Utilisation of green Internet of Things (GIoT) applications towards sustainable performance: The antecedents and consequences of carbon footprint

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Abstract

This study aims to propose and investigate the key factors that predict the Utilization of Green Internet of Things (U-GIoT) applications by business organizations. This study will also look at the effect of using GIoT applications on energy efficiency and carbon footprint reduction, which in turn, contributes to sustainable green performance. Therefore, value-belief-norm theory (VBN) was chosen as the theoretical basis for this study's conceptual model. Two constructs derived from VBN (i.e. biospheric value and ecological worldview) are suggested as key predictors for the use of GIoT applications. The conceptual model is extended by considering the role of green marketing orientation (GMO); green energy awareness; and energy knowledge/ technical capabilities. The current model also suggests that the utilization of GIoT applications would impact both energy efficiency and carbon footprint reduction. Online questionnaires are used to gather data from a purposive sample (n=500) of managers and employees at different levels in different service organizations. Statistical results show strong evidence demonstrating the significant effect of biospheric value; ecological worldview; green marketing orientation (GMO); and energy knowledge/ technical capabilities with GIoT. This study presents a valuable contribution that helps researchers; policy-makers, and practitioners to identify and understand the most important antecedents and consequences of U-GIoT. It is also worth noting for future studies looking at different applications of pro-environmental behaviour such as sustainable practices, green mobility and transportation, paperless work; recycling; reducing waste levels; and smart green solar. Policy-makers, decision-makers, practitioners and specialists in green energy systems (i.e. GIoT) will be able to use this information for future improvement.

Keywords: Green IoT; carbon footprint; Value-belief-norm theory; and green marketing orientation.

1. Introduction

Climate and environmental changes are among the most important challenges affecting the planet and making the lives of 8 billion people under threat. The extent of carbon emission yielded from human activities (carbon footprint) also presents a growing environmental concern which accounts for about 420 parts per million ("ppm" for short) in 2022 (National Oceanic and Atmospheric Administration, 2022; Gueddari-Aourir et al., 2022; Holmatov et al., 2021; Jager et al., 2022; Fernando and Wah, 2017; Fernando and Hor, 2017; Tarifa Fernández, 2022). In detail, industrial and service activities are considered a source of international carbon emission (Statista, 2022a; Gueddari-Aourir et al., 2022). For example, industrial and service activities account for about 34.81 billion metric tons of CO2 in 2020 as indicated in a recent report published by Statista (2022a). In this respect, it is also important to mention that traditional and finite energy sources (i.e. crude oil; and natural gas) are the main causes of carbon emissions (Thollander et al., 2007; Fernando and Hor, 2017; Nath and Siepong, 2022).

Anticipated trends suggest a rise in the global consumption of energy; the alarming numbers and statistics about the carbon emission are more likely to increase as recently reported by Statista (2022b). The negative consequences resulting from the increase in carbon emissions are not confined to the environmental aspect, but have had devastating effects on the economic and health aspects of humans globally (Halldórsson and Kovács, 2010). For example, carbon emissions produced by USA and China led to a loss of more than $1.8 trillion for each of these countries during 25 years starting from 1990 (Dartmouth, 2022). Therefore, organizations are being asked to improve their sustainability strategies and practices. In this respect, business organizations have started focusing on smart green solutions which would help to measure and control the level of carbon footprint (Hoegh-Guldberg et al., 2019; Zeng et al., 2022; Wong et al., 2020; Mousa and Othman, 2020; Kar and Harichandan, 2022; Gholami et al., 2013). Such interest would be attributed to stakeholders' pressure on business firms to implement and conduct their activities in a more environmentally friendly manner (i.e. Mousa and Othman, 2020). Further, high energy costs have made organizations consider effective solutions that help with the efficient use of energy and thus reduce production costs (Zeng et al., 2022).

An important focus for interdisciplinary teams, is investigating the multifactorial nature of climate change and its impact (Dwivedi et al., 2022). Suggestions have been put forth by Dwivedi et al. (2022) for involving the Information Systems (IS) community to continue their efforts with their involvement in creating new networks and techniques aligned with climate change. For example, environmental and digital experts have been commonly called to take advantage of Green Internet of Things (GIoT) (Lund et al., 2017; Zeng et al., 2022; Gholami et al., 2013). Indeed, GIoT would be an effective mechanism to enhance energy efficiency which would lower carbon emissions (Saboori et al., 2012). Effective use of GIoT and smart green systems contribute to enhancing the aspirations of sustainable economic development and reduces the negative environmental and social impact resulting energy mismanagement (Tugcu et al., 2012; Saboori et al., 2012). In this regard, and according to a recent report from Ericsson indicated that smart systems (GIoT) are more likely to decrease the carbon emissions by up to 63.5 gigatonnes by the end of 2030. Therefore, smart energy systems have received considerable attention from 94% of business organizations as essential solutions to issues related to sustainability (Smart Energy International, 2022).

Regardless the potential comprised in GIoT to handle the related issues of carbon footprint emissions and sustainability, there is a question regarding the extent of how much business organizations actively utilise GIoT in their endeavours to reduce the level of carbon footprint. In this respect, Fernando and Hor (2017, p. 63) clearly mentioned that "*Research studies have shown that industrial adoption of energy efficiency has lagged, and some companies have exhibited low organizational and managerial commitment to supporting innovation and investment into energy efficiency*". As GIoT is still in the early stages of introduction, there is limited research investigating the precursors and outcomes of GIoT. Further, having a full picture regarding the successful utilization of GIoT would not be attained considering the technical aspects alone but rather the extent of how much business organizations intend and act altruistically and pro-environmentally (Stern et al., 1999; Han, 2015; Wong et al., 2021). This creates an opportunity for identifying a theoretical foundation to reflect pro-environmental behaviour and values adopted by business organizations.

This study also recognises the importance of examining how GioT usage is influenced by external factors (i.e. market and stakeholders' pressure) so as to maintain their reputation and social corporate responsibility (Wong et al., 2021). For example, 87% of customers are more inclined to have positive attitudes and behaviours toward business organizations that act pro-environmentally and ethically (Solum, 2022). It could be argued that organizations that pay attention to the opinions of their customers regarding environmental and social issues will be keener on optimizing the use of energy and reducing carbon emissions, and accordingly, will be more inclined to adopt GIoT. Therefore, the marketing philosophy (i.e. Green market orientation) is a prerequisite for implementing GIoT successfully into business organizations.

This study is motivated by the research above, to propose and examine the key factors for predicting the U-GIoT applications by business organizations. This study will also examine how GIoT applications affects energy efficiency and reduces the carbon footprint, contributing to sustainable green performance.

This research is expected to add a novel value for both researchers and practitioners working with green smart systems. For example, the findings from this study are expected to assist researchers in this area to identify and understand the most important precursors and outcomes of U-GIoT. It will also present added value for being the first study that integrates VBN theory and marketing orientation theory in one single model. This is in addition to the inclusion of other factors (i.e. energy knowledge/ technical capabilities and energy awareness). Accordingly, the findings will provide a detailed understanding of the most important factors that could guarantee an effective U-GIoT in the business sector. Further, the current study will not only focus on the U- GIoT systems but rather will go further by discovering the consequences of U-GIoT such as carbon emissions reduction; energy efficacy; and sustainable performance. Thus, results of the current study would uncover the key areas that need to be considered by policy-makers, decision-makers, practitioners and specialists in green energy systems.

2. Literature Review

Increasingly, carbon footprint has become an area of interest for researchers from different disciplines and backgrounds (Wiedmann and Minx, 2008; Wong et al., 2018; Wong et al., 2020; Zhao et al., 2018; Haldar and Sethi, 2022). This field of study has taken an upward curve with the current global climate changes issues and the need for solutions to this dilemma (i.e. Kronborg Jensen, 2012; Wong et al., 2018; Al-Mansour and Jejcic, 2017; Haldar and Sethi, 2022; Sharma et al., 2020). A part of carbon footprint research has focused on main causes of such global phenomenon (i.e. Belkhir et al., 2018; Lange et al., 2020) while other parts have addressed the negative consequences of carbon footprint from different perspective social impact (Wong et al., 2020; Bughin et al., 2019); [economic impact] (Khattak et al., 2020; Nguyen et al., 2020; Latif et al., 2018); environmental impact (i.e. Avom et al., 2020; Amri, 2019; Higón et al., 2017); and political impact (Godil et al., 2020). Some studies in the related area of carbon footprints have also looked at how to use smart energy systems on the carbon footprint level (i.e. Navarro et al., 2017; Chowdhury, 2012; Gholami et al., 2013; Ahmed et al., 2017). From a sustainable perspective, research has explored carbon reduction initiatives on sustainability goals, whether at the level of the organization or the environment in general (i.e. Zhao et al., 2018; Grunert et al. 2014; Calcagni et al., 2019).

Earlier it was mentioned that several researchers had argued the reasons why business organizations needed to start reducing carbon footprint levels (i.e. Plambeck, 2012; Bunse, 2011; Okereke, 2007). For example, increasing the cost of traditional energy sources was a primary focus of the organizations' interest and awareness in the related issues of carbon footprint (i.e. Bunse et al., 2011; Plambeck, 2012).

Changes in the customer's shopping lifestyle and customer inclination towards environmentally friendly products and brands have also represented a driving force towards adopting smart solutions to reduce carbon emissions and optimize energy efficiency (Bunse, 2011; Li et al., 2017; Elgaaied-Gambier et al., 2020; Wong et al., 2020; Wallgren and Hojer, 2009; Feucht and Zander, 2018). Even though such studies have considerably enriched the current awareness regarding the drivers that motivate business organizations to do more in terms of reducing the carbon footprint emission, they have not discussed which applicable solutions would be considered and applied. This raises a question regarding the most effective solutions that business organizations would adopt to serve such endeavours. Further, these studies have restricted the main drivers of such organizations' interest in terms of cost reduction and customers' preferences while aspects related to organizational culture; orientation; values; and capabilities have not been fully covered. Accordingly, more efforts by future studies should be paid in exploring such aspects and see how they would shape the ability of business organizations in implementing effective solutions such as utilising highly evolved and smart ecosystems.

In this respect, based on quantitative survey of 1000 customers in Hong Kong, Wong et al. (2020) attempted to discover the extent customers perceive and adopt product with carbon labels. Their results indicated that male customers with a high level of green advocacy tended to adopt environmentally friendly products with low carbon level in comparison with female customers (Wong et al., 2020). Wong et al. (2020) improved the significant influence of customers' awareness, opinions, and intention toward low carbon products. The main concentration of Wong et al. (2020) was on consumer's product with low carbon level but not on the new tech-products that would help customers to track and reduce the level of carbon footprint. In addressing the customer's adoption of carbon labels products, Wong et al. (2020) exclusively addressed the aspects related to individuals' traits; personality; and social norms, which raises questions about the application of Wong's et al. (2020) results from the organizational and service provider's perspective.

A mixed method approach was also used by Feucht and Zander (2018) to discover the customers' preference and desirability of products labelled with low carbon footprint within six European countries. Feucht and Zander's (2018) results indicated that customers prefer products that have a carbon label and will pay more for these (up to 20%) instead of those without a carbon label. The same results were also reported by Zhao et al. (2018); Elgaaied-Gambier et al. (2020); Upham et al. (2011); and Li et al. (2017) regarding the increasing consumer consciousness and preference in environmentally friendly products which are labelled with low carbon. It is important to mention that these studies concentrated on the food consumer market and have addressed the related issues of end customers' adoption of food products labelled with low carbon footprint. Yet, they do not examine the adoption of new systems (i.e. GIoT) that can empower customers to play an active role in controlling and reducing carbon footprint.

Maintain and sustaining corporate image was one of the main factors justifying why business organizations have been engaged in the related activities of carbon footprint reduction as reported by

Plambeck (2012). However, Plambeck (2012) have argued the main consequences that manufacturing organizations would gain by reducing the carbon footprint emission. Further, Plambeck (2012) have fully concentrated on the related issues of carbon footprint over the supply chain sector. This creates a gap in his study to provide an empirical explanation for the related issues of carbon footprint and how it would contribute to corporate image as well as how it would enhance the companies' sustainable performance over different sectors rather than supply chain management

Increasing the level of awareness of adverse consequences among stakeholders and shareholders, whether in the short or long term, creates an increasing pressure on the business organizations to improve their practices in the field of sustainable and environmentally friendly investment (Okereke, 2007). This, in turn, creates a sense of obligation for business enterprises, their partners and customers towards environmental issues, the most important of which is reducing rates carbon footprint (Okereke, 2007).

In line with such interest in related issues of carbon footprint, smart energy systems have also derived a particular attention from practitioners and researchers as effective mechanisms which would help in measuring, mentoring, and controlling carbon footprint (i.e. Lund et al., 2017; Chowdhury, 2012; Navarro et al., 2017; Ahn, Kang, & Hustvedt 2016). In their systematic review study, Lund et al. (2017) found 72 peer reviewed papers that have fully or partially addressed the related issues of smart energy systems. According to Lund et al. (2017), smart energy systems have been considered as a key strategic decision that significantly changed the methods used in designing and developing smart and applicable solutions whilst moving closer to renewable energy and smart, sustainable energy systems. Such a radical shift created a need to design studies using modern methodologies and analytical methods to look at the factors influencing the effective use of smart, sustainable energy systems; at the same time, verifying the feasibility of these systems by measuring their efficiency of energy use and effectiveness in reducing the carbon footprint.

Earlier, Chowdhury (2012) argued the positive role of digital information services in contributing to the initiatives related to environmental sustainability in the library sector. Thus, Chowdhury (2012) obtained and tested both primary and secondary data using a particular kind of mathematical analyses. Their results assured the positive impact of digital information services in reducing the printed content, which in turn, decreases the carbon emissions. Several studies (i.e. Chugh et al., 2016; Haldar and Sethi, 2022; Haseeb et al., 2019; Higon ´ et al. 2017; Watson et al., 2010), have reported that new technologies may also have a negative impact and contribute to increased carbon emissions. This happens because these systems, like any other applications reliant on energy to operate, yield a digital carbon footprint (Chugh et al., 2016).

More recently, the concept of green IT or green system has also been emerged and widely argued and approved as one of the best solution that would increase the efficiency of energy usage as well as decreasing the level of carbon footprint (Elgaaied-Gambier et al., 2020). Conceptually, Green Energy Technologies (GETs) would be defined as “Green Energy Technologies (GETs) can be described as inherently environmentally friendly, offering a promising contribution to achieving net-zero carbon goals.” (Zeng et al., 2022, p. 1). Even though green IT (i.e. GIoT applications) have been taking their place in many business organizations, there are few attempts to evaluate the key factors predicting their success (Elgaaied-Gambier et al., 2020). Also, previous research in the related area of green IT and systems have focused on the individual perspective (Koo et al., 2015; Elgaaied-Gambier et al., 2020) while little attention has been paid to the implications of green IT from an organizational perspective (Bose and Luo 2011; Chugh et al. 2016).

Such of these attempts was conducted by Koo et al. (2015) who examined the continued intention of smart green systems by individuals. Koo et al. (2015) used the Technology Acceptance Model and some other variables to propose two types of motivators (intrinsic and extrinsic) for the usefulness of smart green systems. Their findings supported the role of enjoyment (intrinsic motivator) and saving cost (extrinsic motivator) in enhancing the perceived benefits and ongoing intention to adopt smart green systems. The study by Koo et al. (2015) was conducted in South Korea and only focused on the smart power meter devices. Accordingly, concerns have emerged regarding the generalizability of the results for similar green energy systems as well as other cultural and contextual sectors. Further, the continued intention to keep using smart green systems was the key concentration of Koo et al. (2015) study, while other important aspects related to the viability of using these systems (i.e., energy efficiency and carbon footprint reduction) have not covered in their study. Therefore, a worthy research direction has emerged in Koo's study and should be considered by future studies.

More recently, Hoffmann et al. (2022) proposed and validated three factors (enjoyment, social benefits, and technology beliefs) influencing the customer’s intention to adopt carbon footprint tracking apps. At the organizational level, Gholami et al. (2013) tested the role of attitudes toward green systems and consideration of future consequences on the managers’ adoption green systems. Their results supported the positive impact of both attitudes and consideration of future consequences on the managers’ adoption of green systems, which in turn, predicts environmental performance. Research by Hu et al. (2022) have tested the adoption of GIoT and proposed four kinds of eco-motives (efficiency; effectiveness; responsiveness; and legitimacy). The empirical results of Hu et al. (2022) largely supported all these motives on the adoption of GIoT. According to Hu et al. (2022), GIoT has also a positive role in enhancing green innovation at the organizational level. Other factors associated with the awareness of the impacts of climate and environmental shifts, along with advancement in contemporary environmental issues have led to an increase in the extent of organizations' involvement and interest in GIoT (Tabaa et al., 2020).

In conclusion, GIoT and carbon footprint should not be discussed separately, rather everything they should both be considered comprehensively to serve the goalss related to sustainability at the organisational and national level as well. However, there is a gap in existing literature pertaining to such holistic views of GIoT and carbon footprint (Gholami et al., 2013). Additionally, as discussed in the introduction, having a full picture regarding the successful utilization of GIoT would not be attained by only considering the technical aspects but rather including the extent of how much business organization intend and act altruistically and pro-environmentally (Stern et al., 1999; Han, 2015; Wong et al., 2021). Therefore, a theoretical foundation which can reflect pro-environmental behaviour and values adopted by business organization is required.

3. Conceptual model

Identifying the critical factors that could predict the utilization of GIoT applications by business organizations needs to be investigated. Carefully reviewing the main models and theories over the related area of pro-environmental behaviour and sustainability has led to the selection of the value-belief-norm theory (VBN) (Stern et al., 1999) for the current study's theoretical base. Two constructs derived from VBN (i.e. biospheric value and ecological worldview) were used to predict U-GIoT application. The conceptual model was expanded to include the green marketing orientation (GMO) theory (Chamorro et al., 2009; Leonidou and Leonidou, 2011). Papadas et al. (2017) found that GMO was proposed as a multi-dimensional construct comprising three orientation sub-dimensions: strategic green marketing, tactical green marketing, and internal green marketing. Considering the nature of GIoT, green energy awareness and energy knowledge/ technical capabilities are also proposed as key antecedences of U-GIoT applications (Antunes et al., 2014; Fernando et al., 2017). This model also suggests that the VU-GIoT applications would impact both energy efficiency and carbon footprint reduction. Finally, it is anticipated that both energy efficiency and carbon footprint reduction will directly influence the sustainable green performance (Mousa and Othman, 2020; Gholami et al., 2013).

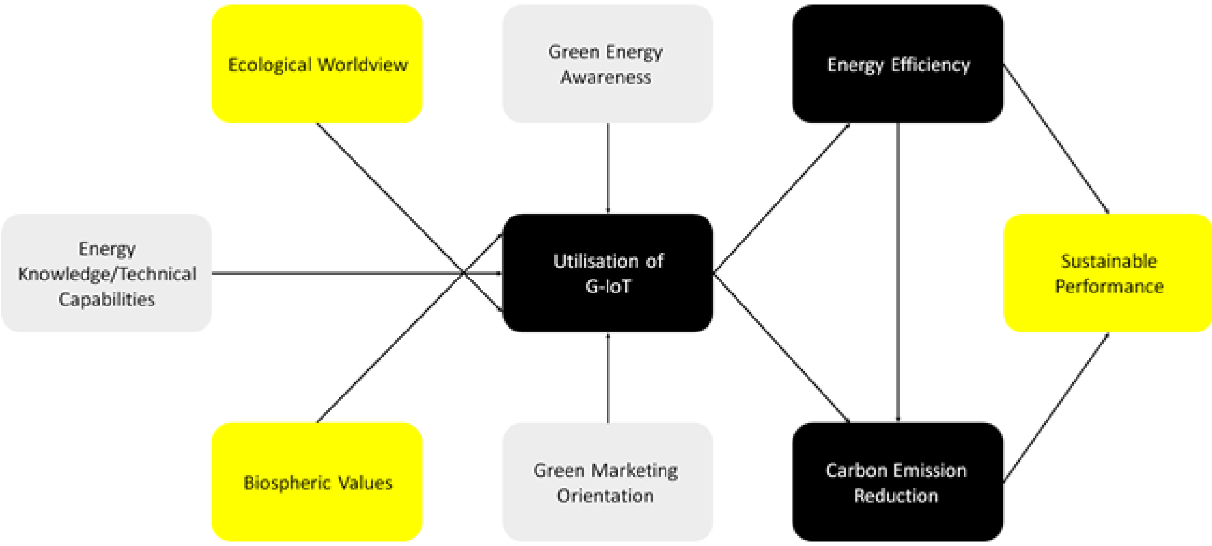

Figure 1: Conceptual Model Adapted from Stern et al. (1999); Chamorro et al. (2009); Leonidou and Leonidou (2011); Papadas et al. (2017); Mousa and Othman (2020); Gholami et al. (2013)

3.1 Value-belief-norm theory

Commonly considered, the VBN theory is the most predictive and comprehensive theoretical model covering important normative aspects that could shape environmental and green behaviour (i.e. adoption green energy system) (Stern et al., 1999; Werff and Steg, 2016; Stern, 2000; Stern et al., 1995; Han, 2015). Initially, the VBN theory was extracted from the norm activation model proposed by Schwartz (1977) and extended using factors from value theory (stern et al. 1999). VBN's main proposition is that individuals usually tend to practice pro-environmental behavior when they have a moral motive (Stern et al., 1999). Such moral norms pertain to the perceptions and beliefs regarding the way people should behave in order to have a positive self-evaluation which is usually a reflection of the individuals' inner values (Fornara et al., 2016; Fransson and Biel, 1997; Thøgersen, 2006). Such moral norms and values have been approved by Werff and Steg (2016); Steg et al. (2005) and Abrahamse and Steg (2009) as positive drivers to adopt new systems and methods that would help in decreasing the carbon footprint as well as being more efficient and sustainable in using the traditional energy sources.

In fact, there are several studies that have approved the validity and applicability of VBN theory in predicting many environmentally friendly behaviors and trends such as customer intention and purchasing eco and environmental friendly products (Stern et al., 1999); green energy system implementation (Steg et al., 2005); acting pro-environmental behaviours (Nordlund and Garvill, 2002); eco-friendly practices such as recycling (Oreg and Katz-Gerro, 2006); perceived environmental risks (Slimak and Dietz, 2006); adoption sustainable solutions (i.e. electric vehicles) (i.e. Slimak and Dietz, 2013). Werff and Steg (2016) have also tested and empirically approved the impact of biospheric values theory over the related area of smart energy systems. Both biospheric values and ecological worldview have received a considerable attention and focus in the VBN theory (Klockner, 2013). Therefore, and in line with what has been proposed by Werff and Steg (2016), the current study model exclusively focuses on values (i.e. biospheric values and ecological worldview) from VBN as key predictors of utilization of GIoT applications.

3.1.1. Biospheric values

According to Steg et al. (2014); Werff et al. (2013); Nordlund and Garvill (2003); Ruepert et al. (2017); Dietz et al. (1998); Steg and De Groot (2012); Steg et al. (2014); Werff et al. (2014); Oreg and Katz-gerro, 2006; Stern (2000), normative beliefs and values (i.e. biospheric values and ecological worldview) that people adopt and believe in could also shape their pro-environmental behaviour. According to Schwartz (1992, p. 1), personal values would be addressed as “the criteria that people use to select and justify actions and to evaluate people (including the self) and events”. In other words, individuals who strongly adopt and believe in biospheric values, will consider environmental and nature issues by being more motivated to engage in pro-environmental behaviour (i.e. the utilization of GIoT applications). This would be attributed to the fact that non-human environmental dimensions are the main concentration of biospheric values as reported by Stern et al. (1995); Stern (2000); Wynveen et al. (2011). Choi et al. (2015); Han (2015); Klockner (2013); and De Groot and Steg (2008) also argued that people who embrace biospheric values will engage in trade off process to compere between the benefits and costs of the pro environmental behaviour. Thus, if people perceive the benefits outweigh the expected costs of such behaviour, they will be more motivated to adopt pro-environmental behavior (Choi et al., 2015). Werff and Steg (2016) have also tested and empirically approved the impact of Biospheric values theory over the related area of smart energy systems. Thus, this study proposes that:

H1: Biospheric values positively influence utilisation of GIoT.

3.1.2. Ecological worldview

According to Stern (2000, p. 411), ecological worldview would be defined as "the propensity to take actions with pro-environmental intent" (Stern, 2000, p. 411). Dunlap et al. (2000); Gkargkavouzi et al. (2019); and Donmez-Turan and Kiliclar (2021) argued worldview as a collection of shared values and beliefs that people would have regarding the environment and how human actions would impact the environment. Ecological worldview would also pertain to general perceptions and attitudes about the negative and harmful impacts of human activities on the environment and nature (Wu, 2018; Donmez-Turan and Kiliclar, 2021). In this respect, Donmez-Turan and Kiliclar (2021) added that the ecological paradigm (ecological worldview) are related to the common beliefs and thoughts regarding the overall impact of environmental issues, like global warming and increased levels of gas emissions. This environmental view relies on the acceptance of shared beliefs that humans disrupt nature's balance, especially in light of the lack of available natural resources, and they then act more pro-environmentally (Klöckner, 2013). Therefore, a high level of ecological worldview promotes a feeling of obligation towards the protection of the environment and nature, and accordingly, contributing to the pro-environmental behaviour (Wu, 2018; Donmez-Turan and Kiliclar, 2021). Indeed, ecological worldview was reported and approved by Brügger et al. (2011) as a value that would encourage pro-environmental behavior. In their recent study, Donmez-Turan and Kiliclar (2021) have significantly and statistically supported the role of ecological worldview in enhancing the pro-environmental behaviour. Another study conducted in China by Wu (2018) has also approved the significant impact of ecological worldview on the children's pro-environmental behaviour as well. Thus, this study proposes that:

H2: Ecological worldview positively influences utilisation of GIoT.

3.2. Green Marketing Orientation

The conceptual model is also extended by considering green marketing orientation (GMO) (Chamorro et al., 2009; Leonidou and Leonidou, 2011; Papadas et al., 2017). Papadas and colleagues (2017, p. 237) conceptualised GMO as "a firm's holistic orientation to the natural environment". Accordingly, GMO is more about presenting a comprehensive management and marketing process concerned with recognizing, anticipating and fulfilling the needs and expectations of individuals and the community together in a sustainable and environmentally friendly manner (Papadas et al., 2017; 2019). Green marketing, as a concept, was originally introduced by Charter (1992) to refer to increasing the level of environmentally friendly administrative and marketing practices and reducing those practices that harm the environment. GMO dimensions and measurement items have been initially proposed and empirically validated by Papadas et al. (2017) who later in 2019 have tested their GMO model and discover adoption GMO would contribute organizational competitiveness, sustainable and financial performance as well (Chung, 2020; Chahal et al., 2014; Dang and Wang, 2022; Papadas et al., 2017; 2019; Bogodistov et al., 2022).

Papadas et al. (2017) proposed GMO as a multi-dimensional construct compriseing three orientation marketing sub-dimensions: strategic green, tactical green and internal. Strategic green marketing orientation pertains to the extent to which higher management considers the pro-environmental issues in conducting its strategic managerial and marketing activities and decisions (Papadas et al., 2019; 2017). Strategic green marketing orientation is also concerned with long-term objectives that serve the organization's strategic vision and mission with regard to environmental dimensions, organizational sustainable performance, and corporate social responsibility (i.e. Papadas et al., 2019; 2017; Stoeckl and Luedicke, 2015). At the second level (i.e. tactical green marketing orientation), Papadas et al. (2017) addressed the short-term marketing actions that make the components of marketing (i.e., product; promotion; pricing; and distribution) more friendly green. Tactical green marketing orientation would be noticed in several marketing practices such as product decisions that increase energy efficiency and reduce carbon emissions; implementing promotional campaigns that increase the level of environmental awareness and encourage environmentally friendly consumption behavior among consumers; using more green distribution channels; and making environmentally friendly products available at affordable prices to a wide range of customers (Papadas et al., 2017). The third dimension, internal GMO includes instilling environmental values throughout the business to establish a green corporate culture on a larger scale (Papadas and Avlonitis, 2014; Papadas et al., 2017). This is more related to the green marketing and managerial practices targeting internal customers (i.e. employees) such as adopting and implementing green human resource management, such as recruitment, training, empowerment, and promotion (i.e. Ogbeibu et al., 2020; Roscoe et al., 2019; Papadas et al., 2017).

There is a growing concern regarding environmental issues and the need to take the necessary procedures to protect the environment in the business environment (Dangelico and Vocalelli, 2017; Hong et al., 2009; Chen and Yang, 2019; Tsai et al., 2020). Therefore, business organizations have started implementing an environmentally friendly philosophy and policy especially those related to managing marketing activities and the relationship with consumers (Chen and Yang, 2019; Tsai et al., 2020; Dangelico and Vocalelli, 2017). Such interest would be attributed to customers' awareness and concerns that products and the way that these products are produced is green. Accordingly, customers are more likely to appreciate and pay premium price for these brands and companies that take care of environmental issues (Chen and Yang, 2019; Dangelico and Vocalelli, 2017; Tsai et al. 2020; Chung, 2020). In fact, green marketing practices have been also considered by marketers as effective mechanisms contributing to brand image, competitive advantage, and sustaining the customer's loyalty and satisfaction as reported by McDonagh and Prothero (2014); Chekima et al., (2016); Jaiswal and Kant (2018); Papadas et al. (2019); Tsai et al. et al. (2020). Thus, business organizations that believe in GMO are more likely to have environmental awareness, and accordingly, adopt pro-environmental behaviour (utilization GIoT) (Dang and Wang, 2022). Thus, this study proposes that:

H3: Green marketing orientation positively influences utilisation of GIoT.

3.3. Green Energy Awareness

Several researchers have reported energy awareness (i.e. Akroush et al., 2019; Bedenik et al., 2015; Dato, 2017) as a key driver for pro-environmental behaviour, especially that related to energy consumption and saving. In general, energy awareness is referred to as the extent of how much people and organizations understand how they would effectively and rationally consume energy (Hassan et al., 2009). In particular, green energy awareness would be identified as the extent of awareness and understanding regarding the best environmentally friendly practices (i.e. renewable energy; GIoT) that help the efficient and effective utilization of energy and thus reducing the percentage of carbon emissions. Fernando and Lin (2017) also proposed several indictors pertaining to the level of green energy awareness over the business organizations. Such indicators are the existence of clear and easy-to-read guidelines and policies that help employees save and use energy optimally.

Energy awareness largely relies on the way how business organizations regularly and effectively communicate and motivate employees and stakeholders to actively engage in green energy programs (i.e. Fernando and Lin, 2017). According to Hassan et al. (2009), energy awareness includes knowing the importance of green energy systems; how much such green system could be used and implemented; and how much these systems would help in saving energy consumption. Related to this, Ma et al. (2011) identified the significant impact of energy awareness on Chinese customer attitudes towards modifying energy consumption behavior as a response to climate and environmental changes and challenges. In South Korea, Ha and Janda (2012) also noticed that customers, who have green and environmental awareness, are more to be intended to buy electrical appliances and small electronic products that are environmentally friendly and use less energy. More recently, Akroush et al. (2019) approved the significant impact of energy awareness in developing the purchase intention green energy products. Thus, this study proposes that:

H4: Green energy awareness positively influences utilisation of GIoT.

3.4. Energy Knowledge/ Technical capabilities

Energy knowledge as a technical capability could be addressed as accumulative experience, knowledge, and competences that help organisations to effectively use green and smart energy systems. Such capabilities considerably help business organizations in their endeavours at all stages of utilising green and smart energy systems (i.e. GIoT) (i.e. Morgan et al., 2009; Wang and Feng, 2012; Buchanan et al., 2014; Berniak-Woźny and Szelągowski, 2022). Energy knowledge could also be identified as the environmental knowledge as discussed by Matteson (2012) and more recently Donmez-Turan and Kiliclar (2021) who assured the role of environmental knowledge as a significant driver of pro-environmental behaviour (U-GIoT). Mei et al. (2012); and Lin (2015) have also investigated and approved the role of energy knowledge and its' positive impact on energy saving and use practices. This can be summarised as thefact that energy knowledge capabilities empower business organisations to understand what the best smart energy solutions available are; how they would buy such systems; and how they could effectively use and sustain such systems (Antunes 2014; Bunse et al., 2011; Filippini et al., 2020; Sun et al., 2021; Müller et al., 2013).

The concept of "Energy Knowledge/Technical Capabilities" was proposed by Fernando and Lin (2017) in their research which aimed to investigate the impact of knowledge management practices on energy efficiency and carbon footprint. They have operationalised "Energy Knowledge/Technical Capabilities" based on several indictors, including the level of knowledge that energy management and committee has regarding the best energy practices; the existence of educational and training energy programs; the level of external collaboration with experts to educate or evaluate current capabilities regarding energy issues; the presence of considered and structured guidelines explaining sequential steps in utilising and sustaining smart energy systems and practices. Thus, this study proposes that:

H5: Energy knowledge positively influences utilisation of GIoT.

3.5. Utilization of GIoT

There is a remarkable consensus in the various industries that the use of smart technological tools (i.e. GIoT and AI) considerably helps in decreasing the carbon footprint while enhancing energy efficiency (He et al., 2021; Huang et al., 2022; Shan et al., 2021; Sun et al., 2019; Liu et al., 2022a and b; Wang and Wang, 2020). For example, according to a survey conducted by Nokia (2022), utilizing smart systems has helped telecommunication companies to save about 30% energy accompanied by a decrease in the level of emitted carbon. This transformation toward green and energy smart systems has zero negative effect on the customer and business performance (Nokia, 2022; Zhao et al., 2022). Nokia's

(2022) survey also indicated that 78% of telecommunication organizations have already utilised smart energy systems (i.e. AI and GIoT). Likewise, IoT systems have been utilised by about 50% of organizations over the retailing context worldwide and most of these organizations (80%) indicated a considerable enhancement in the extent of energy efficiency, and accordingly, their financial performance (Solum, 2022). There is an evidence-base that supports the impact of green smart systems by Wurlod et al. (2018); Wang et al. (2022); and Sun et al. (2019) who provided evidence supporting the positive impact of green innovations on energy efficiency. Thus, this study proposes that:

H6: Utilisation of GIoT positively influences energy efficiency

Practically, smart energy systems have not only empowered business organizations to monitor the energy consumption and carbon emission but also increased their ability to predict the size of energy demand at the level of the organization as a whole and the level of potentials and machines in particular. This, in turn, helps these organizations to accurately anticipate and identify defects in the production system that increase the amount of wasted energy (Zakaryan, 2022; Haldar and Sethi, 2022). In particular, GIoT has been reported as an effective solution which would help business organizations to decrease the level of carbon footprint (Solum, 2022). Therefore, GIoT has been commonly reported as key smart tools contributing to business organizations' ability to reduce carbon footprint and enhancing energy synchronously (Liu et al., 2022b). Liu et al. (2022b) provided evidence supporting the importance of smart systems in decreasing the carbon footprint in China. Thus, this study proposes that:

H7: Utilisation of GIoT positively influences carbon emission reduction

3.6. Energy efficiency

Conceptually, energy efficiency represents a desirable level of performance, which reflects the ability of business organizations to manufacture and deliver goods and services to consumers with the lowest possible level of energy used. Energy efficiency is consistently considered one of the key levers for sustainable organizational performance environmentally, socially and economicly (Li and Lin, 2017; Hrovatin et al., 2016; Bunse et al., 2011). Particularly, energy efficiency helps organizations to cut the expenses related to energy and fuel use and reduce carbon emissions. This helpsorganizations to attain their sustainable objectives as reported by Motlagh et al. (2019). Further, it is widely agreed that the volume of energy use is a key factor contributing to the high level of carbon emissions (Fernando and Hor, 2017). Accordingly, one of the inevitable consequences of increasing energy efficiency is a decrease in carbon emissions (Fernando and Hor, 2017; Saboori et al., 2012). For example, energy efficiency has been considered by European countries as a target so as to reduce carbon emission by 20% in 2020 (Hrovatin et al., 2016). This assumption has been confirmed by Fernando and Hor (2017) who provided statistical evidence approving energy efficiency's role in decreasing the carbon emissions. Thus, this study proposes that:

H8: Energy efficiency positively influences carbon emission reduction.

H9: Energy efficiency positively influences sustainable performance.

3.7. Carbon Emission Reduction

Carbon emissions are among the most important challenges affecting the planet and making lives of 8 billion people under threat due to their negative environmental effects and climate change (National Oceanic and Atmospheric Administration, 2022; Halldórsson and Kovács, 2010; Lam et al., 2010; Gueddari-Aourir et al., 2022; Holmatov et al., 2021; Jager et al., 2022; Fernando and Wah, 2017; Fernando and Hor, 2017). It is also worth mentioning industrial and service organizations bear the greatest responsibility in increasing the level of carbon emissions by size of 34.81 billion metric tons of CO_2 in 2020 (Statista, 2022a). This is in addition to increasing pressure from stakeholders to adopt the best green practices for reducing carbon emissions (i.e. Hoegh-Guldberg et al., 2019; Zeng et al., 2022; Wong et al., 2020; Mousa and Othman, 2020; Kar and Harichandan, 2022; Gholami et al., 2013). Carbon reduction would be one of the most important green practices that business organizations attempt to attain to sustain their performance; increasing customer satisfaction and maintaining their corporate image (i.e. Mousa and Othman, 2020; Wong et al., 2021; Mukonza and Swarts, 2020). For example, 87% customers are more inclined to have a positive attitude and behaviour toward business organizations that act pro-environmentally and ethically (Solum, 2022). Plambeck (2012) stressed that reducing carbon has direct economic benefits (reducing costs), social benefits (improving the organization's reputation), and environmental benefits. Plambeck (2012) also noted that organizations who reduce the level of carbon emissions have a better chance of building distinguished relationships with government agencies and stakeholders, both at the local and international levels. Thus, this study proposes that:

H10: Carbon emission reduction positively influences sustainable performance.

4. Methodology

This study will conduct the empirical part in the service sector in Saudi Arabia. Therefore, online questionnaire were allocated to managers and employees at different levels over different kinds of service organizations (i.e. banking; telecommunication; health; retailing; education; information technology; and tourism). A purposive sample including 500 respondents working in organizational departments and fields involved in issues related to sustainability; green and pro-environmental practices; marketing; energy; and information systems was used to collect data. The data collection process began in early November and ended in mid-December (2023) and had 274 valid responses with response rate 54.8%.

Green marketing orientation was operationalised as a multi-dimensional construct comprising three sub-dimensions: strategic green marketing orientation (SGMO); tactical green marketing orientation

(TGMO); and internal green marketing orientation (IGMO). These three dimensions (SGMO; TGMO; and IGMO) were derived from Papadas et al. (2017) and provided scale measurements. Cordano et al. (2011) and Stern et al. (1999) proposed four scale items that were used to measure ecological worldview (EWRV) while the biospheric values (BSV) construct was tested using scale items by Han (2015); Steg et al. (2014); Blok et al. (2015). Scale measurements proposed and validated by Fernando and Hor (2017) were considered to test energy awareness (EW); energy knowledge/technical capabilities (EKT); carbon emission reduction (CER); and energy efficiency (EEF). Utilization of GIoT was assessed with four scale items recommended by Kros et al. (2011); Gholami et al. (2013); and recently validated by Baabdullah et al. (2021). Finally, Fernando and Wah (2017) and Gholami et al. (2013) proposed five scale items to measure the sustainable performance (SPF).

An even point Likert scale was used to measure the scale items for all constructs except biospheric values (BSV) which was measured using a seven point scale ranging from “not very important” to “very important” as proposed by Han (2015). The back-translation method (Brislin, 1976) was used to translate the questionnaire to Arabic. The Arabic version was then validated by Professors in marketing and management information systems. The validity of translated version was approved by all Professors to measure the latent constructs. Then, researchers conducted a pilot study with a small sample size of 30 participants to assure a higher level of reliability in the scale items used in the current questionnaire. All constructs were able to capture a Cronbach's coefficient alpha value not less than 0.70, which supports the constructs reliability (Nunnally, 1978).

5. Results

5.1. Respondents’ Characteristics

There were a total of 274 valid responses captured with a response rate of 54.8%. The bulk of the respondents were males (61.3%), with females representing about 38.7% of the sample. Approximately 34.5% of the sample participants were within the age group 31-41 followed by those whose ranging in age between 41 to 50. More than half of the respondents held a Bachelor's degree (54.7%) and about 23.8% of sample respondents had a Master’s degree. With regard to the positions in which the respondents work, it was noted that 22.1% of worked as MIS/ IT managers followed by energy mangers (20.2%) while about 13.5% of current study participants were employees working at the operational level. The largest part of the respondents was from sectors like banking (26.6%); telecommunications (25.9%), and retailing (18.9%) (See Table 1).

Table 1: Respondents profiles

Demographic Profile	Number of Participants (N= 274)	Percentage (%)
Gender		
Male	168	61.3
Female	106	38.7

Total	274	100
Age		
18-24	34	12.4
25-30	51	18.7
31-40	95	34.5
41-50	56	20.3
51-60	35	12.8
60+	3	1.3
Total	274	100.0
Education Level		
High school	7	2.5
Diploma	35	12.9
Bachelor	150	54.7
Master	65	23.8
PhD	15	5.4
Other	2	.7
Total	274	100
Position		
CEO	29	10.4
MIS director/ IT Manager	61	22.1
Energy manger	55	20.2
R&D director/manager	29	10.6
Marketing manager	39	14.3
CSR/sustainability manager	24	8.9
Operational level employees	37	13.5
Total	274	100
Sector		
Banking	73	26.6
Telecommunication	71	25.9
Medical and health	29	10.6
Retailing	52	18.9
Information technology	32	11.6
Tourism	11	4.01
Others	6	2.18
Total	274	100

5.2. Descriptive Statistics of Measurement Items

Table 5 shows all scale items used in the current questionnaire that were positively rated by sample participants with mean value not less than 5. The average mean of SGMO items was 5.35 with a standard deviation (STD) value of 0.81. TGMO items were also positively valued by sample respondents with an average value of 5.37 (STD = 0.83). Likewise, IGMO items were able to capture an average value of 5.45 (STD - 1.10). EWRV was positively rated by sample respondents with a mean value of 5.17 (STD = 1.16). Similarly, current sample respondents largely valued items of BSV with a mean value of 5.41 (STD = 1.10). Aspects related to EKT derived a considerable attention for sample participants due to a high mean value (5.44; STD: 1.166) extracted to EKT items. Items of EW were rated positively by sample participants with a mean value of 5.37 (STD = 1.17). Sample respondents highly value the aspects related to both EEF and CER with mean values of 5.26 and 5.15, respectively.

Items used to measure U-GIoT were rated positively by participants with a mean value of 5.15 (STD = 1.095). Sample participants highly rated items of SPF with a mean value of 5.12 (STD = 1.05).

5.3. Structural Equation Modelling

5.3.1. Measurement Model: Confirmatory Factor Analysis

Confirmatory factor analyses was used on 49 scale items in the current study using AMOS22. Several fit indices were considered to measure the measurement goodness of fit (Hair et al., 2010). These fit indices include Chi-Square value (χ^2)/Degree of freedom (CMIN/DF); Goodness of Fit Index (GFI); Adjusted Goodness of Fit Index (AGFI); Normed Fit Index (NFI); Comparative Fit Index (CFI); and Root Mean Square Error of Approximation (RMSEA) (Anderson and Gerbing, 1988; Byrne, 2010; Bagozzi and Yi, 1988). As seen in Table 2, all fit indices were able to capture values within their threshold as such CMIN/DF was 2.841, GFI= 0.924, AGFI= 0.885, NFI= 0.945, CFI= 0.972 and RMSEA= 0.048 (Anderson and Gerbing, 1988; Byrne, 2010; Bagozzi and Yi, 1988). This, in turn, supports the goodness of fit of the current measurement model.

Table 2: Model Goodness of Fit

Fit indices	Cut-off point	Yielded Index
CMIN/DF	≤3.000	2.841
GFI	≥ 0.90	0.924
AGFI	≥ 0.80	0.885
NFI	≥ 0.90	0.945
CFI	≥ 0.90	0.972
RMSEA	≤ 0.08	0.048

Constructs Reliability and Validity

Composite reliability (CR) and Cronbach's coefficient alpha (α) were considered in the current study to inspect reliability (Fornell and Larcker, 1981; Hair et al., 2010). Table 3 presents all nine constructs proposed in the study model which were able to capture a CR value not less than 0.70 (Fornell and Larcker, 1981; Hair et al., 2010; Nunnally, 1978). EW had the highest CR value of 0.927 followed by EKT with CR value of 0.926 (Fornell and Larcker, 1981; Hair et al., 2010). The lowest CR value (0.827) was accounted for by GMO. Likewise, Cronbach's coefficient alpha (α) values were above 0.70 (Nunnally, 1978). EKT recorded the highest α value (0.925) while the minimum value was for GMO with α value of 0.823. This strongly indicates that the items used to measure these variables have a strong internal consistency, and thus it becomes clear that the participants in the study have a clear and common understanding regarding the dimensions of these variables. These results also support the variables proposed in the study model, and they are well defined and understood within the framework of the current study by the study sample participants.

Table 3: Construct Reliability and validity

	CR	(α)	AVE	EWRV	GMO	BSV	EKT	EW	U-GIoT	EEF	CER	SPF
EWRV	0.886	0.884	0.661	**0.813**								
GMO	0.827	0.823	0.617	0.541	**0.785**							
BSV	0.899	0.895	0.689	0.513	0.699	**0.830**						
EKT	0.926	0.925	0.716	0.651	0.687	0.726	**0.846**					
EW	0.927	0.923	0.719	0.668	0.487	0.745	0.724	**0.848**				
U-GIoT	0.905	0.905	0.655	0.723	0.567	0.743	0.731	0.695	**0.809**			
EEF	0.903	0.901	0.651	0.712	0.744	0.732	0.657	0.754	0.767	**0.807**		
CER	0.910	0.908	0.669	0.707	0.786	0.658	0.712	0.758	0.733	0.701	**0.818**	
SPF	0.915	0.911	0.684	0.741	0.712	0.779	0.722	0.746	0.751	0.740	0.693	**0.827**

All nine constructs matched criteria related to constructs validity, including average variance extracted (AVE); discriminant validity; and standardised regression weight (factor loading). Table 3 shows all constructs have an AVE value not less than 0.50 (Hair et al., 2010; Anderson and Gerbing, 1988; Fornell and Larcker, 1981). This study's constructs also met the criteria for discriminant validity, as the inter-correlation values between latent constructs were lower than the square root of the AVE values yielded for all nine constructs in the current study model (Kline, 2005). Furthermore, all scale items had regression weight values not less than 0.50 (Hair et al., 2010) (see Table 4). It is important to note that GMO was identified as a multi-dimensional construct (second order factor) comprising three sub-dimensions: SGMO; TGMO; IGMO (first order factors). In Table 4, SGMO; TGMO; and IGMO adequately and significantly loaded on GMO with standardised regression weight values above 0.50 and ranging from 0.724 (IGMO); 0.731 (SGMO); to 0.724 (IGMO).

The AVE values ranged between 0.719 as the highest value recorded for EW and 0.617 as the lowest value. Such results support the scale items considered in this study to measure the related constructs. This means that results of AVE and factor loading reflects that these scale item accurately measure their latent constructs. This supports the constructs' convergent validity. On the other hand, results of discriminant validity confirm that the constructs in this t study share more variance with its scale items than with other constructs. This, accordingly, confirms that each construct in current study model is unique and captures a specific aspect while these aspects are different from other constructs.

Table 4: standardised regression weight (factor loading)

Item		Construct	Estimate	Mean	Std	Item		Construct	Estimate	Mean	Std
SGMO	<---	GMO	.731			**EW1**	<---	EW	.899	5.35	1.19
TGMO	<---	GMO	.890			**EW2**	<---	EW	.786	5.42	1.14
IGMO	<---	GMO	.724			**EW3**	<---	EW	.833	5.37	1.13
SGMO1	<---	SGMO	.641	5.25	.83	**EW4**	<---	EW	.906	5.38	1.19
SGMO2	<---	SGMO	.997	5.69	.77	**EW5**	<---	EW	.810	5.36	1.20
SGMO3	<---	SGMO	.960	5.14	.76	**CER1**	<---	CER	.815	5.17	1.05
SGMO4	<---	SGMO	.991	5.35	.89	**CER2**	<---	CER	.858	5.05	1.07
TGMO1	<---	TGMO	.734	5.41	.85	**CER3**	<---	CER	.807	5.07	1.08
TGMO2	<---	TGMO	.804	5.58	.94	**CER4**	<---	CER	.816	5.28	1.16
TGMO3	<---	TGMO	.861	5.22	.77	**CER5**	<---	CER	.791	5.19	1.08

TGMO4	<---	TGMO	.913	5.30	.79	**EEF1**	<---	EEF	.818	5.23	1.07
IGMO1	<---	IGMO	.998	5.44	1.02	**EEF2**	<---	EEF	.829	5.27	1.06
IGMO2	<---	IGMO	.986	5.47	1.22	**EEF3**	<---	EEF	.811	5.26	1.00
IGMO3	<---	IGMO	.983	5.48	1.11	**EEF4**	<---	EEF	.773	5.29	1.11
IGMO4	<---	IGMO	.588	5.43	1.06	**EEF5**	<---	EEF	.803	5.28	1.19
EWRV1	<---	EWRV	.805	5.15	1.08	**U-GIoT1**	<---	U-GIoT	.798	5.07	1.05
EWRV2	<---	EWRV	.834	5.21	1.09	**U-GIoT2**	<---	U-GIoT	.794	5.16	1.17
EWRV3	<---	EWRV	.759	5.15	1.28	**U-GIoT3**	<---	U-GIoT	.814	5.22	1.03
EWRV4	<---	EWRV	.852	5.18	1.19	**U-GIoT4**	<---	U-GIoT	.866	5.16	1.13
BSV1	<---	BSV	.839	5.44	1.11	**SPF1**	<---	SPF	.783	5.01	1.02
BSV2	<---	BSV	.827	5.45	1.05	**SPF2**	<---	SPF	.864	5.18	1.12
BSV3	<---	BSV	.836	5.42	1.14	**SPF3**	<---	SPF	.827	5.19	1.01
BSV4	<---	BSV	.818	5.33	1.10	**SPF4**	<---	SPF	.874	5.14	1.08
EKT1	<---	EKT	.911	5.51	1.18	**SPF5**	<---	SPF	.783	5.05	.98
EKT2	<---	EKT	.791	5.44	1.14						
EKT3	<---	EKT	.815	5.39	1.12						
EKT4	<---	EKT	.894	5.47	1.24						
EKT5	<---	EKT	.812	5.39	1.15						

5.3.2 Structural Model Analyses

Out of ten hypothesised paths of the current study model, nine were supported to be significant (see Table 5). Four factors (GMO; EWRV; BSV; and EKT) could predict 0.83 of variance (R^2) in the Utilization of U-GIoT. Both GIoT and EEF predict 0.48 of variance (R2) in CER while about 0.63 of variance accounted in EEF. About 0.53 of variance was accounted in SPF. The path coefficient analyses, U-GIoT was significantly influenced by GMO (γ=0.641 $p<0.000$); EWRV (γ=0.523, $p<0.277$); BSV (γ=0.381, $p<0.000$); and EKT (γ=0.419, $p<0.000$). EW's impact on Utilization GIoT was non-significant (γ=0.082, $p<0.725$). U-GIoT was able to significantly predict both EEF (γ=0.407, $p<0.008$) and CER (γ=0.327, $p<0.015$). Finally, SPF was significantly influenced by both EEF (γ=0.657, $p<0.000$) and CER (γ=0.198, $p<0.003$).

Table 5: Structural Model Results

Hypothesised paths			Estimate	S.E.	C.R.	P
GIoT	<---	GMO	.641	.058	6.895	***
GIoT	<---	EWRV	.277	.049	3.430	***
GIoT	<---	BSV	.381	.048	4.654	***
GIoT	<---	EW	.082	.129	.352	.725
GIoT	<---	EKT	.419	.031	13.519	***
EEF	<---	GIoT	.794	.064	13.825	***
CER	<---	GIoT	.327	.161	2.428	.015
CER	<---	EEF	.407	.165	2.642	.008
SPF	<---	EEF	.657	.139	5.231	***
SPF	<---	CER	.198	.051	3.882	.003

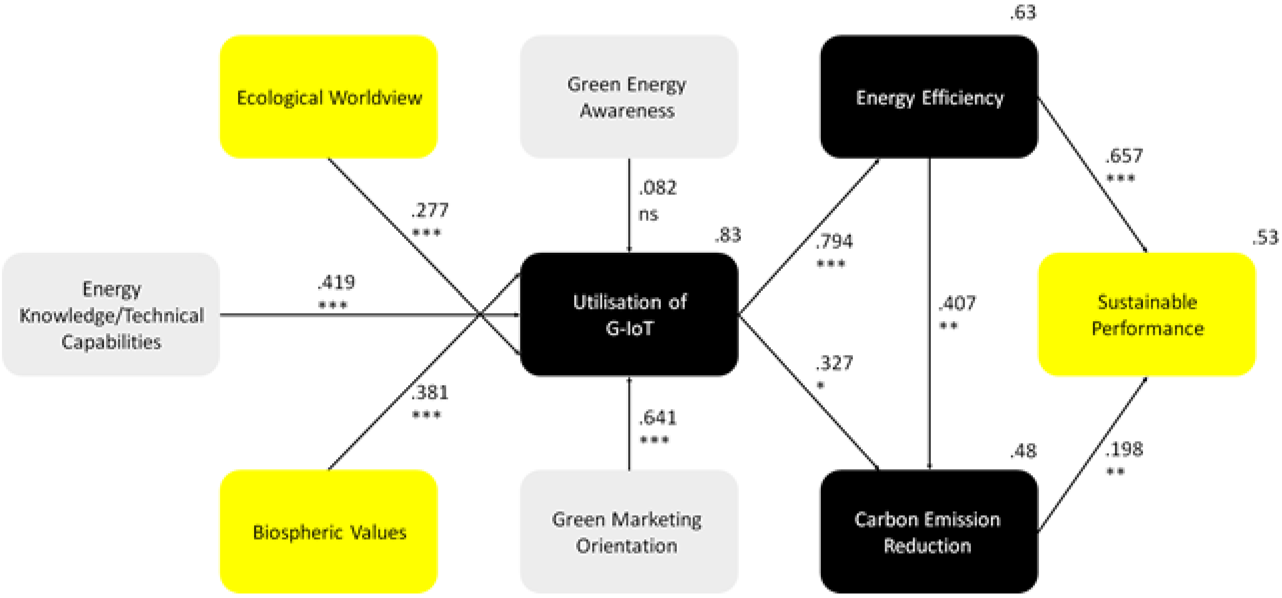

Figure 2: Structural Model

6. Discussion

This study has identified key factors that would predict the U-GIoT systems in business organizations to address carbon emissions and energy efficiency. Another question has also been raised regarding the impact of reducing carbon footprint emissions and energy efficiency on the organization's sustainable performance. As seen in the prior section, statistical results provided strong evidence confirming what has been suggested in the present study model which was able to account 0.83; 0.48; 0.63; and 0.53 of variance (R^2) in the U-GIoT; CER; EEF; and SPF, respectively. This supports the selection of the VBN theory and green marketing orientation as an appropriate theoretical base.

The path coefficient analyses suggests the VBN theory factors (biospheric and ecological) significantly impacted the U-GIoT (see Table 5). Accurately, current study respondents express considerable interest in aspects related to ecological values, which in turn, reflects on the level of GIoT utilisation. In different words, the high level of U- GIoT has been observed as a mainstream technology within organizations whose employees show their concern and fear about the nature balance and its sensitivity, and how it is vulnerable to be affected by human misuse of limited natural resources. It has been commonly argued that individuals, who strongly believe in ecological worldview values, will practice pro-environmental behaviours (Stern, 2000; Dunlap et al., 2000; Gkargkavouzi et al., 2019; Donmez-Turan and Kiliclar, 2021). In this respect, GIoT has been reported as one of the most effective mechanisms that serves organization’s endeavours related to environmental protection and reducing carbon emissions.

Biospheric was also empirically approved to have a significant role in enhancing the U-GIoT. In fact, people who strongly adopt and believe biospheric values are more inclined to perceive the benefits of pro-environmental behaviour more favourably. Thus, they are more motivated to implement the best practices (GIoT) that help in sustaining their pro-environmental endeavours. The current study participants were noticed to highly value items used to measure the biospheric beliefs with a mean value of 5.41 (see Table 4), which reflects the relative importance given by them towards these dimensions such as reducing carbon emissions; and protecting nature. Such results are parallel with those reported by Choi et al. (2015) and Werff and Steg (2016).

Green marketing orientation has been approved to be the most significant factor predicting U-GIoT. This means that the highest level of U- GIoT systems were observed among business organizations that adopt a marketing philosophy that is keen on environmentally friendly activities at all levels: strategic; tactical; and operational. Such interest in GMO philosophy was clearly noticed via the positive evaluation of the study participants relating to the questions regarding the dimensions of the green marketing orientation, such as the mean values accounted to SGMO; TGMO; and IGMO were 5.35; 5.37; and 5.45, respectively. In fact, business organizations are increasingly getting involved in GMO practices due to the increasing level of environmental concerns that impact the organization's reputation and ability to retain its customers (Dangelico and Vocalelli, 2017; Hong et al., 2009; Chen and Yang, 2019; Tsai et al., 2020; Dangelico and Vocalelli, 2017). Current study results pertaining to the impact of GMO on U-GIoT are similar to what has been approved by Dang and Wang (2022).

As expected, EK was confirmed to have a significant role enhancing U-GIoT with regression value of 0.407. In other words, a strong understanding of energy inevitably leads to an advanced level of GIoT use. Practically, the distinctive and sensitive nature of GIoT systems and their overlap with the other systems over the organizations makes their operation difficult. Therefore, organizations' technical experience and knowledge considered as prerequisite to assure effective and successful use of GIoT. This would be attributed to the important role that EK as technical capabilities play in helping companies to select and operate the most efficient GIoT systems (Antunes 2014; Bunse et al., 2011; Filippini et al., 2020; Sun et al., 2021; Müller et al., 2013). Such results positively supporting the impact of EK on U-GIoT are not far from those yielded in studies undertaken by Mei et al. (2012); Tran (2014); Lin (2015); and Fernando and Lin (2017).

Path coefficient results supported what has been proposed regarding to the impact of U-GIoT in enhancing the energy efficiency while reducing carbon emissions. It was noted that in organizations that used green systems successfully, the rates of efficient use of energy increased and the percentage of carbon emissions decreased in parallel. U-GIoT has enriched the organizations competencies in measuring; monitoring; predicting both energy consumption and carbon emissions. In is therefore important to note that U-GIoT has been increasingly considered by business organizations as part of the environmental compliance policy, especially with regard to reducing carbon emissions. For example, a report published by the Global e-sustainability initiative (2015) indicated that revaluation in information communication technologies would help to reduce about 20% of Greenhouse Gas (GHG) emissions by 2030. It is also expected that about 63.5 gigatons emissions would be decreased by implementing GIoT by the end of 2030, as recently reported by Ericsson (Solum, 2022).

As per the current conceptual model (H9 and H10), path coefficient results strongly supported the significant impact of carbon emission reduction and energy efficiency on sustainable performance. It has been commonly reported that the energy bill represents a large part of the organization's costs, especially with the global rise in oil and gas prices (Mukhtarov et al., 2022; Wong et al., 2013). A higher level of energy efficiency means lower average costs of energy use within the organization, and this therefore helps in improving the short- and long-term financial and non-financial performance of the organization. Reducing the rate of carbon emissions is evidence that confirms the organization's keenness on environmental compliance and its application of environmentally friendly practices, and accordingly; sustaining customer satisfaction and corporate image (i.e. Mousa and Othman, 2020; Wong et al., 2021; Mukonza and Swarts, 2020).

6.1. Theoretical Contribution

As mentioned in the introduction, GIoT is still in the early stages of implementation, and therefore, there is a growing and continuous need to know and understand all the factors that can help in the success of using such technology, especially in organizations with pro-environmental goals. Further, many previous studies in this area have technically addressed theire related issues of GIoT and how it could predict carbon emissions and business performance (Ramanathan et al., 2022; Pirson and Bol, 2021). However, several studies have addressed other aspects related to value systems; awareness; knowledge; and business/ marketing philosophy (i.e. Green market orientation) (i.e. Dang and Wang, 2022; Werff and Steg, 2016). Accordingly, this research offers a worthy investigation that can help scholars in this area to identify and understand the most important antecedents and consequences of U-GIoT.

This study proposes a comprehensive model which covers the most important predictors of U-GIoT. This research provides a considerable contribution for being the first study that has integrated VBN theory and marketing orientation theory in one single model. This integrated model has been extended by considering other factors (i.e. energy knowledge/ technical capabilities and energy awareness). The expanding theoretical horizon of the current study model not only integrates both VBN and GMO but also considers new mechanisms that would enhance U-GIoT. Furthermore, the results confirm the predictive validity of this integrated model as identified by the amount of variance (R^2) in U-GIoT (0.83).

Despite numerous studies addressing the VBN on the pro-environmental behaviour (i.e. Fornara et al., 2016; Han, 2015; Oreg and Katz-Gerro, 2006), the impact of both ecological worldview and biospheric values on the adoption of GIoT has not been fully covered. Therefore, this study comprises another contribution via uncovering new potentials and enhancements that could help accelerate the adoption of GIoT. This also gives evidence of the importance of value systems and culture that organizations must adopt and share with their employees at all levels in relation to promoting environmentally friendly practices through the adoption of green technology systems.

A careful review of the main body of literature identifies the largest part of prior studies considering the intention to adopt green systems (i.e. GIoT) (Hoffmann et al., 2022; Koo et al., 2015; Mishra et al., 2016) or the adoption of such systems (Gholami et al., 2013; Hu et al., 2022). Yet, a few attempts have looked at the consequence of these systems from a broader view. This study has gone a step forward by considering the consequences of U-GIoT such as carbon emissions reduction; energy efficacy; and sustainable performance. The statistical results prove the significant impact of green technology on these aspects, and this reinforces the conviction that investment in green technology is not only a matter of environmental compliance, but directly impacts the efficiency of the organization and its ability to achieve economic and social success and the environment as well.

6.2. Practical Contribution

Besides the theoretical value added by this study for academics and researchers, policy-makers, decision-makers, practitioners and specialists in green energy systems (i.e. GIoT) would benefit from the findings about the key areas of improvement. For example, the significant role of biospheric values and ecological worldview identifies the importance of instilling and strengthening values related to environmental protection; reducing pollution rates; increasing respect for practices related to preserving the planet. In this respect, there is a constant need to conduct awareness campaigns for employees and organizational staff at all levels that reinforce the necessity of adopting biospheric values and enhancing behaviour related to pro-environmental behaviour. Therefore, it is highly suggested to redesign the communication process to be more effective in delivering engaging content that focuses on environmental and green values. Such content would be customised based on the employee's level of awareness of biospheric values and ecological worldview. It is also recommended to consider other non-traditional means of communication in delivering such content to employees, and thus it is possible to rely on informal communication channels such as using social media platforms.

Findings from this study draw the attention to the import role of green marketing orientation for enhancing the U-GIoT. Therefore, policy-makers, decision-makers, practitioners and specialists in GIoT should pay more attention to three dimensions of GMO: (i.e. SGMO; TGMO; and IGMO). For example, SGMO dimension means that green marketing practices are not just a boom or a temporary action, but rather a strategic decision that includes reformulating the vision and long-term marketing goals of the organization in a way that takes the environmental dimensions and the need to preserve nature into account. It is also important to ensure that SGML does not only contribute to the pro-environmental aims but also sustain the organization' competiveness and financial performance (Papadas et al., 2017). It is highly recommended proposing new strategic guidelines that consider environmental standards in selecting the organizational partners. Long-term marketing goals should focus on the need to invest in research and development projects in sustainable energy andreduce carbon emissions as well.

The IGMO gives clues to the importance of spreading and promoting pro-environmental culture and values among internal customers (employees). Having such cultural and value systems would also require organizations to expand in green human resources practices, such as green training and involvement in green hiring (Mousa and Othman, 2020; Papadas et al., 2017). This will guarantee the attraction of human resources that have a cultural and value system that believes in the importance of environmental practices. It would be recommended that conducting and developing training programs should focus on such environmental culture and values. The vision and long-term green marketing objectives, which are documented in the green marketing strategy, should be clearly delivered to employees at all levels as they are responsible for converting them to actions.

Marketers and practitioners engaged in the green energy program at the departmental levels, should focus their attention on TGMO dimension, as they are responsible for transforming what has been documented in the SGMO vision and objectives to the lower and operational level in the business organizations. In this regard, more efforts should be placed on enhancing the quality of the communication process and content for the related issues of pro-environmental energy. Further, the organization should seek to encourage green practices (i.e. paperless policy; using digital communication; recycling; using eco-systems like e-commerce and digital remote working) at the level of middle and operational management.

Energy knowledge has been approved in the current study as key driver of successful U-GIoT. Therefore, more efforts are requested from policy-makers and practitioners to enhance the level of EK that employees should have at all level in the organizations. A highly specialized training program in energy and green smart systems should be developed and customized based on the employees skills and knowledge needs. In this respect, the organization can seek help from external experts and specialists in energy and smart green systems to determine the level of skills and current capabilities of employees in such area, and accordingly, identify training needs and design effective training programs. Since success in implementing IoT systems is cumulative over time, there is a need to build a sophisticated energy management database. It is also highly recommended having well-designed and readable guidelines regarding the systematic process of implementing and using green energy systems

6.3. Limitations and Future Research Directions

Beyond the theoretical and practical values identified, there are several limitations that need to be discussed and considered in future research. This study was a cross-sectional study as both antecedences and consequences of U-GIoT were tested at one point in time. Generalizability of the current study results for the long-term, may be limited. This is brought to light by the fact that the nature of investing in green smart technology and the results achieved are usually realized in the long-term. Therefore, future studies are highly recommended conducting a longitudinal study to discover how the antecedences and consequences of U-GIoT would be different by the passage of time. Further, this study occurred within the Saudi service sector, and thus, may impact the generalizability of study's results to other sectors: industrial; agricultural; governmental; and non-profitable. Future research studying green technology applications in these sectors are required. This study also considered U-GIoT as kind of pro-environmental practices that business organizations should take into account. Thus, it is worth future studies looking at different applications of pro-environmental behaviour including pro-environmental practices such green mobility and transportation, paperless work; recycling; reduce the level of waste; and smart green solar.

7. Conclusion

Practically, environmental and digital experts have been commonly called to take advantage of smart systems such as GIoT. GIoT would be an effective mechanism to enhance energy efficiency and thus reduce carbon emissions. However, there is a question regarding the extent of how much business organizations actively utilise GIoT in their endeavours to reduce the level of carbon footprint and enhance the energy use efficiency. Another question would be raised about the effectiveness of carbon footprint reduction in enhancing the organization's ability to improve its sustainable performance. Consequently, this study is motivated to propose and examine key factors that could predict the U-GIoT applications by business organizations. Figure 1 represents the conceptual model proposed based on VBN (Stern et al., 1999). Two constructs derived from VBN (biospheric value and ecological worldview) were identified as predictors of U-GIoT applications. The conceptual model was extended by considering the role of GMO (Chamorro et al., 2009; Leonidou and Leonidou, 2011; Papadas et al., 2017). In light of the nature of GIoT, green energy awareness and energy knowledge/ technical capabilities are also proposed as key antecedences of U-GIoT applications (Antunes et al., 2014; Fernando et al., 2017). This model also suggests that the U-GIoT applications would impact both energy efficiency and the reduction of carbon footprint. Finally, both energy efficiency and reducing carbon footprint were expected to have a significant influence on sustainable green performance (Mousa and Othman, 2020; Gholami et al., 2013). A purposive sample size of 500 respondents who work in service sector in Saudi Arabia was employed to collect the empirical data. Structural equation modelling results largely supported the impact of proposed factors (biospheric values; ecological worldview; green marketing orientation; and energy knowledge technical capabilities) as a key driver of U-GIoT. Empirical results also supported the importance of U-GIoT in enhancing energy efficiency and decreasing carbon emersions, which in turn, positively accelerates the sustainable green performance.

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