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Effects of Block Chain Adoption on Green Innovation: Moderating the Role of Intention to Use

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This study examines the moderating effect of intention to use on the relationship between blockchain technology and green innovation within the manufacturing sector of Saudi Arabia. The research employed a quantitative methodology and adopted a cross-sectional design. Data was obtained from a sample of manufacturing entrepreneurs using a self-administered questionnaire and a convenient sampling method. The research hypothesis was tested using the Partial Least Squares (PLS) - Structural Equation Modelling (SEM) technique. The findings suggest that both sustainable attitudes and sustainable behaviours exert a significant impact on the adoption of green innovation. However, it was observed that social perception does not have a significant effect on the perception of green innovation. The presence of another indirect moderating effect is observed, wherein the intention to use exhibits a significant and positive moderating influence on the relationship between sustainable orientation, social perception, and green innovation. However, it was found that the intention to use did not serve as a significant moderator between sustainable attitudes and green innovations. This study contributes to the advancement of a sustainable economy by offering a contemporary and scholarly assessment of the manufacturing sector. The initial investigations into blockchain technology primarily centred around the examination of organisational structures, consensus mechanisms, and performance-related issues. Subsequently, the researchers of this study examined the potential benefits of blockchain technology in the context of various case studies pertaining to energy consumption. The research study also introduced the concept of a moderating effect, as previous studies primarily concentrated on the direct effects of mediation. The study contributed to the existing body of literature by examining the extended moderating effect of intention to use on the relationship between blockchain technology and green innovation, specifically within the context of manufacturing companies in Saudi Arabia.

Keywords: Block chain, green innovation, intention to use, Saudi Arabia.

INTRODUCTION

The contemporary era encompasses an economic system that encompasses the acquisition of resources and the equitable distribution of said resources among the populace (Frizzo-Barker et al., 2020; Li, 2021). Technological advancement, particularly through the utilisation of Blockchain Open Innovation (BOI), has significantly contributed to the growth of countries and the progression of humanity. The topic of BOI has garnered significant attention in contemporary times due to its adoption of environmentally friendly practices and the associated advantages of implementing green initiatives (Frizzo-Barker et al., 2020; Li, 2021). The methods of conducting transactions are undergoing significant changes, with blockchain technology (BT) and open innovation (OI) emerging as key facilitators of these transformative processes (Jiang & Zheng, 2021; Polas et al., 2022). The global acceptance of BT and OI can be attributed to their significant importance. Currently, business enterprises are expanding their research studies by utilising a widely accepted method that is continuously improving through the use of digital tools.

The current business landscape places significant emphasis on sole proprietors and small enterprises, with a notable trend of increased attention from businesses. Simultaneously, customers and consumers are actively engaging in the process and assuming the role of co-creators. The necessity for blockchain-open innovation to undergo a reinvention process arises from its inherent limitations. This reinvention should be guided by a renewed sense of conviction and a re-evaluation of ideas that prioritise ethical principles (Kibria & George, 2022). The ubiquitous nature of blockchain technology (BT) prompts an intriguing examination of the relationship and interaction between BT and the Bank of India (BOI). Notably, the most captivating aspect of BT lies in its capacity to modernise the innovation process (Jiang & Zheng, 2021). By leveraging the assistance of BT, organisations can effectively implement business strategies and gain a competitive advantage in the market by enhancing their ability to rethink and adapt.

Green entrepreneurship (GE) serves as the primary driver of the green economy (GEC). The adoption of green innovations (GNI) in Saudi Arabia has exerted a significant influence on environmental concerns, thereby making a substantial contribution to the country's economic growth (EG) (Dubey, Gupta, Mikalef, & Akter, 2023; Mansfeld & Winckler, 2008; Ren et al., 2023). Therefore, eco-innovation plays a significant role in the development of ecological support systems and presents opportunities for addressing the depletion of natural resources (Hou et al., 2021; Ren et al., 2023). The gross national income (GNI) has been widely regarded as a

fundamental cornerstone for the advancement of industries, taking into account a multitude of factors. Businesses are increasingly adopting GNI methods in response to growing customer demand for eco-friendly products, the desire for a pollution-free environment, the well-being of the community, and government revenue management. The escalation of human desires and inclinations, coupled with the constraints imposed by limited resources, governmental policies, and community pressures, compel firms to strive for a harmonious equilibrium between corporate growth and sustainable long-term development (Dong et al., 2022; Polas et al., 2022).

The concept of genetic engineering (GE) has been evolving in response to the imperative of achieving sustainable development (SD) (Khan et al., 2021). In contrast, General Electric (GE) is widely regarded as a mechanism for enhancing quality of life and fostering enduring economic well-being. General Electric (GE) possesses the capacity to provide support in addressing various challenges, promoting the well-being of individuals, and optimising resource utilisation, as elucidated by the economic tetrahedron framework (Hou et al., 2021; Kouhizadeh & Sarkis, 2018). Several scholarly studies (Bai, Cordeiro, & Sarkis, 2020; Dong et al., 2022; Gao, Lin, & Lu, 2022) have provided evidence suggesting that the transition towards a green economy is effectively achieving its intended societal and economic objectives. The phenomenon of "Go Green" has been embraced on a global scale. GE also plays a role in the transformation of the green economy (GEC). According to Malhotra (2004), General Electric (GE) plays a significant role in fostering an environmentally sustainable and prosperous economy. This is achieved through the use of blockchain technology.

Therefore, the adoption of blockchain technology has garnered significant interest from various sectors, encompassing technology developers, financial institutions, startups, and energy firms, as well as academic and governmental institutions globally (Dong et al., 2022; Hou et al., 2021). This emerging technology has attracted widespread attention. Many industrial managers across various industries believe that BT possesses the capacity to yield numerous innovations and benefits. Blockchain technology (BT) is enabled by the decentralised nature of digital currencies (Yu et al., 2022). In a distributed system, the implementation of protected data storage techniques enhances the safety and reliability of the data. The blockchain technology exhibits fundamental attributes such as immutability and decentralisation (Schulz & Feist, 2021; Turoń, 2022).

BT has the potential to enhance the efficacy of markets, economies, processes, and the utilisation of resources in order to attain environmentally sustainable outcomes. Moreover, the utilisation of green energy sources has been found to contribute significantly to the mitigation of carbon dioxide emissions and the reduction of the greenhouse effect (Gajdzik & Wolniak, 2022a; Gausdal, Czachorowski, & Solesvik, 2018). Blockchain technology (BT) involves the creation of a secure and private network using a new framework introduced by Saudi Arabian industries. This framework incorporates the concept of graphic identification (GI) and aims to reduce the risks associated with the traditional server architecture. By eliminating the reliance on traditional centralised cloud servers, Bluetooth (BT) technology enables the continuous analysis of physical activities through a secure and energy-efficient infrastructure. Consequently, the Internet of Things (IoT) ecosystem exhibits a heightened emphasis on environmental sustainability, thereby fostering "green" innovation. The utilisation of blockchain technology is increasingly prevalent in the realm of green innovation (Gajdzik & Wolniak, 2022b; Weinreich et al., 2020).

Furthermore, the adoption of sustainable and environmentally friendly practices within the green orientation can contribute to the preservation and conservation of natural resources (Hernández-Dionis, Pérez-Jorge, Curbelo-González, & Alegre de la Rosa, 2022). The existing body of literature suggests that the utilisation of the GE strategy remains limited and calls for increased emphasis on its implementation. The implementation and adoption of green practices (GP) within the context of public attitudes, particularly in the workplace, are essential for the promotion of sustainable development (SD) and the establishment of environmental stewardship (Hawaldar et al., 2022). Promoting green innovation in manufacturing companies is a challenging endeavour due to the specific characteristics associated with standardised discoveries (Afshar Jahanshahi & Brem, 2020; Jiang & Zheng, 2021).

In order to circumvent the limitations imposed by industry standards, manufacturing companies must broaden their search for new sources of knowledge beyond their traditional industrial skill set, encompassing both internal and external avenues. Manufacturing companies, particularly those in the business sector, encounter limitations in generating the necessary information solely through internal research and development (R&D) efforts. According to the concept of open innovation (OI) utilising business ties (BT), as discussed by Afshar Jahanshahi and Jia (2018) and Hou et al. (2021), organisations engage in collaborative interactions with both competitors and external partners, leveraging their respective expertise, knowledge, and resources. Organisations are increasingly embracing environmentally sustainable practices, wherein both internal and external information blocks are being made more receptive. In this context, firms are swiftly adopting green infrastructure (GI) methods (Jahanshahi, Khaksar, Yaghoobi, & Nawaser, 2011; Khan et al., 2021) with the aid of blockchain technology.

There is a necessity to develop a comprehensive policy that focuses on addressing fundamental concerns related to environmental challenges and enhancing sustainable practices through the use of blockchain technology. It is recommended that the government make efforts to eliminate the obstacles hindering the adoption of environmentally friendly living practices, as suggested by ElSherif, Alomari, and Alkatheeri (2016). These barriers can be mitigated by cultivating a mindset of receptiveness towards innovation and actively engaging in collaborative

research endeavours with external researchers and participants (Afshar Jahanshahi & Jia, 2018; Schulz & Feist, 2021).

Based on the preceding discourse, it has been suggested that blockchain technology plays a significant role in the economies of developed nations (Han et al., 2023). However, it is noteworthy that its adoption in developing economies is still in its nascent phase (Han et al., 2023).

Furthermore, previous studies have primarily concentrated on examining the direct impact of sustainable attitude (SUA), sustainable orientation (SUO), and social perception (SUP) on green innovation (GNI) (Guo, Zhang, & Zhang, 2022). However, there has been limited attention given to investigating the indirect moderating effect, as existing research has primarily focused on the mediating effect of intention to use (Polas et al., 2022). Previous studies have also demonstrated inconsistent findings (Polas et al., 2022; Zhang, Yang, & Lv, 2022). According to Baron and Kenny (1986), it is posited that the presence of inconsistent results necessitates the inclusion of a moderating variable. Therefore, the concept of intention to use may serve as a moderating variable in the relationship between exogenous and endogenous variables.

Additionlly, prior research has predominantly focused on countries other than Saudi Arabia, with limited investigations conducted on the manufacturing sector of Saudi Arabia. Manufacturing companies in Saudi Arabia have significantly contributed to the social and economic aspects of the country (AlAzzawi, 2021). Therefore, the purpose of this study is to examine the moderating influence of intention to use on the relationship between blockchain adoption and green innovation in the manufacturing sector of Saudi Arabia, building upon existing research gaps. The findings have the potential to inform researchers and policymakers about the implications of technology adoption for promoting green innovations. The study was divided into five sections. The first section provided an introduction, followed by a literature review in the second section. The third section outlined the research methodology, while the fourth section presented the data analysis and findings. Lastly, the fifth section encompassed the discussion and future recommendations.

REVIEW OF LITERATURE

Green Innovation

The term "coopetition" is assumed when discussing the concepts of "open innovation (OI) and blockchain technology (BT)." Indeed, the utilisation of classification algorithms, artificial intelligence methodologies, and data science techniques has proven to be advantageous for competitors in gaining a market edge through the consolidation of their data and information (Gao, Lin, & Lu, 2022; Kouhizadeh & Sarkis, 2018; Will & Güroğlu, 2016). In order to enhance the efficacy of this collaboration, the implementation of a novel governance model centred around the notion of a shared information source has become necessary. The implementation of complete blockchain open innovation posed significant challenges and may not be applicable to all use cases. The achievement of this objective is contingent upon the network encountering intense competition (Aboelmaged & Hashem, 2019; Bai, Cordeiro, & Sarkis, 2020).

Nevertheless, our belief was that the integration of BT, alongside other sophisticated open-source technologies, and the implementation of blockchain open innovation had the potential to generate the most groundbreaking value. The fundamental aspect underlying the interaction between individuals and organisations may revolve around the absence of trust in blockchain-based business services, which is rooted in the principles of integrity and confidentiality within the human-technology service alliance. Individuals have the ability to access and review their transaction records on the Bitcoin network, as it consistently retains a permanent transaction history at every node within the blockchain (Dong et al., 2022; Khan et al., 2021; Nurgazina, Pakdeetrakulwong, Moser, & Reiner, 2021; Turoń, 2022). Furthermore, individuals may opt for anonymity in order to protect their privacy and facilitate third-party verification of their identities (Chuard et al., 2022; Millers & Gaile-Sarkane, 2021), given that blockchain transactions are recorded through both private and public methods, such as the utilisation of extensive data sequences that are not readily accessible.

Sustainability Orientation

Several strategies were implemented in order to attain sustainable performance by preserving a necessary way of life for the future and maintaining ecological balance (Majid Gilani & Faccia, 2022; Poberezhna, 2018). Previous concepts aimed at achieving sustainability have been encompassed within the broader framework of sustainability, which has established a connection with the environment in order to safeguard future generations from deprivation (Chang et al., 2018; Fatoki, 2021). The utilisation of this methodology proved to be advantageous in the process of operationalizing sustainability, as it encompassed the consideration of various dimensions such as social, environmental, and economic aspects (Polas & Raju, 2021; Will & Güroğlu, 2016). Individuals who demonstrate an interest in the environment tend to exhibit greater involvement in sustainable initiatives (Cheng, 2020; Nurgazina, Pakdeetrakulwong, Moser, & Reiner, 2021; Polas et al., 2022).

According to research (Aboelmaged & Hashem, 2019; Jiang, Lyu, Ye, & Zhou, 2020; Millers & Gaile-Sarkane, 2021), people who exhibit a propensity for incorporating sustainability considerations into their activity planning demonstrate a profound appreciation for the sustainability movement. The concept of sustainable orientation (SO) encompasses the examination of both cultural and environmental factors (Majid Gilani & Faccia, 2022). The concept of SO was primarily conceived with the objective of establishing and fostering sustainable enterprises (Cheng, 2020; Nurgazina, Pakdeetrakulwong, Moser, & Reiner, 2021; Polas et al., 2022). Numerous studies have demonstrated a significant and positive correlation between the adoption of green innovation and sustainable operations (Majid Gilani & Faccia, 2022; Purwanto et al., 2022). Fatoki (2021) discovered that the adoption of GI enhances the advantageous impacts of SO. Entrepreneurs

operating businesses have also disclosed that governmental intervention (GI) yields favourable effects on social outcomes (SO) (Afshar Jahanshahi, Al-Gamrh, & Gharleghi, 2020; De la Vega Hernández, Urdaneta, & Carayannis, 2023; Jiang, Lyu, Ye, & Zhou, 2020).

Sustainability Attitude

Attitude can be conceptualised as an individual's subjective evaluation or appraisal of another person's conduct within specific contextual circumstances (Huong et al., 2021; Polas et al., 2022). Individuals may exhibit a range of attitudes, encompassing both negative and positive perspectives, towards a particular situation or behaviour. These attitudes have the potential to influence the motivation to adopt green infrastructure (GI). Furthermore, a number of studies have demonstrated that individuals' perception and attitude play a significant role in motivating their entrepreneurial aspirations, with emotional implications for their adoption of the GI (Chang et al., 2018; Sánchez-Bravo et al., 2020; Wang, 2020). According to recent studies conducted by Adomako and Amankwah-Amoah (2021) and Zhang, Zhang, and Zhou (2021), it was found that attitude plays a significant role in shaping individuals' intention towards sustainability (Ling, Tong, & Ahmed, 2013; Sánchez-Bravo et al., 2020) and their commitment to pro-environmental behaviours.

The self-mental attitude of individuals has been found to influence their preferences and engagement in specific behaviours. Furthermore, the manner in which individuals approach and engage in cognitive processes holds significant significance in the acceptance and implementation of green entrepreneurship and green innovation (Arici & Uysal, 2022; Kim & Hall, 2021). Numerous scholarly investigations have elucidated the impact of attitude on the adoption of green initiatives (GI) (Polenzani, Riganelli, & Marchini, 2020; Zailani et al., 2015). The studies conducted by Huang, Li, and Lee (2021) and Abu Seman et al. (2019) have demonstrated that individuals' attitudes have a significant impact on their pro-environmental performance, leading to the emergence of green innovation. According to Sung and Park (2018), individuals' attitudes, whether positive or negative, can influence their motivation to engage in sustainable behaviours that contribute to the advancement of the green economy. In their study, Tjahjadi et al. (2020) observed a correlation between individuals' opinions and their consumer environmental behaviour.

Social Perception

Social perception has influenced both group and individual activities as external factors. societal pressures have an impact on people's behavior, particularly in relation to gender identity (Abdullah, Zailani, Iranmanesh, & Jayaraman, 2016). There is an increasing level of concern among individuals regarding the perception of their social image by the general public. The analysis conducted in this study focused on the personal conduct of entrepreneurs, specifically examining their social perception and intention to implement green innovation (GI). The findings of this analysis revealed a positive association between these factors and the achievement of green economic stability (Flores & Jansson, 2021; Tölkes, 2020). Social perception refers to the influence it has on individuals' inclination to accept or reject certain behaviours. This influence has prompted business professionals to embrace green innovation (GI) through the implementation of green entrepreneurship (GE) activities (Arici & Uysal, 2022; Huong et al., 2021; Jiang, Lyu, Ye, & Zhou, 2020). Social perception (SP) encompasses individuals' perceptions of the societal expectations and pressures that influence their behaviour, leading them to either conform to or deviate from these expectations (Arici & Uysal, 2022; Chang et al., 2018).

According to a growing body of research, people's self-perception in society has an impact on their motivation to engage in green entrepreneurship and innovation. Consequently, this heightened their inclination to engage in such behaviour and prompted them to embrace environmentally-friendly innovations that incorporate green energy technologies. The influence of public opinion plays a significant role in shaping individuals' decisions to engage in criminal activities (Arici & Uysal, 2022; Tölkes, 2020). Rural individuals exhibited a greater propensity to embrace technological advancements, thereby facilitating an improved and contemporary way of life (Aydın & Alvarez, 2020; Tih & Zainol, 2012). In the contemporary global context, individuals residing in diverse geographical regions are afforded equitable opportunities for personal development and advancement. Individuals experience heightened levels of optimism as they progress and develop within societal and business contexts (Pan, Liu, Bai, & Ma, 2021; Tih & Zainol, 2012). The perception of individuals residing in rural areas is characterised by gratitude and optimism, which subsequently influence their inclination to embrace green practices and engage in green entrepreneurship (Polas et al., 2022).

This section examines the empirical correlation between blockchain technology, intention to use, and green innovation.

Blockchain Technology, Intention to use, Green Innovation

BT and GI are considered to be significant components of blockchain technology due to their positive environmental impact compared to fossil fuels. These green, renewable energy sources have emerged as crucial elements in the context of blockchain technology. Geothermal heat, wind, rain, and sunlight are examples of renewable energy sources that have the potential to be harnessed for electricity generation (Flores & Jansson, 2021; Guo, Wang, & Chen, 2020; Guo, Wang, & Yang, 2020). These resources are used for the production of environmentally friendly and sustainable energy. In contemporary times, the advancement of renewable energy equipment has facilitated entrepreneurs in generating environmentally friendly energy through the utilisation of these technologies, thereby reducing their reliance on costly electricity (Huong et al., 2021). The objective of implementing green practices is to harness and utilise the plentiful and cost-free energy resources bestowed by the natural environment. The smart grid is a contemporary electricity generation system that enables digital

communication through the utilisation of information technology (Qiu, Hu, & Wang, 2020; Thukral, 2021).

Smart grids have the potential to address the various obstacles associated with security, connectivity, and data transmission. Renewable energy sources exhibit volatility and unpredictability, necessitating the integration of advanced technologies into the current network (El-Kassar & Singh, 2019; Feng et al., 2020). To promote the utilisation of sustainable resources and foster environmental improvement, a smart-grid system based on blockchain technology is implemented. The recently introduced forking attack is applied in an inverse manner to the blockchain within the suggested paradigm. In the context of the energy grid concept, stakeholders have been engaged through a combination of centralised power and decentralised peers. The implementation of this technological advancement holds promise for augmenting ethical smart grid systems and fostering environmental sustainability (Alsharari, 2021; Alshurideh, Kurdi, Shaltoni, & Ghuff, 2019). The blockchain system is presumed to possess the capability to effectively forecast and present information pertaining to energy-related impacts (Adolphs, Nummenmaa, Todorov, & Haxby, 2016; Ahmad, Madi, Abuhashesh, & Nusairat, 2020).

The enhancement of the energy supply network has the potential to promote environmentally friendly practices, resulting in the development of advanced market models for green infrastructure (Li et al., 2019; Singh, Jain, Munjal, & Rakesh, 2019). The utilisation of smart contracts and blockchain technology holds the potential to provide transparent and secure platforms that facilitate the development of innovative and environmentally sustainable business solutions (Anggadwita & Dhewanto, 2016; Ye, Hofacker, Peloza, & Allen, 2020). In a separate study, Polas et al. (2022) discovered that sustainable orientation and a sustainable attitude exert a positive and statistically significant impact on green innovation. However, the researchers found that social perception has an insignificant effect on green innovation, as indicated by the same study. The present study provides additional evidence that a sustainable orientation can have an impact on green innovation (Guo, Wang, & Chen, 2020; Polas et al., 2022). Moreover, previous research has also demonstrated that social perception and a sustainable attitude have a positive and significant influence on green innovation (Guo, Wang, & Chen, 2020; Yu, Park, Lee, & Han, 2021). Thus, based on previous discussion, following hypothesis is formulated below.

H1: sustainable orientation has positive and significant effect on green innovation.

H2: sustainable attitude has positive and significant effect on green innovation.

H3: social perception has positive and significant effect on green innovation.

H4: intention to use has significant moderating role between sustainable orientations and green innovation.

H5: intention to use has significant moderating role between sustainable attitude and green innovation.

H6: intention to use has significant moderating role between social perception and green innovation.

RESEARCH FRAMEWORK

Based on the preceding discourse, it has been suggested that blockchain technology plays a significant role in the economies of developed nations (Han et al., 2023). However, it is noteworthy that its adoption in developing economies is still in its nascent phase (Han et al., 2023). Furthermore, previous studies have primarily concentrated on the direct impact of sustainable attitude (SUA), sustainable orientation (SUO), and social perception (SUP) on green innovation (GNI) (Guo, Zhang, & Zhang, 2022). However, there has been limited attention given to the indirect moderating effect, as research has mainly been conducted on the mediating effect of intention to use (Polas et al., 2022). Previous studies have also demonstrated inconsistent findings (Polas et al., 2022; Zhang, Yang, & Lv, 2022). According to Baron and Kenny (1986), the presence of inconsistent results necessitates the inclusion of a moderating variable. Hence, the concept of intention to use has the potential to serve as a moderating variable in the relationship between exogenous and endogenous variables. Furthermore, prior research has predominantly focused on countries other than Saudi Arabia, with limited investigations conducted on the manufacturing sector of the latter. Manufacturing companies in Saudi Arabia have significantly contributed to the social and economic landscape of the country (AlAzzawi, 2021). The purpose of this study is to examine the moderating role of intention to use in the relationship between blockchain adoption and green innovation within the manufacturing sector of Saudi Arabia, building upon existing research gaps. The variables under investigation are depicted in Figure 1 below.

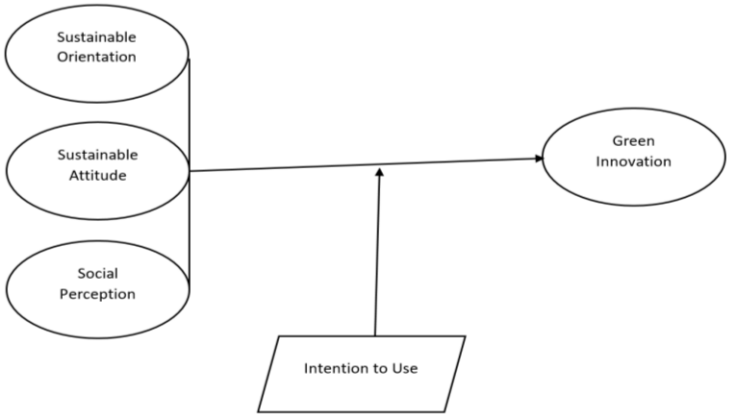

Figure 1: Research Framework

RESEARCH DESIGN AND RESEARCH INSTRUMENT

The primary objective of this study is to examine the impact of environmental management blockchains on green innovation, taking into consideration the moderating effect of intention to use. In the present study, a positive approach was employed to gain an understanding of empirical knowledge derived from a hypothesis (Krmela, Šimberová, & Babiča, 2022). The quantitative investigation encompassed various factors (Kaur et al., 2022). Saudi Arabia has implemented significant economic reforms in recent years, making it a compelling case for analysis. To promote the adoption of sustainable and environmentally friendly practices, Saudi Arabia has implemented a series of regulations pertaining to sustainability and engaged in training initiatives. The present investigation focuses on the manufacturing sector of Saudi Arabia. Manufacturing firms have been responsible for approximately one-third of global carbon dioxide emissions and energy consumption (Huang & Li, 2017).

Saudi Arabia is considered to be the most environmentally sustainable city among the leading cities worldwide in terms of green initiatives (Tang et al., 2018). In the past decade, there has been a significant increase in the recognition and interest surrounding the concept of the "green worldview" (Singh, Giudice, Chierici, & Graziano, 2020). Given the significance of this subject matter, it is imperative to undertake this investigation. In order to assess the level of green innovation (GNI), we utilised a set of four items as proposed by Chang, Chen, and Lu (2019). The measurement of the sustainability attitude (SUA) was conducted using four items that were derived from the research conducted by Chen and Hung (2016). Four items were used to measure social perception (SUP), which were adopted from the study conducted by Kervyn, Fiske, and Yzerbyt (2015). Finally, the construct of "intention to use" (INU) was assessed using a set of four items that were adopted from the research conducted by Chang and Cheung (2001). The survey questionnaire employed a Likert scale consisting of five points, where a rating of 1 indicated strong disagreement and a rating of 5 indicated strong agreement.

DATA COLLECTION PROCEDURES

Data collection was conducted by distributing self-administered questionnaires among manufacturing entrepreneurs. A total of 500 research questionnaires were distributed, out of which 250 were received. The data collection process employed a convenient sampling technique, which was suggested by research assistants who possessed local expertise in the field of research. In order to enhance comprehension among respondents, our questionnaires incorporate two languages, namely English and Saudi Arabian. The absence of common method bias was confirmed by the finding that Harmon's one factor value was below 50%, indicating the absence of such bias. According to Cocco, Pinna, and Marchesi (2017), the presence of multicollinearity is suggested when the values of the variance inflation factor (VIF) are less than 1 or greater than 10. The variance inflation factors (VIF) in our study were found to be below 5, indicating the absence of multicollinearity concerns.

DATA ANALYSIS AND FINDINGS

In order to validate the precision of our analysis, we conducted "Partial Least Squares (PLS)-structural equation modelling (SEM)" on our research model. Smart PLS is employed in order to assess the validity, reliability, and feasibility of data analysis. Cocco, Pinna, and Marchesi (2017) suggest that it may be possible to determine the necessary sample size by utilising the partial least squares structural equation modelling (PLS-SEM) approach. It has been demonstrated that partial least squares structural equation modelling (PLS-SEM) is a highly valuable tool for effectively managing both structural models and measurements. Furthermore, it has been found to be effective in evaluating intricate route models (Pournader, Shi, Seuring, & Koh, 2020). PLS-SEM has the potential to effectively handle small sample sizes and yield highly accurate outcomes. Partial Least Squares Structural Equation Modelling (PLS-SEM) was identified as a suitable tool for our research inquiry. The evaluation of the measurement and structural model involved the utilisation of statistical measures, including tests for convergent validity and discriminant validity.

Assessment of Inner Model

The results of the measurement model have been presented below. The magnitude of the outer loading (Esmaeilian, Sarkis, Lewis, & Behdad, 2020) may exceed 0.5. According to the findings presented in Table 1, the outer loading results exceed the threshold of 0.5. When the composite reliability results exceed a threshold of 0.7, it is recommended to evaluate the internal consistency of the reliability. The findings indicate that the reliability of the study is 0.7 or higher. Andoni et al. (2019) suggests that a Cronbach's alpha coefficient greater than 0.7 is advisable. The results presented in Table 1 indicate that the Cronbach alpha value exceeds 0.7. As a result, it can be observed that all values of the construct satisfy the criteria set forth by Cronbach's alpha. The concept of "average variance extracted" (AVE) is utilised in order to evaluate the degree of convergent validity. In order to uphold convergent validity, it is necessary for the loading factors of both items to exceed 0.5. The AVE value exceeded 0.5. All the aforementioned outcomes are anticipated and presented in Table 1 and Figure 2, as depicted below.

Table 1. Reliabiltiy and Validity

	Alpha	CR	AVE
GNI	0.905	0.934	0.779
INU	0.876	0.905	0.705
SUA	0.806	0.844	0.575
SUO	0.89	0.924	0.753
SUP	0.771	0.82	0.605

Source: Authors estimations

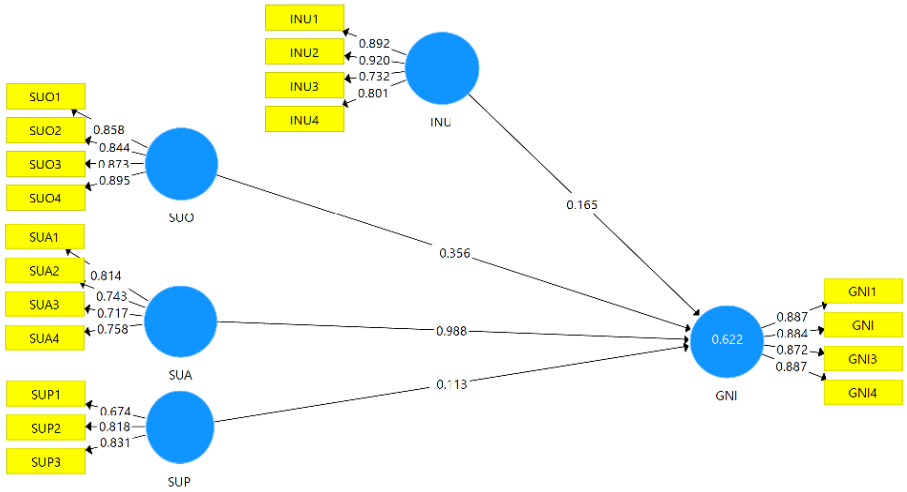

Figure 2: Measurement Model

Furthermore, Table 2 presents a comparison between latent variables and their respective square roots. The Fornell-Larcker method was utilised to evaluate the validity of the proposed model (Miglani, Kumar, Chamola, & Zeadally, 2020). The square root of the figures for the whole variables, as well as the average of the square values, are found to be greater than the other diagonal values. This observation suggests that the construct demonstrates discriminant validity in relation to Fornell Larcker. The present study provides empirical evidence supporting the discriminant validity of the research model. Furthermore, Table 2 below displays the descriptive statistics. Nevertheless, the heterotrait-monotrait (HTMT) values were found to be below 0.85, as indicated in previous scholarly works. This implies that the HTMT readings should consistently be below 0.85 in order to establish discriminant validity. Hence, the findings indicate that the construct exhibits discriminant validity, as depicted in Table 3, presented below.

Table 2. Desriptives and Fornell and Larcker

	Mean	SD	GNI	INU	SUA	SUO	SUP
GNI	3.134	0.982	0.883				
INU	3.451	0.897	0.361	0.84			
SUA	3.562	0.882	0.736	0.428	0.759		
SUO	3.652	0.872	0.354	0.38	0.73	0.868	
SUP	3.451	0.762	0.342	0.809	0.563	0.658	0.778

Source: Authors estimations

Table 3. HTMT

	GNI	INU	SUA	SUO	SUP
GNI					
INU	0.331				
SUA	0.667	0.435			
SUO	0.393	0.401	0.089		
SUP	0.426	0.071	0.78	0.809	

Source: Authors estimations

Coefficient of Determination (R Square)

The R-squared values for the coefficient of determination were calculated using the Smart PLS software. The collective influence of exogenous variables on the endogenous variable yielded a coefficient of 0.45, suggesting a 45 percent alteration in the dependent variable. In contrast, Khatoon et al. (2019) proposed the utilisation of three alternative R2 values, namely CUO at 20 percent, SUP at 25 percent, and SUO at 30 percent, in order to assess the three distinct impacts. Based on the findings, it can be observed that the independent variables exert a significant impact on the dependent variable, IU. Following the process of moderation, the obtained R square value of 55 percent suggests a significant influence of INU on the adoption or rejection of the green innovation strategy (Pournader, Shi, Seuring, & Koh, 2020).

The R square values of the INU moderating effect exceed 50 percent, indicating that the study's objectives have been successfully accomplished. Additionally, the lower value of the standardised root mean square residual (SRMR) suggests that this particular model is appropriate for the given dataset (Moosavi, Naeni, Fathollahi-Fard, & Fiore, 2021). According to Zhang and Wen (2017), the model has a higher predictive value than zero. The assessment of the predictive capability of the widely used PLS path model is conducted through the utilisation of cross-validated communality approaches. The predictive validity of the model is evident in Table 4. The intention to use it has a moderate impact on the adoption of green innovations. In general, the model demonstrates a high level of fitness and exhibits a notable ability to generate accurate predictions.

Table 4. Q Square

	SSO	SSE	Q² (=1-SSE/SSO)
GNI	1352	705.986	0.478
INU	1352	1352	
SUA	1352	1352	
SUO	1352	1352	
SUP	1014	1014	

Source: Authors estimations

Direct Analysis

Table 4 displays the direct results of the hypotheses. Bootstrapping was employed to calculate the t values. When conducting social science research, it is common practice to consider a 95% confidence level, as indicated by the p-value provided by Smart PLS (Durst & Gerstlberger, 2020). The initial hypothesis received empirical support as the data revealed a significant and positive correlation between the adoption of sustainability strategies and the utilisation of environmentally friendly innovations. The findings of our study are consistent with

the research conducted by Durst, Svensson, and Palacios Acuache (2021), as well as Gharleghi and Jahanshahi (2020). The adoption of green innovation is supported by a positive influence on sustainability attitudes, as hypothesised. The findings of our study are consistent with the results reported by Lumpkin and Dess (2001) as well as Dinc and Hadzic (2018). The results of the study revealed that there is no significant correlation between social perception and the adoption of green innovation. This finding contradicts the initial hypothesis that was proposed. These results are consistent with previous findings that have also demonstrated similar outcomes (Polas et al., 2022). The anticipated outcomes are presented in Table 5 below.

Table 5. Direct Effect Results

	Original Sample	Sample Mean	Standard Deviation	T Statistics	P Values
SUA -> GNI	0.988	0.985	0.049	20.119	0.000
SUO -> GNI	0.356	0.348	0.059	6.024	0.000
SUP -> GNI	0.113	0.114	0.071	1.586	0.113

Source: Authors estimations

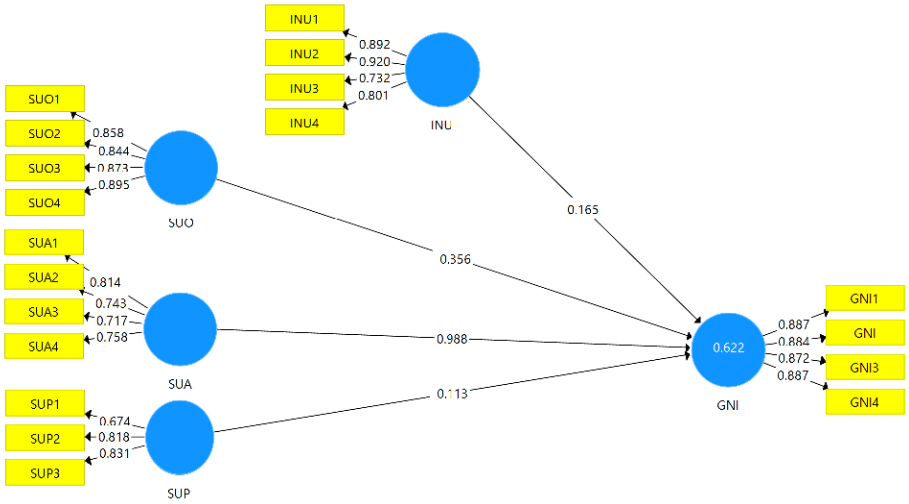

Figure 3: Structural Model

Moderating Analysis

This study used a two-step method to look at how intention to use affects the relationship between SUP, SUO, and SUA and green innovation (GRI), with a focus on the early intention to use. The results of this study indicate that the transformations SUP*INU → GRI and SUO*INU → GNI have a statistically significant indirect relationship. The researchers conducted an analysis of the impacts of INU, SUP, and SUO on GNI in order to observe the moderating effect of INU. The findings suggest that there is no significant relationship between sustainable attitude and gross national income (GNI) when considering the moderating effect of individual need for uniqueness (INU). However, the moderating effects of self-unique orientation (SUO) and social unique orientation (SUP) on INU are positively and significantly related. This indicates that INU plays a significant role as a moderating variable for the relationship between SUO and SUP, as shown in Table 6 below. Hence, the outcomes obtained in our study align with the research discoveries of Pollack et al. (2016) as well as Li (2020). The anticipated outcomes of the moderating effect are presented in Table 6 below.

Table 6. Moderating Effect Results

	Original Sample	Sample Mean	Standard Deviation	T Statistics	P Values
INU*SUA -> GNI	0.089	0.088	0.071	1.258	0.209
INU*SUO -> GNI	0.110	0.113	0.046	2.398	0.017
INU*SUP -> GNI	0.123	0.121	0.057	2.174	0.03

Source: Authors estimations

DISCUSSION AND CONCLUSION

The utilisation of blockchain technology has demonstrated its considerable importance in facilitating the effective management of financial markets, smart cities, e-governance, and energy systems, thereby fostering green innovation and the development of a sustainable ecosystem (Cao & Chen, 2019). Blockchain technology facilitates transparent, unadulterated, unaltered, and secure transactions. The rapid integration of blockchain technology with the Internet of Things (IoT) is currently taking place. Research on the Internet of Things (IoT) and its development has proven beneficial in addressing the challenges and obstacles encountered in the implementation of blockchain technology. In recent years, there has been a growing interest in blockchain technology (Comrey & Lee, 2013). This study was conducted to examine the significance of blockchain technology in enhancing eco-friendly Internet of Things (IoT) systems, as well as explore the various factors that impact blockchain technology. The aim of this study appears to be to examine the timely and suitable evaluation of

blockchain technology within the environmentally sustainable and eco-friendly sector of the Internet of Things (IoT). The green economy experiences enhancement through the adoption of sustainable and environmentally-friendly Internet of Things (IoT) practices.

The findings of this study indicate that societal perspective, sustainable mindset, and sustainability orientation significantly impact the development of green initiatives and mindsets. Green innovations have the potential to facilitate the advancement of educational and mindfulness programme frameworks that prioritise the integration of sustainable practices and green innovation. These practices are beneficial for the establishment of environmentally sustainable companies. The implementation of green practices facilitates the establishment of environmentally friendly enterprises, thereby enabling Saudi Arabia to successfully transition towards a green economy. To ascertain the alignment between economic benefits and the green agenda, the green economy places significant emphasis on fostering green innovation and cultivating a green mindset among manufacturing entrepreneurs. The findings of this study are consistent with prior research conducted by Polas et al. (2022), which also demonstrated a positive and significant relationship between green attitude, sustainable orientation, and green innovations.

The impact of social perception on green innovation was found to be statistically insignificant, suggesting that social perception does not play a significant role in driving green innovation (Polas et al., 2022). These findings are consistent with prior research (Liu, Guo, Zhang, & Mao, 2023). The moderating effect of intention to use was found to have a positive and significant impact on the relationship between social perception, sustainable orientation, and green innovation. However, it was found to have an insignificant effect on the relationship between green attitude and green innovation. This suggests that the construct of intention to use is not a significant moderating variable between green attitude and green innovation. Based on the aforementioned findings, it can be inferred that sustainable attitude, sustainable attitude, and social perception are significant variables that can assist organisations in enhancing their green innovations, thereby bolstering their competitiveness on an international scale.

IMPLICATIONS OF THE STUDY

The study made a valuable contribution to the existing body of literature, encompassing both theoretical and practical aspects. Previous research has primarily concentrated on nations other than Saudi Arabia, with limited emphasis on developing countries. Hence, this research has made a valuable contribution to the existing body of literature from the perspective of Saudi Arabia. Furthermore, previous research has predominantly examined the direct impact of social perception, sustainable attitude, and sustainable orientation on green innovation. However, there has been limited investigation into the indirect influence of the moderating effect of intention to use. Consequently, this study makes a valuable contribution to the existing literature by exploring the moderating effect, as previous studies have primarily focused on either direct effects or mediating effects (Polas et al., 2022). Current research plays a pivotal role in fostering the growth of the green economy by offering cutting-edge information and scholarly assessments. The initial investigation of blockchain technology focused on the analysis of system architectures, performance challenges, and distributed consensus mechanisms. In this study, the researcher examined the potential benefits of utilising blockchains in relation to various energy consumption scenarios.

This study conducted an analysis of various blockchain activities (Armstrong & Overton, 1977), with the aim of shedding light on specific domains in which entrepreneurs and stakeholders actively seek environmentally friendly innovations. We have examined several projects that are currently in the early stages of development and have focused on studying the critical aspects of decentralisation, security, and scalability that are still being implemented. The widespread adoption of blockchain technology in the energy sector is hindered by various obstacles, such as regulatory, competitive, and legal barriers. These impediments pose a significant risk to energy firms. The findings of this study will provide insights into the potential of this technology and its commercial viability, as well as its acceptance within the broader community. Furthermore, the results of the study generate enthusiasm and drive for the expansion of environmentally conscious entrepreneurial ventures, particularly those operating on a smaller scale, such as small and medium-sized enterprises. The purpose of this study is to provide education and inspiration to aspiring entrepreneurs in order to promote the adoption of environmentally friendly practices.

This will be achieved by fostering entrepreneurial innovations and cultivating a mindset conducive to establishing businesses that prioritise sustainability. The ultimate goal is to encourage a sustainable attitude and social perception, as well as a sustainable orientation towards business endeavours. These sustainable practices offer a viable approach to increasing profitability and enhancing the firm's value while also promoting a sustainable and improved standard of living (Hair Jr, Sarstedt, Hopkins, & Kuppelwieser, 2014; Roldán & Sánchez-Franco, 2012). This study contributes to the existing literature on the utilisation of national habitat improvement strategies to enhance eco-economic outcomes (Hair Jr, Hult, Ringle, & Sarstedt, 2021; Peng & Lai, 2012). The results of this study could also be valuable for the adoption of sustainable strategies in companies and the evaluation of eco-friendly business practises that aim to enhance the value of communications while avoiding actions that harm the environment. Sustainable business possesses a distinct capability to guide the operational approach of a business. The generation of profit and the pursuit of sustainability through value creation are interconnected, thereby exerting influence on both society and the environment.

Furthermore, it is recommended that the achievement of environmentally sustainable innovation performance be

facilitated by combining technological absorptive capability with the principles of open innovation and technological orientation within the context of Industry 4.0. Enterprises should prioritise the enhancement of initiatives for collaborative innovation that have a lasting impact on green innovation. Not only does it confer advantages to environmental and ecological innovations, but it also proves advantageous in terms of governmental subsidies and tax benefits for green practices. Governmental subsidies have the potential to mitigate business expenditures and enhance the overall value generated by the firm. In conclusion, the establishment of partnerships centred around open innovation serves as a means to foster and promote green innovation. This type of innovation, which is typically not readily achieved within the regular operations of a business, often necessitates the provision of incentives (Becker, Rai, Ringle, & Völckner, 2013; Bickel et al., 2012).

LIMITATIONS AND FUTURE RECOMMENDATION

The present study is subject to certain limitations. This study focused on entrepreneurs in Saudi Arabia, a developing nation. Future research could be conducted on entrepreneurs in other developed economies to explore potential variations in the findings. The study employed a quantitative research methodology to collect data on numerical variables. However, it is worth noting that there are several alternative qualitative research approaches. Consequently, future investigations could explore qualitative or mixed methods to gain insights into potential variations in the findings. In order to conduct a study analysis, we gathered cross-sectional data. Data collection was limited to a single locality due to the challenges encountered in directly approaching manufacturing entrepreneurs. Additionally, a small sample size was used for analysis. It is recommended that future researchers engage in research at both national and international levels, encompassing various financial and non-financial sectors while taking into account the concept of green innovation and its associated components.

Furthermore, it is worth noting that these additional economic sectors offer intriguing prospects for future research, particularly in the realm of social enterprises operating within the context of the green economy. The application of sustainability transformations can aid in understanding the role that firms play in the global environmental crisis (GEC). The limitless potential of blockchain technology (BT) and its ability to effectively address challenges would significantly transform the landscape of efforts aimed at establishing a sustainable ecosystem for global natural intelligence (GNI). The ongoing investigation aims to develop a novel framework that can serve as a basis for future research endeavours, fostering scholarly engagement in conducting comprehensive analyses and providing enhanced understanding of emerging phenomena within the realm of blockchain technology, environmentally sustainable practices, and green innovations. Furthermore, the study examined the mediating effect of three exogenous variables and one endogenous variable. However, it is suggested that future research should explore the possibility of incorporating additional exogenous variables to enhance the predictive relevance and coefficient of determination.

Based on the findings, it is advisable for policymakers and practitioners to incorporate and employ the strategies of open innovation. The approach utilised in innovation management that has demonstrated the highest level of acceptability involves the enhancement of green innovations. Furthermore, the focus of our study lies in the manufacturing sector, with a particular emphasis on the limited availability of resources and the inclination towards lower-risk strategies. Consequently, there is a heightened necessity to implement open innovation practices within small-scale enterprises. Irrespective of their respective roles, impacts, and applications in specific industries, we conducted an analysis of the provided components within the manufacturing sector in Saudi Arabia. Hence, it is recommended that forthcoming studies investigate additional industries, particularly those pertaining to the achievement of green innovation.

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