theoretical Framework: The Impact of Green Energy Use in the Construction-related Manufacturing Sector on GDP

3.1. Defining the Construction Sector

Defining the construction sector is challenging due to its diverse activities. The **Pearce Report (2003)** outlines two primary definitions:

- **Narrow Definition**: Focuses solely on on-site construction activities, including site preparation, infrastructure construction, installation, and finishing work. This aligns with the **SIC 45 code** used in input-output tables.
- **Broad Definition**: Encompasses the entire construction lifecycle, including material extraction, manufacturing, professional services (e.g., architecture, design, facilities management), and after-sales support.

The broader definition highlights the interconnectedness of the sector, as activities like mining and management are directly tied to on-site construction. For instance, without material extraction, on-site construction cannot occur, and without management, construction projects may lack direction. This interdependence underscores the importance of adopting a broader perspective when evaluating the sector’s economic impact.

According to the Pearce Report, the narrow definition contributes approximately **5% of GDP**, while the broader definition accounts for **10% of GDP**. This significant difference highlights the need for a comprehensive approach to understanding the sector’s true value (Pearce, 2003).

3.1.1. Diversification in Construction

Construction companies have expanded their activities beyond traditional on-site work, diversifying both **upstream** (e.g., mining raw materials) and **downstream** (e.g., facilities management, product sales). This diversification helps companies remain competitive and resilient in a volatile market. For example, some firms now offer end-to-end services, from design to maintenance, making them more attractive to clients. Abisuga AO, Okuntade TF (2020)

However, diversification is not limited to construction firms. Companies like **Marks & Spencer** have entered the market by offering services such as security, recognizing the potential for additional revenue streams. This trend reflects the sector's evolving nature and the growing importance of innovation and specialization (Fang et al., 2021).

3.1.2. Construction and Value Added

The construction sector is a significant, distinct component of the economy, contributing to the production of the built environment. In the UK, approximately **1.2 million people** were directly employed in construction in 1991, excluding self-employed workers, material suppliers, and professionals like architects and engineers. This workforce is responsible for creating and maintaining infrastructure, from residential buildings to transportation networks (Dirma, V., et al.(2024).

The sector's production process involves multiple stages, from design and material extraction to final assembly. Each stage adds value to the final product, whether it's a residential building, a commercial structure, or infrastructure like roads and bridges. The built environment not only provides shelter and facilitates activities but also connects communities through transportation and utility networks.

3.2. The Contribution of the Manufacturing Sector for Construction to GDP.

The construction sector plays a vital role in economies worldwide, though its impact varies depending on a country's development stage. In developing countries, the focus is often on raw material extraction and infrastructure development, such as roads and railways. In industrialized nations, the emphasis shifts to professional services and the sale of finished products.

In the UK, for example, high housing costs and rising interest rates have led to a growing DIY and maintenance industry, as homeowners opt to renovate existing properties rather than build new ones. This trend reflects the sector's adaptability to economic conditions.

The construction sector contributes to the creation and maintenance of the built environment. In a narrow sense, it is classified as a secondary sector, transforming raw materials into finished products. However, the broader definition includes primary sector activities (e.g., mining) and tertiary sector services (e.g., design, facilities management). In the UK, the sector contributes 6% of GDP under the narrow definition and 20% under the broader definition (Pearce Report, 2003).

Assessing the value of the construction sector and its contribution to the economy is a complex yet essential task. Highlighting its importance ensures that it remains a priority on government agendas, particularly in developing and newly developed countries. The construction sector lays the foundation for economic growth by creating infrastructure that supports other industries, while also playing a critical role in achieving energy efficiency and sustainability goals.

3.3. The Role of the Manufacturing Sector for Construction in Sustainable Development.

The construction sector is increasingly recognized for its role in sustainable development. By implementing energy-efficient technologies, such as advanced insulation and solar panels, the sector contributes to environmental sustainability. International Energy Agency (2019), emphasizes the economic, social, and cultural aspects of sustainable construction, highlighting its importance in achieving global sustainability goals.

The adoption of sustainable materials in green construction has significant implications for both environmental preservation and economic efficiency. These materials, characterized by their reduced pollution and enhanced performance, are pivotal in advancing green construction practices. Key sustainable materials include biochar, bioplastics, agricultural waste, animal wool, fly ash, and self-healing concrete, each contributing uniquely to the sector:

- **Biochar**

Biochar, produced through the thermochemical conversion of plant and wood biomass at temperatures below 700-800°C in an oxygen-free environment, is renowned for its high porosity, low weight, and extensive surface area (Legan et al., 2022). Industrial methods like gasification, roasting, and pyrolysis are commonly employed for its production. In construction, biochar enhances the mechanical properties of concrete, with studies showing that substituting traditional concrete materials with biochar from bagasse and rice husk can significantly increase tensile and compressive strength (Asadi Zeidabadi et al., 2018). Additionally, biochar's role in carbon sequestration and improving cement mortar hydration further bolsters its application in construction, enhancing fire resistance and thermal stability (Wang et al., 2020a).

- **Bioplastics**

Bioplastics, derived from bio-based or petroleum sources, offer a sustainable alternative to conventional plastics. They are utilized in creating biodegradable geotextiles and natural membrane facades, contributing to the durability and aesthetic flexibility of construction materials (Friedrich, 2022). Their application in insulating walls and non-structural components like partition walls demonstrates their versatility and efficiency in green construction.

- **Agricultural Waste**

Agricultural waste, rich in fibers and minerals, has been effectively repurposed in construction to enhance concrete performance and create sound-absorbing panels (Manan et al., 2021; Maderuelo-Sanz et al., 2022). Its use in insulating materials not only reduces energy consumption but also mitigates environmental impacts, showcasing its potential in sustainable construction practices.

- **Animal Wool**

Animal wool, particularly sheep's wool, is valued for its thermal and acoustic insulation properties. Its application in cement mortars has shown improvements in flexural strength and fracture toughness, making it a viable additive in green construction materials (Fantilli et al., 2017). Moreover, its sound insulation capabilities enhance the acoustic quality of concrete wall components (Ghermezgoli et al., 2021).

- **Self-Healing Concrete**

Self-healing concrete incorporates materials that automatically repair cracks, significantly extending the lifespan of construction elements and reducing maintenance costs. This technology not only enhances the durability and strength of concrete but also contributes to lower carbon emissions by minimizing the need for new cement (Huseien et al., 2019).

In conclusion, the integration of sustainable materials like biochar, bioplastics, agricultural waste, animal wool, and self-healing concrete into green construction not only enhances the structural and environmental performance of buildings but also aligns with global sustainability goals. These materials offer a promising pathway toward reducing the carbon footprint of the construction industry while providing economic benefits through improved efficiency and reduced energy consumption.

3.4. The Economic and Social Structure of the Manufacturing Sector for Construction

The construction sector operates within a specific social and economic framework, characterized by property rights, labor commodification, and the separation of design and implementation. These structures have evolved over time, shaping the roles of producers, consumers, and financiers in the construction process. For example, the UK’s construction sector has undergone significant changes over the past four decades, reflecting broader economic and social trends Alyousef R (2022).

Government initiatives and the future of the manufacturing sector in the Gulf countries are closely intertwined, with state support playing a pivotal role in driving growth and diversification. Recognizing the need to reduce reliance on oil revenues, Gulf Cooperation Council (GCC) countries have launched numerous strategies to bolster their manufacturing sectors. For instance, the National Manufacturing Strategy emphasizes the creation of advanced manufacturing value chains through innovative technologies. A notable example is the Abu Dhabi government’s investment of AED 10 billion to expand the manufacturing sector, which has led to the establishment of industries in metals, food, construction materials, chemicals, and electrical equipment, creating thousands of skilled jobs and boosting economic contributions Amoruso FM, Schuetze T (2022).

The economic value of the construction sector can be viewed in two ways: its **value to the economy** and its **value in the economy**. The former emphasizes its role as a growth engine and catalyst for other industries, while the latter focuses on its direct contribution to metrics like Gross Domestic Product (GDP). A robust construction sector often indicates a thriving economy, as it provides the necessary infrastructure for other industries to flourish. However, both evaluations rely on a clear definition of the sector to ensure accurate and comparable data.

3.5. The Impact of Technological Advancement and Innovation on the Development of the Manufacturing Sector for Construction.

The Gulf region is leveraging **Industry 4.0 technologies**, such as artificial intelligence, data analytics, and robotics, to transform its manufacturing capabilities. These advancements are enhancing efficiency and productivity, particularly in energy-intensive sub-sectors like petrochemicals, cement, and aluminum production. As the sector evolves, it is becoming a key driver of economic diversification, helping Gulf countries reduce their dependence on oil and foster sustainable growth (Bosu et al., 2023).

3.5.1. Future Prospects

The outlook for the Gulf's manufacturing sector is promising, with significant opportunities for growth and innovation. Despite challenges such as oil price volatility and global economic uncertainties, the region's focus on economic diversification is expected to strengthen its economy. The United Arab Emirates, in particular, is well-positioned to capitalize on its strategic location and industrial capabilities, further enhancing the sector's prospects. Productivity in manufacturing remains a critical factor for economic growth and job creation, underscoring its importance in shaping the Gulf's future economic landscape (Chen et al., 2021).

3.5.2. Key Sub-Sectors and Resilience

The manufacturing sector in the Gulf has demonstrated remarkable resilience, with sub-sectors like petrochemicals, automotive, aerospace, and defense emerging as major contributors. Strong government support, coupled with a focus on technology and innovation, has enabled the region to overcome challenges and achieve significant development. As Gulf countries continue to prioritize manufacturing, they are likely to solidify their position as key players in the global manufacturing arena. Amoruso FM, Schuetze T (2022)

3.5.3. Strategic Importance of Manufacturing

Manufacturing is a cornerstone of economic sustainability and competitiveness, contributing **16.5% of global GDP in 2020**. Its interconnectedness with infrastructure, supply chains, logistics networks, and labor markets creates productive linkages within national economies, generating positive indirect impacts. For GCC countries, manufacturing growth is essential for achieving economic diversification, creating job opportunities, and increasing non-oil exports. With forecasts indicating a decline in oil revenues by 2040 or earlier, the urgency to diversify revenue sources has intensified.

3.5.4. GCC Policy Initiatives

GCC countries have implemented several policies to strengthen their manufacturing base, including:

- **Export-Oriented Infrastructure**: Developing logistics centers, seaports, and airports to enable local manufacturers to efficiently serve international markets.
- **Industrial Free Zones**: Establishing free zones that offer 100% foreign ownership, exemptions from import/export duties, and easy access to logistics services.
- **Market Access**: Ensuring tariff-free access to GCC consumer markets under the Gulf Cooperation Council Customs Union and leveraging membership in the World Trade Organization and the Greater Arab Free Trade Area (GAFTA).
- **Energy-Intensive Manufacturing**: Utilizing cheap energy and low raw material costs to support sub-sectors like petrochemicals, cement, and aluminum production.

These initiatives have enabled Gulf countries to develop a comparative advantage in energy-intensive manufacturing. For example, Saudi Arabia's **SABIC** is one of the world's largest petrochemical manufacturers, while **Emirates Global Aluminum** and Bahrain's **Alba** are among the top aluminum smelters globally. Other successful sub-sectors include refined petroleum products, basic chemicals, fertilizers, plastics, rubber, cement, and metal casting. Liu T, et al. (2022).

The Gulf's progress in manufacturing is reflected in the **Competitive Industrial Performance Index** by the United Nations Industrial Development Organization (UNIDO), which ranks GCC countries between 30 and 60 out of 152 nations. This index highlights the region's growing industrial capabilities and its potential to become a global manufacturing hub.

3.6. The Impact of Green Energy Use on the Manufacturing Sector for Construction.

The concept of "green" encompasses several critical components, including environmental considerations, sustainability, life cycle assessment, circular economy principles, sustainable materials, and waste recycling. El-Sayegh SM, et al. (2021). However, the interpretation of "green" varies among different stakeholders, such as governments, construction departments, researchers, and construction companies. Each group approaches the concept from its own perspective and employs distinct criteria to define and implement green practices. The motivations driving these stakeholders also evolve throughout the life cycle of a construction project. Therefore, achieving carbon neutrality in the construction sector requires a deep understanding of how these diverse stakeholders perceive and respond to these driving forces. Legan M, et al.(2022).

3.6.1. Challenges of Implementing Green Construction

The shift toward green construction represents a broader societal movement aimed at achieving environmental sustainability. To foster this transition, it is essential to identify and address the barriers hindering the adoption of green construction practices. As shown in Fig. 12, these barriers include economic costs, time constraints, lack of educational awareness, and gaps in policy frameworks .Dymnicki, A., et al. (2021).

Economic cost is one of the most significant and sensitive challenges in adopting green construction. Friedrich D (2022) analyzed the marginal costs of green construction for 336 BREEAM-certified buildings and found that green design costs were 32% higher than those of traditional construction. Similarly, refurbishment and fit-out costs were 32% and 28% higher, respectively. Additionally, the extended development timelines for green projects increase financing costs and reduce the return on equity for developers. For example, Uğur and Leblebici (2018) reported that the construction costs for two LEED-certified buildings in Turkey rose by 7.43% (Gold certification) and 9.43% (Platinum certification) compared to conventional projects. These financial challenges highlight the need for innovative solutions to make green construction more economically viable. Anyanwu, O. C., & Kur, K. K. (2024).

4. Evolution of the Manufacturing Sector for Construction in the GCC and China (2000–2023)

The construction sector plays a significant part in the entire economy of any country. How that role manifests itself will differ greatly from one country to the next; in developing countries, the extraction of raw materials and on-site construction activity are likely to be the most important, as the country seeks to establish significant infrastructure in the form of roads, railways, and constructions. In industrialized nations, the focus is on providing professional services and selling finished products.

Broadly speaking, the construction sector contributes to the creation and maintenance of the built environment. In a restricted sense, the construction industry is classified only as a secondary sector, as it accounts for the transformation of manufacturing materials into a finished product. The construction industry involves three sectors: primary, secondary, and tertiary. Raw resources are transformed into manufactured materials, followed by professional services and final product sales. Cheng, D.,et al. (2021)

The weightings of each segment of the chain will differ from one nation to the next, influenced by their degree of development, with poor countries having a larger concentration of primary and secondary sector enterprises and industrialized countries like the United Kingdom having many more tertiary sector companies. The construction industry makes a significant contribution to the country's GDP .Alyousef R (2022)

4.1. Evolution of the Manufacturing Sector for Construction in the GCC (2000–2023).

In the first half of 2022, GCC nations were given contracts valued $40 billion, and the projects market in the area is anticipated to flourish through the rest of the year and beyond.

By the end of June 2022, the GCC's planned or ongoing projects were valued at almost $2.65 trillion, according to The Economist, which used a variety of government statistics. Future prospects are wide-ranging and mostly focused in Saudi Arabia and the United Arab Emirates, which together make up 20% and 60% of the GCC's scheduled transportation and construction projects, respectively. Shaik SA, et al, 2022.

The GCC's construction industry is expected to develop rapidly in the near to medium term, outpacing the overall economy and averaging growth of 3.5–4% annually in 2023–2024. The positive prognosis is a result of the GCC's continued pursuit of long-term development plans for the energy and non-energy sectors, as well as the increase in project funding made possible by record-high oil export earnings. The construction industry has a sizable backlog of projects spanning a variety of industries, such as commercial and residential real estate, industrial developments, and infrastructure related to energy, electricity, water, and transportation. Many contracts for these projects have not yet been issued. Qiao L, et al. (2021).

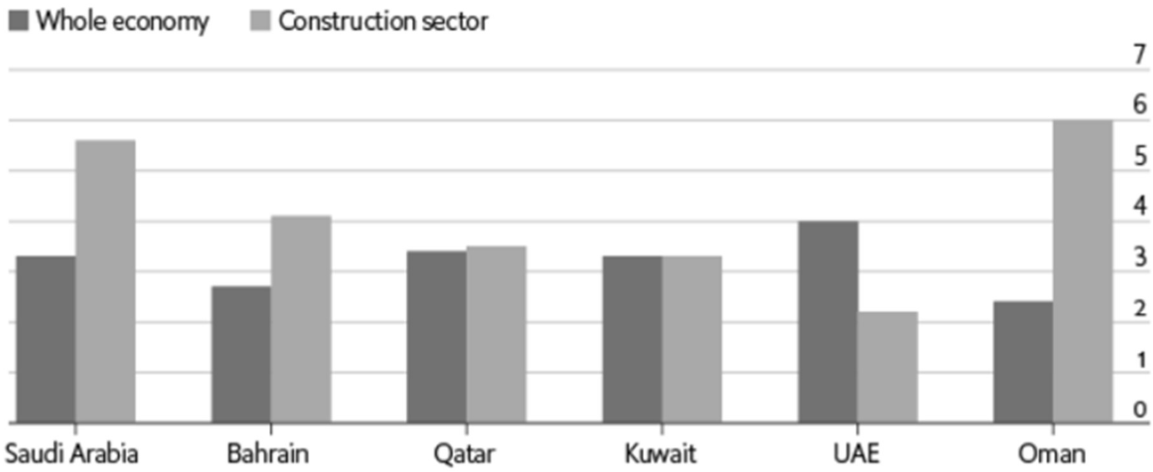

FIGURE 1: CONSTRUCTION SECTOR IN GCC

Source: Green Building Materials Market Size Growth Forecast 2024-2028

4.2. Evolution of the Manufacturing Sector for Construction in China (2000–2023).

With the new aim, China widens its efforts to make the building and construction sector as green as feasible in response to increased urbanization, as well as the national "Dual Carbon" ambitions, which include a 2030 target for peak carbon emissions and full carbon neutrality by 2060.

According to official statistics, 77% of China's new urban construction projects in 2020 were categorized as green buildings.

Green buildings are those that save energy, reduce carbon emissions, create healthy and environmentally friendly residential settings, and offer enjoyable usage experiences throughout the asset's lifespan.

China's National Green Building Rating System (GBL) was developed in 2006 and uses a three-star system to evaluate residential, commercial, and public structures.

While our understanding of sustainable development has grown in recent years, it took an unprecedented environmental and health disaster, Covid-19, to raise our collective awareness and perceive it as a necessary condition for both the planets and our own existence. The issue has sparked changes in many aspects of society, from racial relations and sustainable food to greener transportation and reduced plastic usage.Green Building Standards And Certification Systems (2023)

However, sustainable growth necessitates significant adjustments to the building sector. Though not well recognized to the public, it is clearly defined by all specialists and governments in their approaches to sustainable development.

This massive threat to the building sector is most visible in China, where the epidemic began. Any viewer of the nation can witness the huge expansion of its megalopolises, as well as the construction of new infrastructure and high-rise buildings to house the rising urban population.

Given the massive number of materials required and the energy spent, there is clearly a pressing need to discover solutions to make new building activity sustainable. UNIDO. (2021).

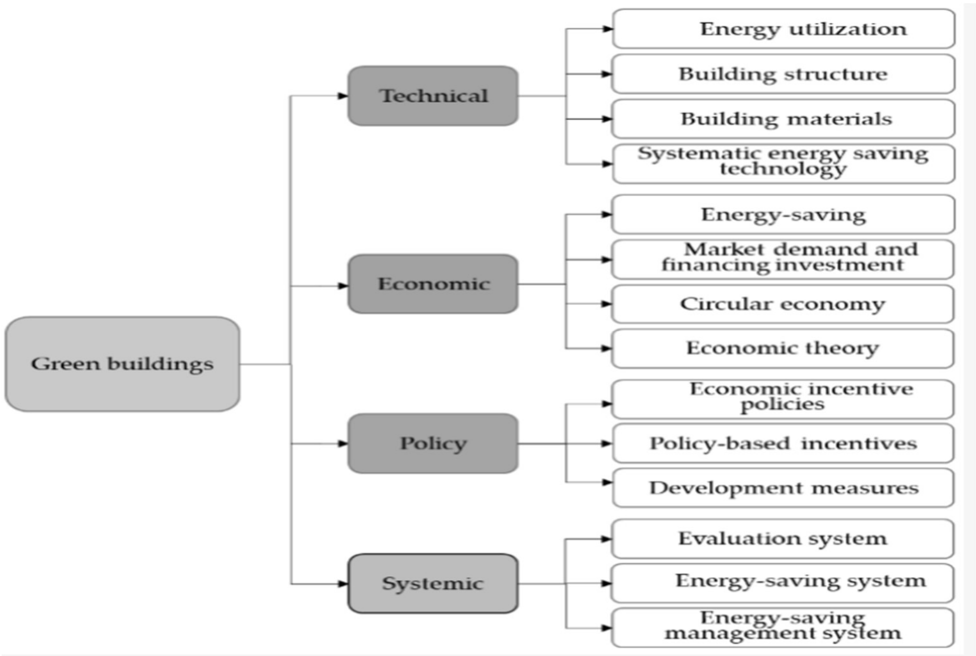

Figure 2. Classification of four sub-dimensions of green building in China

Source: Green Building Materials Market Size Growth Forecast 2024-2028

5. An Econometric Model for Estimating the Impact of Green Energy Use on GDP in the GCC and China (2000–2023).

In this study, we use Panel data to analyze the relationship between variables, and the time series extends from the year 2000 to 2023, and the independent variables used in this estimation are based on what is stated in the standard models used in previous similar studies; the primary (dependent) variable shown in this empirical study is the value added of the manufacturing sector.

Table1. Variables definition and source

Variable	Description	Source
Y (INDEPENDENT) SCP INDICATOR **MFV**	Manufacturing, value added (current US$)	World Bank Data
X1(GREEN ENERGY VARIABLE) **CO_2**	CO_2 emissions from manufacturing industries and construction (% of total fuel combustion)	World Bank Data
X2 (GREEN ENERGY VARIABLE) **NGS**	Natural gas supply	World Bank Data
X3 (GREEN ENERGY VARIABLE) **REC**	Renewable energy consumption (% of total final energy consumption)	World Bank Data
X4(GREEN ENERGY VARIABLE) **FEC**	Fossil fuel energy consumption (% of total)	World Bank Data
X5 (ENERGY EFFICIENCY, SCP INDICATOR) **EEF**	Total energy supply per unit of GDP, (energy efficiency)	World Bank Data
X6 (CONTROL VARIABLE) **GCF**	Gross capital formation (current US$)	World Bank Data
X7(CONTROL VARIABLE) **GDP**	GDP (current US$)	World Bank Data
X8(CONTROL VARIABLE) **INF**	Inflation, consumer prices (annual %)	World Bank Data
X9 (SCP INDICATOR) **R&D**	Research and development expenditure (% of GDP)	World Bank Data

5.1. GCC MODEL

First, we must assess each variable's behavior and quality, and this test can help us uncover information, history, and patterns in the data. As a result, we use this test to assess the data, namely descriptive statistics, normality, and correlations between variables. The table below discusses data characteristics, goodness, and outliers using the mean, median, and standard deviation.

TABLE 2: Summary of descriptive statistics

	LFEC	LGDP	LINF	LMFV	LNGS	LRD	LREC	LGCF	LEEF	LCO
Mean	4.5915	25.95	8.2635	17.561	12.955	0.5375	0.0511	24.594	8.1849	3.182
Median	4.6051	25.92	1.4694	23.076	12.867	0.3807	0.0099	24.497	8.1825	3.1891
Maximum	4.6051	27.73	23.809	25.798	15.158	2.7757	0.6523	26.403	8.6783	3.9939
Minimum	4.5084	23.58	-1.1292	4.5839	8.9725	-1.7687	0.0000	21.821	7.589	2.3351
Std. Dev.	0.0269	1.051	10.338	9.2323	1.6157	0.6966	0.0907	1.1072	0.2159	0.3933
Skewness	-1.760	-0.326	0.6984	- 0.6816	- 0.5069	0.6324	3.9748	-0.3653	- 0.1461	-0.0054
Kurtosis	4.365	2.464	1.5140	1.4994	2.7419	5.0712	21.851	2.6110	3.127	2.1740
Sum	4.5915	3737.2	1189.9	2528.9	1865.5	77.412	7.3717	3541.5	1178.6	458.20
Sum Sq. Dev.	4.6051	157.9	15284.2	12188.	373.36	69.412	1.1784	175.32	6.669	22.128
Obs.	4.6051	144	144	144	144	144	144	144	144	144

SOURCE: Prepared by researcher on E- views

Table 10: Display summary statistics for the used data set after applying the logarithm of the variables is positive, indicating that the distribution was skewed towards the right, while others are negative, meaning skewed towards the left.

On the other hand, kurtosis revealed that it almost meets its analog condition of the expected value of three (3). While the value of foreign direct investment amounted to more than three. This suggests that the distribution is peaked or leptokurtic. However, the probability of all variables was

Table 3. Correlation matrix

Correlation Probability	LMFV	LINF	LGDP	LGCF	LFEC	LEEF	LCO	LNGS	LRD	LREC
LMFV	1.000000									

LINF	-0.993564	1.000000								
	0.0000	-----								
LGDP	0.690390	-0.621099	1.000000							
	0.0000	0.0000	-----							
LGCF	0.549510	-0.470144	0.971196	1.000000						
	0.0000	0.0000	0.0000	-----						
LFEC	-0.337639	0.359835	-0.148702	-0.102296	1.000000					
	0.0000	0.0000	0.0753	0.2224	-----					
LEEF	-0.233529	0.234810	-0.226581	-0.148305	-0.101313	1.000000				
	0.0048	0.0046	0.0063	0.0761	0.2269	-----				
LCO	0.061857	-0.040341	0.175017	0.181632	0.017803	-0.317241	1.000000			
	0.4614	0.6312	0.0359	0.0294	0.8323	0.0001	-----			

LNGS	0.725911	-0.672837	0.857119	0.824226	0.008082	-0.211213	0.251019	1.000000		
	0.0000	0.0000	0.0000	0.0000	0.9234	0.0110	0.0024	-----		
LRD	-0.364566	0.384488	-0.101834	-0.014718	0.079772	0.217011	0.225076	-0.169209	1.000000	
	0.0000	0.0000	0.2246	0.8610	0.3419	0.0090	0.0067	0.0426	-----	
LREC	0.129564	-0.134216	0.173342	0.175722	-0.500775	-0.187237	0.301820	0.103754	0.100887	1.000000
	0.1217	0.1088	0.0377	0.0351	0.0000	0.0246	0.0002	0.2159	0.2289	-----

SOURCE: Prepared by researcher on E- views

found to be positive and relatively low, as all variables in the model were statistically insignificant at the 5% significance level.

These results lead us to accept the implied null hypothesis that the data set is roughly standard. There is also an interesting relationship between the mean and median for all the variables in the model. The mean-to-median ratio of all data sets lies within unity.

The scatterplot in Figure (8) visualizes the bivariate relationships between the dependent variable MFV and each of the explanatory variables. The plots show some variable has positive correlations with MFV and some have no relationship.

The panel cointegration test

Before estimating the model, the cointegration relationship between the variables must be confirmed. To examine this property, we use the Johansen-Fisher test. It is from Johansen (1980) and Johansen and Jocelius (1990) tests for maximum likelihood analysis. Rejecting the null hypothesis that contains less than two integrated vectors at any level means that there is a cointegration relationship between the variables. However, the need for a significance level of less than 5% to infer that there is only one integration vector in both tests may not be sufficient

TABLE4: panel cointegration tests

Hypothesized	Trace test	Prob.	Max-Eigen test	Prob.
r≤0	8.318	0.7598	8.318	0.7598
r≤1	6.931	0.8621	25.35	0.0132
r≤2	5.545	0.9373	42.39	0.0000
r≤3	1.386	0.9999	93.49	0.0000
r≤4	0.000	0.0000	110.5	0.0000
r≤5	110.5	0.0000	110.5	0.0000
r≤6	168.5	0.0000	112.9	0.0000
r≤7	107.9	0.0000	71.95	0.0000
r≤8	72.53	0.0000	72.53	0.0000

SOURCE: Prepared by researcher on E- views

Long Run Regression:

The FMOLS and DOLS methods are proposed by Pedroni (2001, 2004) and Kao and Chiang (2000) respectively. The FMOLS is a non-parametric method that corrects autocorrelation and heteroscedasticity by eliminating the correlation between the explanatory variables and the random term.

The DOLS is a parametric method that eliminates the correlation between the explained variables and the error terms by adding the lag terms of the explanatory variables, the DOLS is an extension of Stock and Watson's (1993) estimator. DOLS estimator uses parametric adjustment to the errors by including the past and the future values of the differenced I(1) regressors.

The long-term relationship indicates that there is a statistically significant positive impact of impact of corporate governance on the dividend payout policy. We have performed the cointegration tests since all series faced I(1) based on the ADF, PP unit root test and Perron unit root test. The comparison of the long-run estimates by the PMG, FMOLS and DOLS techniques is applied.

Table5 : Panel cointegration estimation

Variables	FMOLS	DOLS	OLS
LINF	-0.840667 0.0000	-0.834143 0.0000	-0.834143 0.0000
LGDP	0.307556 0.2974	0.395097 0.2252	0.395097 0.0999
LGCF	0.560494 0.0658	0.478396 0.1482	0.4783 96 0.0500
LEEF	0.131413 0.5081	0.129222 0.5553	0.129222 0.4228
LCO	0.222970 0.1808	0.191722 0.3147	0.191722 0.1722
LNGS	0.074262 0.3702	0.065494 0.4762	0.065494 0.3330
LRD	0.041440 0.6590	0.014447 0.8933	0.014447 0.8553
LREC	-1.589316 0.0222	-1.721587 0.0313	-1.721587 0.0036
LFEC	-0.731720 0.4125	-0.65677 0.3713	-0.656770 0.5137
R-squared	0.996625	0.996331	0.996331
Adjusted R-squared	0.996443	0.996142	0.996142
S.E. of regression	0.551975	0.573426	0.573426
Sum squared resid	39.60799	44.71919	44.71919

SOURCE: Prepared by researcher on E- views

The cointegration estimation model demonstrates strong explanatory power, as evidenced by the R-squared and adjusted R-squared values of 99% across all three models. Additionally, the F-statistic values confirm the model's validity and reliability for predictive purposes.

5.2. China's Model

The next equation represents the investigated variables:

$$MFV_{it} = \alpha_0 + \beta_1 CO2_{it} + \beta_2 REC_{it} + \beta_3 FEC_{it} + \beta_4 EEF_{it} + \beta_5 GCF_{it} + \beta_6 GDP_{it} + \beta_7 INF_{it} + \beta_8 NGC_{it} + \beta_9 R\&D_{it} + \mu_{it}$$

Table-8- Display summary statistics for the used data set after applying the logarithm. The skewness of some variables is positive, indicating that the distribution was skewed towards the right, while others are negative, meaning skewed towards the left.

On the other hand, kurtosis revealed that it almost meets its analog condition of the expected value of three (3). While the value of foreign direct investment amounted to more than three. This suggests that the distribution is peaked or leptokurtic. However, the probability of all variables was found to be positive and relatively low, as all variables in the model were statistically insignificant at the 5% significance level.

Table 6: Summary of descriptive statistics

	LMFV	*LCO*	*LNGS*	*LREC*	*LFEC*	*LEEF*	*LGCF*	*LGDP*	*LINF*	*LRD*
Mean	28.10	3.415	14.03	2.740	4.482	8.417	28.55	29.41	2.189	0.523
Median	28.56	3.418	14.25	2.669	4.480	8.468	28.94	29.71	1.986	0.612
Maximum	29.24	3.536	15.56	3.388	4.562	8.705	29.68	30.58	5.925	0.961
Minimum	25.11	3.296	12.18	2.428	4.380	8.011	26.73	27.82	-0.731	-0.112
Std. Dev.	1.096	0.072	1.056	0.291	0.052	0.227	0.985	0.923	1.663	0.322
Skewness	-1.138	0.014	-0.302	1.102	-0.369	-0.251	-0.557	-0.440	0.494	-0.503
Kurtosis	3.553	1.770	1.955	3.037	2.394	1.654	1.861	1.759	3.227	2.076
Jarque-Bera	5.492	1.512	1.457	4.860	0.912	2.062	2.539	2.313	1.028	.8656
Probability	0.064	0.469	0.482	0.088	0.633	0.356	0.280	0.314	0.598	0.393
Observation	24	24	24	24	24	24	24	24	24	24

SOURCE: Prepared by researcher on E- views

Furthermore, the empirical results of this preliminary analysis indicate a high interrelationship between these variables, meaning that a strong positive association is detected between.

Table 7: Results of unit root test

variables	ADF- TEST	
	level	*Difference*
LMFV	2.052829	-2.974556 N***
LCO2	-0.421480	-3.757509N***
LNGS	3.110509	-3.861330N***
LFEC	4.197683	-2.559610N***
LEEF	0.876275	-4.236698C***
LGCF	0.208374	-3.294013T***
LGDP	-2.447229	-3.683633N***
LINF	-0.368908	-8.491248C***
LRD	2.941675	-3.745654N***

SOURCE: Prepared by researcher on E- views

Note: (*), (**) and (***) mean that the variable is stationary at 10% , 5% and 1%, respectively

The numbers beside the critical values represent the number of lags, while *t, c,* and -after the critical values represent the variant of the series trend and constant, constant, and no constant or trend, respectively.

After ensuring that all variables are stationary at the first difference. The relationship is estimated using the FOMOLS model. The FOMOLS model is estimated using the logarithm of the model variables.

Table 8: Results of cointegration tests

Hypothesized	tau-statistic	Prob.	z-statistic	Prob.
r≤0	-6.296856	0.1220	-23.96191	0.4557
r≤1	-4.450862	0.6500	-21.84248	0.6328
r≤2	-5.042176	0.4312	-24.86626	0.3899
r≤3	-5.303487	0.3450	-25.63577	0.3269
r≤4	-4.372943	0.6917	14.14518	1.0000
r≤5	-3.898478	0.8358	-2938.473	1.0000
r≤6	-5.740352	0.2580	14.85982	1.0000
r≤7	-6.960278	0.0579	-140.6651	0.0001
r≤8	-4.573556	0.6084	-54.92486	0.0001
r≤9	-3.951973	0.8184	-19.08464	0.8234

Source: Prepared by the researcher using E. Views program

After ensuring that all variables are stationary at the first difference. The relationship is estimated using Fully Modified Least Squares (FMOLS) model, The FMOLS method produces reliable estimates for small sample size and provides a check for robustness of the results.

Table 9:OLS model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LCO	-1.545230	1.769860	-0.873080	0.3973
LNGS	0.011473	0.346093	0.033149	0.9740
LFEC	4.895484	5.253151	0.931914	0.3672
LEEF	-1.887184	1.813457	-1.040656	0.3157
LGCF	2.720604	1.502531	1.810680	0.0917
LGDP	-3.521556	1.651277	-2.132626	0.0511
LINF	0.024615	0.036226	0.679492	0.5079
LRD	1.850109	1.681151	1.100501	0.2897
LREC	-1.527351	1.069727	-1.427795	0.1753
C	56.25140	55.11755	1.020572	0.3248

R-squared	0.980873	Mean dependent var	28.10798
Adjusted R-squared	0.968576	S.D. dependent var	1.096426
S.E. of regression	0.194360	Akaike info criterion	-0.143870
Sum squared resid	0.528863	Schwarz criterion	0.346986
Log likelihood	11.72644	Hannan-Quinn criter.	-0.013646
F-statistic	79.77046	Durbin-Watson stat	1.687592
Prob(F-statistic)	0.000000		

SOURCE: Prepared by researcher on E- views

The OLS model shows that the model has high explanatory power, which is represented by the R-squared of 98 %.

Diagnostic test results

Table 10 presents the results of the Ramsey test, Breusch-Godfrey test, ARCH test, and VIF test. The Ramsey test indicates that the model is stable, with minimal issues related to omitted variables, and the results are statistically significant. The Breusch-Godfrey test confirms the absence of serial autocorrelation, supported by a statistically significant p-value. The ARCH test reveals no evidence of heteroscedasticity, while the VIF test demonstrates that there is no multicollinearity among the independent variables.

Table 10: Diagnostic test for the model

Diagnostic Tests	*Breusch-Godfrey test (Autocorrelation)*	*VIF test (Multicollinearity)*	*ARCH test (Heteroscedasticity)*	*Ramsey test (Identification)*	*Jarque-Bera test (Normality)*
	0.308	*0.001312: 27.59560*	*0.353*	*0.000*	*(0.06)*

SOURCE: Prepared by researcher on E- views

Table 11: Compare the GCC MODEL with Chinese model

VAR.	GCC	CHINA
MFV (Manufacturing, value added)	*IND. V*	*IND. V*
CO2 **(CO_2 emissions from manufacturing industries and construction (% of total fuel combustion))**	INSIG.	INSIG.
NGS **(Natural gas supply**	INSIG.	INSIG.
REC **(Renewable energy consumption (% of total final energy consumption)**	INSIG.	INSIG.
FEC **(Fossil fuel energy consumption (% of total)**	INSIG.	INSIG.
EEF (Total energy supply per unit of GDP, (energy efficiency	INSIG.	INSIG.
GCF (Gross capital formation (current US$)	INSIG.	**P.SIG.**
GDP	P.SIG.	N.SIG.
INF	N.SIG.	INSIG.
R&D (Research and development expenditure (% of GDP)	INSIG.	INSIG.

7- Findings, Recommendations, and Future Research:

7.1. Study Findings.

The study findings are as follows:

a. The variable (NGS) Natural gas supply: From the results of the three models, the variable has an insignificant relationship with manufacturing value added for the GCC countries.

b. The variable (INF) Inflation, consumer prices. From the results of the model, the variable has a negative significant relationship with Manufacturing, value added (current US$), where if INF increased by 1 unit the manufacturing value added will decrease for the GCC countries.

c. The variable (GDP): From the results of the model, the variable has a positive significant relationship with Manufacturing, value added (current US$) for OLS model, where DOL and FMOLS results are insignificant relationship.

d. The variable (GCF) Gross capital formation (current US$): From the results of the model, the variable has a positive significant relationship with manufacturing value added for FMOLS and OLS models, where the relation is insignificant for model DOL.

e. The variable (FEC) Fossil fuel energy consumption (% of total): From the results of the model, the variable has an insignificant relationship with manufacturing value added for the GCC countries.

f. The variable (EEF Total energy supply per unit of GDP, (energy efficiency): From the results of the model, the variable has an insignificant relationship with manufacturing value added for the GCC countries.

g. The variable (CO2) CO2 emissions from manufacturing industries and construction (% of total fuel combustion): From the results of the model, the variable has an insignificant relationship with manufacturing value added for the GCC countries.

h. The variable (REC) Renewable energy consumption (% of total final energy consumption): From the results of the model, the variable has a negative significant relationship with manufacturing value added for the GCC countries, for all models.

i. The variable (RD) Renewable energy consumption (% of total final energy consumption): From the results of the model, the variable has an insignificant relationship with manufacturing value added for the GCC countries, for all models.

China's Model:

a. The variable (NGS) Natural gas supply: From the results of the model, the variable has insignificant relationship with Manufacturing, value added (current US$),

b. The variable (INF) Inflation, consumer prices (annual %): From the results of the model, the variable has insignificant relationship with the manufacturing value added.

c. The variable (GDP): From the results of the model, the variable has a negative significant relationship with Manufacturing, value added (current US$), where if GDP increased by 1 unit the manufacturing value added will decrease by 3.5 US$.

d. The variable (GCF) Gross capital formation (current US$): From the results of the model, the variable has a positive significant relationship with Manufacturing, value added (current US$), where if GCF increased by 1 unit the manufacturing value added will decrease by 2.7 US$.

e. The variable (FEC) Fossil fuel energy consumption (% of total): From the results of the model, the variable has insignificant relationship with manufacturing value added.

f. The variable (EEF Total energy supply per unit of GDP, (energy efficiency): From the results of the model, the variable has a positive significant relationship with Manufacturing, value added (current US$), where if EEF increased by 1 unit the manufacturing value added will increase by 0.44 US$.

g. The variable (CO2) CO2 emissions from manufacturing industries and construction (% of total fuel combustion): From the results of the model, the variable has insignificant relationship with Manufacturing, value added (current US$).

h. The variable (R&D) Research and development expenditure (% of GDP): From the results of the model, the variable has insignificant relationship with Manufacturing, value added (current US$), where if CO2 increased by 1 unit the manufacturing value added will decrease by 0.08 US$.

i. The variable (REC) Renewable energy consumption (% of total final energy consumption): From the results of the model, the variable has insignificant relationship with Manufacturing, value added (current US$).

7.2. Recommendations:

Based on the document provided, here are some recommendations that can be extracted:

- Promote Sustainable Energy Paths: Base energy strategies on effective resource conservation, environmental protection, social acceptability, risk reduction, and collaborations with developing countries.
- Reduce Reliance on Fossil Fuels: Transition the construction industry to reduce its dependence on oil and other fossil fuels and lower CO2 emissions.
- Implement Stringent Government Policies: Governments should implement policies along with advanced tools for carbon emission analysis, calculation, and the adoption of sustainable materials to reduce emissions.
- Address Economic Costs: Find innovative solutions to make green construction more economically viable, as economic cost is a significant challenge.
- Increase Educational Awareness: Increase awareness and education about the benefits and methods of green construction.
- Close Policy Framework Gaps: Address gaps in policy frameworks to support the adoption of green construction practices.
- Utilize Industry 4.0 Technologies: Leverage technologies like AI, data analytics, and robotics to enhance efficiency and productivity in manufacturing.
- Diversify Revenue Sources: Given the potential decline in oil revenues, GCC countries should intensify efforts to diversify revenue sources through manufacturing.

7.3. Future Research

- The document does not explicitly detail specific avenues for future research. However, based on the content, we can infer potential areas for future investigation:
- Stakeholder Perceptions of Green Construction: Further research is needed to understand how diverse stakeholders perceive and respond to the driving forces behind carbon neutrality in the construction sector.
- Innovative Solutions for Economic Viability: Given that economic cost is a significant challenge in adopting green construction, research into innovative solutions to make green construction more economically viable is essential.
- Policy Framework Gaps: Further studies could explore and address the gaps in policy frameworks that hinder the adoption of green construction practices.
- Impact of Industry 4.0 Technologies: Investigating how the integration of Industry 4.0 technologies, such as AI, data analytics, and robotics, can further enhance efficiency and productivity in the manufacturing sector for construction would be valuable.
- Diversification of Revenue Sources: Research on effective strategies for GCC countries to diversify revenue sources through manufacturing, considering the potential decline in oil revenues, is warranted.
- Long-term impacts of green energy: Future research could investigate the long-term effects of green energy on economic prosperity, green economic recovery, and overall sustainability, using data from a wide range of countries and employing various analytical methodologies.

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المستخلص

يُعد قطاع البناء أكبر مستهلك للطاقة في العالم، وهو يُنتج عدم كفاءة في استهلاك الطاقة، مما يجعله هدفاً محتملاً لتحقيق الهدف المشترك المتمثل في التنمية المستدامة. ومع ذلك، فإن الاستهلاك المفرط للطاقة في البناء يؤثر سلباً على البيئة، بما في ذلك تلوث الهواء، وظاهرة الاحتباس الحراري، وتأثير الجزر الحرارية الحضرية، وغيرها من الآثار الضارة على صحة الإنسان والنمو الاقتصادي الاجتماعي. وتُعد الطاقة القائمة على الوقود الأحفوري المصدر الرئيسي للتلوث البيئي، حيث تمثل 84.7٪ من استهلاك الطاقة العالمي. بينما تمثل مصادر الطاقة المتجددة والطاقة النووية 5٪ و4٪ من إجمالي استهلاك الطاقة الأولية على التوالي.

يجب على صناعة البناء أن تقوم بتحول كبير نحو مستقبل طاقة مستدام. وفقاً لـ "هينيكي وفيشديك" (2006)، يجب أن تستند "مسارات الطاقة المستدامة" إلى مبادئ مثل الحفاظ الفعال على الموارد وحماية البيئة، والقبول الاجتماعي، وتقليل المخاطر والمساهمة في الحد من النزاعات الدولية، والتعاون العادل مع البلدان النامية. إن تبني القطاع لمثل هذا النظام سيتطلب حتماً تقليل الاعتماد على النفط والوقود الأحفوري الآخر، وخفض انبعاثات ثاني أكسيد الكربون، وتدخلات لتقليل التكاليف الاجتماعية، والاهتمام المناسب باختيار المواد، والتحول نحو الطاقة الخضراء أو المتجددة.

الكلمات المفتاحية: الطاقة الخضراء؛ التغيرات المناخية؛ دول مجلس التعاون الخليجي؛ قطاع التصنيع؛ نموذج الانحدار المتعدد