Influence of Information Technology in Achieving Construction Sustainability: Investigative study for Key Drivers and Barriers

Rizwan U. Farooqui[1], Aqsa Zaffar[2], Rana Rabnawaz Ahmed[2]
[1]Mississippi State University, Mississippi, USA
[1]NED University of Engineering and Technology, Karachi, Pakistan
rfarooqui@caad.msstate.edu

Abstract
In recent past, sustainability has gained significant attention due to growing environmental concerns, economic burdens, and social expectations around the world. The construction sector being a technology driven sector, demonstrates the use of various information technologies and it is believed that with the effective use of such technological support, sustainability can be better achieved. Therefore, the aim of this study is to find out and prioritize the key drivers and barriers to the effective adoption of sustainability as influenced by the use of information technology from the viewpoints of technical experts, design engineers, and construction managers. A quantitative methodology was employed, and data was collected by developing a questionnaire survey. The survey comprised of 25 factors i.e., 12 drivers and 13 barriers respectively, which are categorized into economic, social, environmental, technological and design, and legislative aspects. A descriptive statistics and the Pearson's correlation analysis were used to examine the responses of professionals working across different job roles. The results show that the economic and legislative factors are the most important drivers, whereas high expenses and regulatory gaps are the main barriers. Furthermore, the correlation study shows that the technical jobs have different views about the barriers but, have great agreement on drivers. This study leads to the conclusion that in order to remove barriers and promote the adoption of sustainability, an integrated strategy including financial incentives, industry-wide cooperation, and regulatory assistance is required.

Keywords
Sustainability, Information Technology, Drivers, Barriers, Correlation Analysis

1. Introduction
As per Brundtland (1987), the concept of sustainability is defined as, "the development which meets the needs of the present without compromising the ability of future generations to meet their own needs". As industrialization evolved, sustainability has become a significant concern in the global marketplace (Jamwal et *al.,* 2021). The term sustainability integrates social, environmental and economic concerns (Gimenez, et *al.,* 2012). It is exceedingly wide and challenging for organizations to comprehend and implement. The social components of sustainability are thus not explicitly included in the ecological approach that dominates most of the attention on sustainable development (Dao, et *al.,* 2017).

1.1.Sustainability and the Triple Bottom Line framework
A more modern approach to the sustainability has been the triple bottom line (TBL) concept (Dao, et *al.,* 2017). The TBL captures the essence of sustainability by measuring the impact of an organization's activities on the world including its social, human, and environmental capital as well as its profitability and shareholder values. Special attention is paid to the environmental element as problems in this field are most visible, significant and challenging to solve (Zhivkova, 2022). The economic line of TBL framework refers to the impact of the organization's business practices on

the economic system. The economic line ties the growth of the organization to the growth of the economy and how well it contributes to support it (Alhaddi, 2015). It corresponds with the value that the company creates and extends beyond its financial performance and financial concepts like cash flow, shareholder value, and sales growth to include the operational and economic business impact on society (Correia, 2019). The social line of the TBL refers to conducting beneficial and fair business practices to the labor, human capital, and to the community. The idea is that these practices provide value to the society and give back to the community. Examples of these practices may include fair wages and providing health care coverage. Aside from the moral aspect of being "good" to the society, disregarding social responsibility can affect the performance and sustainability of the business. Recent examples in the industries have revealed that there are economic costs associated with ignoring social responsibility (Alhaddi, 2015). Similar to the social aspect of TBL, environmental initiatives impact the business sustainability of the organizations. It pertains to the efficient use of energy recourses, reducing greenhouse gas emissions, and minimizing the ecological footprint, etc. (Alhaddi, 2015).

1.2.Sustainability and the Information Technology

Over the past 20 years, sustainability has become a key idea in business, development, cities, and economies (Scoones, 2007). Sustainable development is a crucial but contentious topic as a result of the global demand for environmentally friendly activities. Since most of the daily activities and company operations depend on technology, green IT has become more popular (Dezdar, 2017). It entails managing knowledge to address environmental concerns, such as lowering carbon footprints through energy-efficient methods like shutting down unused systems or creating data centers with minimal energy use (Mithas, et *al.,* 2010).

Corporate strategies and management systems are increasingly incorporating social and environmental responsibility (Giovannoni and Fabietti, 2013) due to the demand from society and government. In order to improve efficiency, competitiveness, and welfare, almost every country engages in international economic exchanges. Global integration and sustainable development are promoted by cross-border commerce in labor, capital, goods, and services (Zhivkova, 2022). Investors are shifting their investments to companies that embrace corporate sustainability because of its capacity to control risks and generate long-term value for shareholders (Knoepfel, 2001).

2. Problem Statement and Research Objective

Academicians and construction organizations, along with the global initiatives, supports an integrated approach to sustainability. However, little is known about the implementation problems (Giovannoni and Fabietti, 2013). The need to stop environmental damage and implement sustainable business practices is being increasingly recognized (Jenkin, et *al.,* 2011). Unregulated problems like population expansion, energy scarcity, water scarcity, and climate change would negatively impact economies and human well-being, according to scientists, economists, governments, and enterprises (Arowoshegbe et *al.,* 2016). Even sustainability is recognized as being crucial for long-term industry growth, putting it into practice is considered quite difficult. The findings of this study are intended to improve informed decision-making, encourage sustainable behaviors, and assist organizations and policymakers in creating focused initiatives.

This study examines how sustainable practices can be integrated into IT by identifying key adoption drivers and barriers. The objectives of this study are 1) to determine the organizational, financial, social, technological, and environmental factors that affects sustainability in IT; and 2) to analyze the identified drivers and barriers using spearmen correlation coefficient technique.

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3. Research Methodology

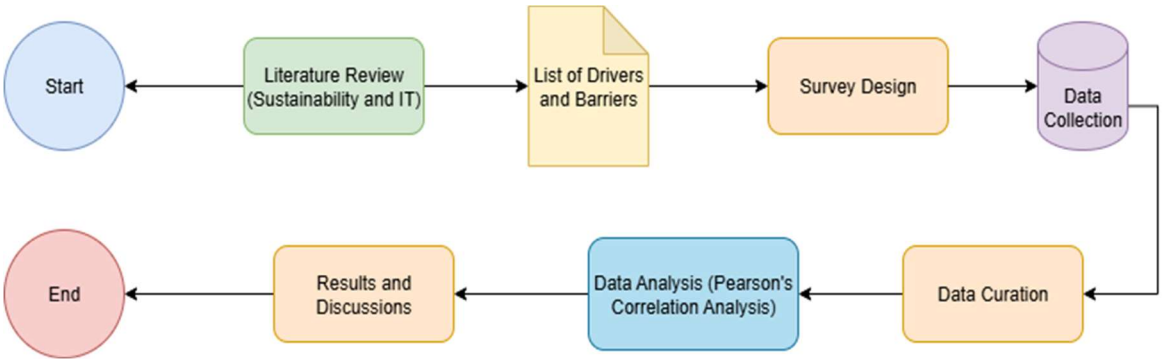

Fig. 1. Methodology of the study

The project's outcomes will help construction companies embrace sustainable practices, which will increase company efficiency and the impact on the environment. Below, Figure 1. Shows the research methodology adopted in this paper.

This study starts with literature review using key words sustainability and IT, through which different research articles were shortlisted. From the reviewed articles list of drivers and barriers were obtained. Afterwards, a questionnaire survey was designed to collect data for drivers and barriers prioritization. Furthermore, Pearson correlation coefficient analysis was performed to assess the correlation that exists b/w different group of audiences. At the end, results and discussion are presented.

4. Data Collection

A questionnaire survey consisting of 25 items i.e., 12 drivers and 13 barriers, was developed and distributed to industry experts. Each item was given a 5-point Likert scale. Respondents rated each item on a 5-point Likert scale (1=Strongly Disagree to 5=Strongly Agree). The final sample of 61 responses was analyzed using Excel to examine correlations between factors across different job roles.

5. Data Analysis and Results

The respondents were divided into three distinct groups i.e., Construction Managers, Design Engineers and Technical Specialists. The shortlisted drivers and barriers are presented in Table 1.

5.1. Reliability Analysis

Reliability analysis was performed using IBM SPSS Statistics 27 Software. To evaluate the internal consistency of scale used in study. In particular, Cronbach's Alpha was computed for all three groups as shown in Table 2 and Table 3 respectively, with the focus on both drivers and barriers to ascertain the degree of accuracy to which the components are measured.

Table 1. Classification of key Drivers and Barriers

Classification Category	Drivers	Barriers
Economic Drivers	✓ Reduced long-term costs. ✓ Availability of affordable training and educational courses. ✓ Secure and stable long-term growth.	✓ Low economic gain through green business and services. ✓ High initial capital cost. ✓ Uncertainty about return on investment.
Social Drivers	✓ Engagement with stakeholders (Clients, community, etc.). ✓ Social acceptance of green practices. ✓ Adoption of Green IT by more organizations.	✓ Resistance to change from traditional technologies. ✓ Lack of cooperation and networking. ✓ Not seen as a priority by senior management
Environmental Drivers	✓ Corporate strategy prioritizes sustainability in decision making processes. ✓ Designated staff responsible for environmental matters. ✓ Familiarity with green products/processes.	✓ Complexity of integrating green practices into existing systems. ✓ Lack of green materials suppliers.
Technological and Design Drivers	✓ Pressure from IT vendors to adopt green practices.	✓ Lack of knowledge and awareness of green building technologies. ✓ Lack of green building technological training for project staff. ✓ Lack of technical expertise and skills.
Legislative Drivers	✓ Government regulations. ✓ Financial incentives	✓ Absence of legal requirements for sustainability. ✓ Lack of incentives for sustainable practices.

Table 2. Reliability Statistics for the drivers of different categories

Reliability Statistics for Drivers	
Cronbach's Alpha	No of Items
0.855	12

The Cronbach's Alpha is found to be 0.855 for the drivers and 0.821 for the barriers. A satisfactory Cronbach's Alpha value indicated that the items exhibited good internal reliability. Since both values exceed 0.7, the data is considered reliable for further analysis.

Table 3. Reliability Statistics for the barriers of different categories

Reliability Statistics for Barriers	
Cronbach's Alpha	No of Items
0.821	13

5.2. Descriptive Statistics

Descriptive statistics method of analysis was used following the reliability analysis to give a thorough picture of the data. Mean of responses was calculated across different categories.

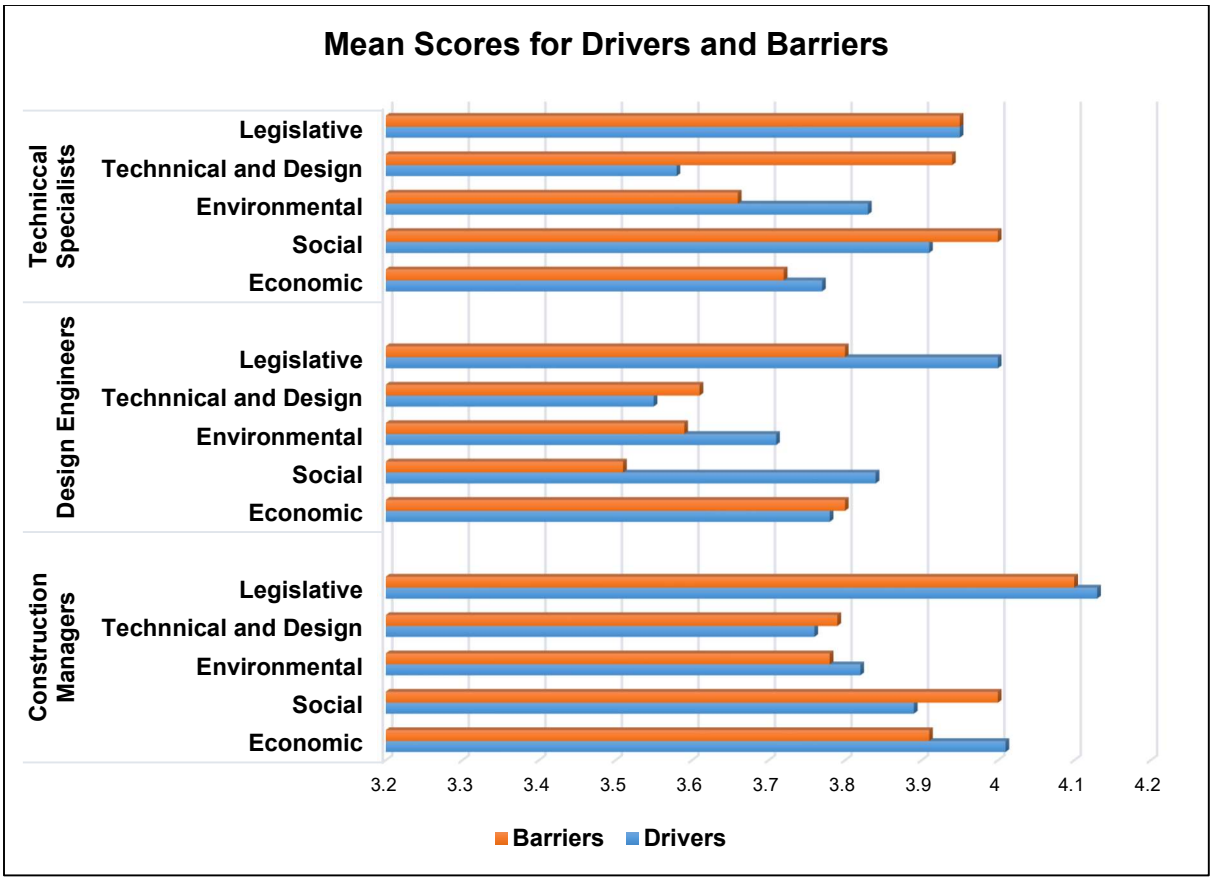

Fig. 2. Mean for the drivers of different categories

The bar graph in the Figure 2, displays the average scores of the five categories of drivers and barriers. The Legislative drivers ranked highest overall, particularly among Construction Managers (4.13). Economic drivers were also significant, especially for Construction Managers (4.01). Technological & Design drivers were slightly lower in influence, especially for Design Engineers (3.55). Whereas, Legislative barriers were the most significant challenge for Construction Managers (4.10). Economic barriers were highest for Design Engineers (3.80), suggesting budget constraints in design processes. Social barriers were notably high among Construction Managers and Technical Specialists (4.00), reflecting concerns about stakeholder resistance.

5.3. Pearson's Correlation Coefficient

The study utilized the Pearson correlation coefficient, which quantifies the linear relationship between two continuous variables, in this case the perceptions of barriers and drivers across various job roles. Since each category's mean value makes up the data, Pearson's correlation aids in determining the strength and direction of the relationship between these values across different job roles.

Table 4. Correlations between drivers according to different job roles

Job Role	Construction Managers	Design Engineers	Technical Specialists
Construction Managers	1	-	-
Design Engineers	0.89782545	1	-
Technical Specialists	0.685975499	0.920871306	1

Table 4 shows the correlation b/w drivers according to different job roles. There is a strong positive correlation b/w construction managers and design engineers (0.897), as well as, between design engineers & technical specialists (0.920). Whereas, there is a moderate positive correlation (0.685) b/w construction managers and technical specialists. This suggests that all three job roles perceive drivers for sustainability adoption similarly, with the strongest agreement between Design Engineers & Technical Specialists.

Table 5. Correlations between barriers according to different job roles

Job Role	Construction Managers	Design Engineers	Technical Specialists
Construction Managers	1	-	-
Design Engineers	0.39881610	1	-
Technical Specialists	0.55849515	-0.219149698	1

Table 5 indicates the correlation b/w barriers according to different job natures. There is a weak positive correlation b/w construction managers and design engineers (0.398). Whereas, there is a moderate positive correlation (0.558) b/w construction managers and technical specialists. While, a weak and negative correlation exists b/w design engineers & technical specialists (-0.219). The negative correlation between Design Engineers & Technical Specialists suggests that these two groups have opposing perceptions about barriers.

6. Discussion

6.1 Key Findings on Drivers

The analysis shows how different roles prioritize sustainability drivers. Legislative drivers received strong ratings from all groups, with construction managers scoring the highest (4.13), emphasizing the significance of rules for quality and compliance. Due to their emphasis on teamwork, Technical Specialists (3.91) and Design Engineers (3.84) placed more emphasis on social drivers than Construction Managers (3.89). Due to their budgetary obligations, construction managers gave economic drivers top priority (4.01), whereas technical specialists (3.77) and design engineers (3.78) gave them lower ratings since they place greater emphasis on design and innovation. Due to their practical implementation function, specialists (3.58) rated technological drivers higher than engineers (3.55), indicating a modest discrepancy. All groups gave environmental drivers modest grades (3.71–3.84), suggesting that economic and regulatory considerations take precedence over them.

6.2 Key Findings on Barriers

Similar to the pattern observed with drivers, the survey found different views of barriers across job roles. Design engineers experienced more economic challenges (3.80) from budgetary restrictions on materials and designs, while construction managers faced the greatest legislative hurdles (4.10) from their compliance obligations. Because implementation issues were not entirely evident during the design phase, technical specialists reported the highest technological hurdles (3.94), whereas engineers reported 3.59. Both managers (4.00) and experts (4.00) were more impacted by social barriers than engineers (3.51), indicating that they face similar difficulties in managing stakeholders. Interestingly, all groups gave financial or regulatory constraints a higher priority than environmental barriers, which is in line with the driver's analysis's secondary importance rating. All groups gave environmental drivers modest ratings, suggesting that economic and regulatory considerations take precedence over them.

6.3 Correlation between Drivers and Barriers

The correlation study showed clear trends in the perceptions of sustainability variables by roles. Design engineers and technical specialists exhibited a good correlation of 0.92 for drivers, indicating a shared technical focus on innovation and compliance. Their lower agreement (0.68) with construction managers highlighted the different interests of managers (costs/execution) and technical responsibilities (efficiency/technology). Barrier perceptions varied more significantly. The limited connection (0.39) between design engineers and construction managers demonstrated the differences in their challenges that is design/regulatory versus operational/financial. Interestingly, there was a negative correlation (-0.22) between Technical Specialists and Design Engineers on obstacles, highlighting their different viewpoints on implementation difficulties versus design limitations. These findings show that whereas technical roles generally agree on the factors that influence the adoption of sustainability, their experiences with these obstacles vary greatly depending on their specific positions within the project lifecycle.

7. Conclusions and Recommendations

This study aimed to explore the main driving forces and obstacles to the industry's adoption of sustainability from the viewpoints of technical experts, design engineers, and construction managers. According to the results, legislative drivers are consistently thought to have the greatest influence across all categories, underscoring the significance of governmental rules and incentives in promoting sustainable practices. While social and technological factors were more important for technical specialists and design engineers, economic factors were found to be especially important for construction managers. On the other hand, legal and economic hurdles were found to be the most significant difficulties. While design engineers were more concerned with budgetary constraints, construction managers and technical specialists emphasized regulatory restraints.
It also reveals an intriguing relationship between drivers and barriers. Despite being recognized, environmental considerations were not given top priority, suggesting a possible discrepancy in the industry's current priorities. Based on these results, this study recommends the necessity of a comprehensive strategy for adopting sustainability, in which laws, financial incentives, and industry cooperation are essential for converting obstacles into facilitators.

8. Limitations and Further Research

Despite the fact, this study, offers insightful information about the factors that encourage and hinder the adoption of sustainability in the IT sector. This study has few limitations as well, firstly, the 61-person sample size might not adequately represent the range of viewpoints from various geographical locations or project sizes. Furthermore, the study is cross-sectional, which means that while sustainability trends and policies are always changing, it represents industry perspectives at a particular moment in time. Future study could concentrate on comparison studies across several geographic regions to comprehend how sustainability adoption differs under various economic and regulatory contexts.

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