Green Intellectual Capital and Business Sustainability in the Egyptian Industrial Companies: The Mediating Role of Green Innovation

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Scientific Journal for Financial and Commercial Studies and Research (SJFCSR)

Faculty of Commerce – Damietta University

Vol.4, No.1, Part 1., January 2023

APA Citation:

Shabana, M. M. M. (2023). Green Intellectual Capital and Business Sustainability in the Egyptian industrial companies: The Mediating Role of Green Innovation, ***Scientific Journal for Financial and Commercial Studies and Research***, Faculty of Commerce, Damietta University, 4(1)1, 1059-1096.

Website: https://cfdj.journals.ekb.eg/

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Abstract

Purpose- This study aims to examine the impact of Green Intellectual Capital on Business sustainability through mediating Green Innovation in Egyptian industrial companies.

Design/methodology/approach – Data were collected from 269 employees working at industrial companies in Damietta Port and the industrial zone at New Damietta. PLS-SEM method was used to examine the mediating role of Green Innovation in the relationship between Green Intellectual Capital and Business Sustainability.

Findings – The main finding of the study is the level of Green Innovation increased significantly when manufacturing companies invest more in Green intellectual Capital and then green innovation has a significant effect on business sustainability. Furthermore, green intellectual capital has a direct effect on business sustainability. In addition, Green Innovation partially mediates the relationship between Green Intellectual Capital and Business Sustainability.

Originality/value – The novelty of this study is the contribution of green intellectual capital in achieving business sustainability. In the light of results and to cope with the rising green concerns of the manufacturing companies especially in Egypt, many recommendations were suggested to maximize the impact of Green Intellectual Capital on Business Sustainability.

Key Words: Business sustainability; Green Intellectual Capital; Green Human Capital; Green Structural Capital; Green Relational Capital; Green Innovation; Economical Sustainability; Social Sustainability; Environmental Sustainability.

1. Introduction

Egypt suffers from many problems concerned with pollution and environmental degradation. According to World Bank's estimates, the cost of air pollution as about 5% of the annual gross national product, equivalent to $ 2.42 billion annually. These indicators reflect an increase in the health and economic burden of pollution. Furthermore, the cost of air pollution in Egypt and the environmental impact resulting from it will not decrease because it depends mainly on coal that represents a third of the electricity mix according to the energy strategy 2035 (World Bank, 2019). Therefore, the contribution of this paper emerges from the fact that Egypt occupies a lower rank according to the University of Cambridge's 2021 sustainable development growth (SDG) Index, as it is ranked 82nd out of 165 countries, with a score of 68.6 out of 100 (https://www.businesstodayegypt.com/). In addition, Sustainability Index for Egypt (S&P/EGX ESG) is down by 7.4% in 2019 (Egyptian Exchange Market, 2019). All these indexes show that there is a problem in BS in Egypt.

Consequently, Egypt has adopted effective steps to accommodate green environment through issuing the required legislation, or by providing innovative financing mechanisms for green projects such as green bonds and adopting many ambitious goals in this field such as green hydrogen production, solar energy, wind energy, low-carbon, and electric transport projects.

Moreover, the International Energy Agency report asserted that global carbon dioxide emissions resulting from energy use would rise by 1.5 billion tons in 2021 (IEA, 2021). This represents the highest annual increase recorded since the world turned intensively towards fossil fuels after the financial crisis in 2010. This is a dire warning that the economic recovery from the Covid crisis will have a harmful sustainable effect on our climate. Unless governments worldwide move quickly towards starting to cut emissions, we will likely face a worse situation in 2022.

Today, the world is characterized by environmental degradation and accelerating global warming; in this scenario, the manufacturing industry is marked as one that must go "green" (Latif *et al.*, 2022). Therefore, the "green" issue has become a universal concept because most natural resources have been depleted and damaged because of rapid industrialization and urbanization (Nisar *et al*., 2021; Rasheed *et al*., 2021;

Sathasivam *et al*., 2021). Therefore, both scholars and industry practitioners have given more attention to the notion of being green over the past few decades due to the increasing trend of green politics worldwide to overcome environmental pollution because of harmful practices for organizations that damaged the environment.

Consequently, there is an urgent need for all kinds of organizations to take green initiatives to properly solve the negative impact of environmental issues by recommending practices to be followed by businesses that reduce their carbon footprints (Chaudhry, 2016). Therefore, many organizations have realised the importance of shifting towards a green organization to improve their brand image, increase margins, and enhance competitive advantage, if they are referred to as a green organization in point of view stakeholders (Makarim, 2021; Yusliza *et al*., 2021; Alshaabani *et al*., 2021).

Accordingly, researchers highlighted HRM practices that encourage organizations' green behaviours to overcome many environmental challenges, including water and air pollution, biodiversity loss, and climate change (Yusliza *et al*., 2021; Malik *et al.*, 2020). Nearly all governments have been putting environmental regulations and policies to pressure manufacturing companies to be green. Furthermore, many firms face a burden from stockholders if environmental standards are violated (Malik *et al*., 2021; Chen, 2011).

Green Innovation (GI) is technological innovation related to environmental protection and improvement. It reinforces environmental policies that play an essential role in shaping change towards the achievement of business sustainability (Arsawan *et al*., 2021; Yusliza *et al*., 2020; Li *et al*., 2017). Therefore, Mazzanti *et al*. (2021) highlighted the vital role of GI in modifying products and processes to reduce the harmful effect of modern industrialisation on the environment. Moreover, Hao *et al*. (2021) proved that GI has a positive lag effect on enterprise value after 2 to 6 years especially in heavy pollution industries and non-high-tech industries. Therefore, GI is conducive to the win–win situation of economic development and environmental protection (Tang *et al.*, 2018).

Nisar *et al*. (2021) argued that Green Intellectual Capital (GIC) could lead towards green and pro-environmental behaviours that ensure business sustainability (BS) because human resources have the capabilities and knowledge to develop green processes and procedures that keep the environment from degradation.

Accordingly, the relevance and contribution of this study to the knowledge base of business sustainability can be justified in many ways: **firstly**, to the best of our knowledge, this study is one of the few studies to empirically examine the relationships herein considered, particularly, the proposed link between GIC and BS through mediating role of GI across firms located in a developing country especially Egypt, while prior research has typically focused on this relationship across firms located in developed countries. **Secondly**, according to the Resource-Based View (RBV), an organization can be viewed as a collection of humans, physical and organizational resources. These resources are valuable, inimitable and are the main source to achieve organizational effectiveness if they are utilized effectively and this in turn will achieve BS. **Thirdly**, Egypt bears at least EGP 47 bn a year because of air pollution and this has a harmful effect on human resources which are the main source to achieve BS (world bank, 2019). For all of this, GIC and GI are the main determinants of BS. Accordingly, based on the resource-based view (RBV) and intellectual capital-based view (ICV) theory, this study investigated the impact of GIC and GI on BS.

2. Literature review and Hypotheses Development

This study depends mainly on both RBV and Intellectual Capital-based View Theory (ICV) to develop its hypothesis. ICV theory concerns with concentration and dynamics of knowledge capital rooted in a firm and is postulated to have direct relationship with its organizational performance/ competitive advantage which supports business sustainability (Haldorai *et al*., 2022; Youndt and Snell, 2004). On the other hand, RBV argues that management should pay more attention to vital resources that are valuable, unique, hard to duplicate and irreplaceable especially in developing countries (Tjahjadi *et al.*, 2022). Hence, the current study will be using the RBV and ICV theory to explain the relationship between GIC and GI on the BS.

2.1 Relationship between GIC and BS

Academics and practitioners have devoted more attention to sustainability in the past few years, and it is also expected to remain an area of discussion for managers and academics during the following decades. Furthermore, as businesses operate in a highly competitive global economy, they must be responsible for the environment (Weerakoon *et al*., 2021; Yong *et al*.,

2019). Therefore, environmental issues will continue to increase, and they will worsen if nothing is done to solve them due to the seriousness of environmental pollution (Novianto and Prabowo, 2021; Gong *et al*., 2018). Consequently, Malik *et al*. (2021) concluded that stakeholders have immense pressure to formulate strategies that should support sustainable behaviours, and human resources teams aim to bring sustainability and pro environmentalism in almost all mechanisms of HRM.

Sustainability is concerned with keeping the natural environment from degradation for current and future generations to decrease the negative impact of businesses on human health, social well-being, and economic growth. Yusoff *et al*. (2021 p: 627) pointed out that sustainability means "*development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs*".

Many organizations are investing in green activities because this investment makes stakeholders feel that an organization is devoted sincere efforts to environmental and social goals (Úbeda-García *et al*., 2021; Yusliza *et al*., 2020). Nowadays, organizations try to play their vital role to meet the needs of the human community in terms of green goods and services through rational exploitation of various natural resources and thus harmonizing the economic and environmental dimensions at the same time, which are main dimensions in BS (Hamod and Majeed, 2021).

Therefore, there is a considerable investment in resources and considerable efforts in GIC to attract the best talents and obtain a competitive edge. GIC has emerged as a safe way to get out of existing environmental challenges in this knowledge-driven economy era and the change in society's environmental agenda. Hence, Stakeholders have put pressure on firms in recent years to seek sustainable, environmental business practices. Consequently, it is essential to discover green measures by focusing more on intangible assets through GIC to achieve better performance that might increase BS (Alam *et al*., 2021). However, it is crucial to look at GIC as a plausible solution for BS because integrating green concepts in HRM functions must be carried out from the start. This will help in shaping the mindset of employees to have a vision of sustainability (Palguna, 2021; Yusoff *et al*., 2021). Nowadays, creating a green environment requires firms to invest more in GIC due to its crucial role in maintaining BS (Ali *et al*., 2021).

Additionally, GIC enables organizations to comply with strict international environmental regulations, and this creates value-added for the organization among its stakeholders and enables it to be sustainable (Yong et al., 2019). Therefore, Yusoff *et al*. (2021) asserted that GIC minimizes environmental impact and provides a competitive advantage to organizations and increases its ability to be sustainable and long-term survival.

Moreover, GIC considers the plausible solution to solve the environmental issues towards achieving sustainability and charging higher prices for green products (Malik *et al*., 2021; Yusoff *et al*., 2019). The organizations actively engaging in GIC can enhance BS because human capital stills are the only intangible element responsible for utilizing other resources. In addition, GIC increases productivity, improves the organization's images, improves customer relations, and keeps a positive relationship with green suppliers (Ullah *et al*., 2021; Omar *et al*., 2017; Mishal *et al*. 2017; Cavicchi and Vagnoni; 2017).

Many past pieces of research concluded that GIC is positively related to the economic, environmental, and social performance of business organizations (Ur Rehman *et al*., 2021; Wang and Juo, 2021; Yusliza *et al*., 2020; Aboelmaged and Hashem, 2019). In addition, Ali *et al*. (2021) stated in their study that small and medium firms with higher GIC tend to adopt GI to a greater extent to reinforce BS. Moreover, GIC had a positive relationship with a competitive advantage and then BS (Shoaib *et al*., 2021; Yahya *et al*., 2019; Yusoff *et al*., 2019). Therefore, Yadiati *et al*. (2019) argued that GIC could be the crucial attribute of supporting BS.

GIC promotes BS through alignment of GIC dimensions (named: GHC, GSC and GRC) with the company's objectives to maintain its sustainability in the long term. Finally, GIC is still a novel concept, and it is not well-known among academicians and practitioners, and this issue needs more research (Yusoff *et al*., 2019).

As a result, it is hypothesised that GIC would boost BS as the following:

Hypothesis 1: ***GIC has a significantly positive effect on BS.***

GIC involves three integrative dimensions, which are:

1- Green Human Capital (GHC)

According to Resource-based View Theory (RBV), a firm can maximize its competitive advantage through its human resources characterised by rare, inimitable, valuable, non-substitutable and non-tradable (Agyabeng-Mensah and Tang, 2021). Therefore, GHC, which involves intangible assets of employees in terms of knowledge, experience, capabilities, skills, creativities, genetic inheritance, and commitments altogether, can direct towards environmental protection and then BS (Sugiyanto and Febrianti, 2021; Chang and Chen, 2012; Chen, 2008).

In this regard, Yadiati *et al*. (2019) appreciated the critical role of GHC to meet the objectives of sustainable development through the implementation of green corporate practices. Therefore, GHC plays a crucial role as a driving force for green structural capital (GSC) and green relational capital (GRC) (Sabbir and Taufique, 2021; Chahal and Bakshi, 2014). Moreover, employees who have more extraordinary skills and knowledge of green activities help in improving the efficiencies through reduction of waste, cost, and consumption, and this ensures achieving BS because GHC considers a vital strategic resource for a sustainable competitive edge in today's age of ever-changing environment (Yusliza *et al*. 2020; Mas, 2019).

Little is known about the processes by which GHRM practices lead employees to behave eco-friendly despite GHRM practices positively influence green employee behaviour because GHC involves intangible assets such as knowledge, skills, capabilities, creativities, wisdom, experience, attitude, and commitments of employees, which are essential for achieving BS in the current competitive market environment (Cahyono and Hakimn, 2020; Yusliza *et al*., 2020; Kim *et al*., 2019).

Accordingly, the first sub-hypothesis, **H1.1,** can be formulated as follows:

H1.1: ***GHC has a significantly positive effect on BS.***

2- Green Structural Capital (GSC)

GSC has been defined as "*the stocks of organizational capabilities, organizational commitments, knowledge management systems, reward systems, information technology systems, databases, managerial mechanisms, operation processes, managerial philosophies, organizational culture, company images, patents, copy Rights, and trademarks, etc. about environmental protection or green innovation within a company*" (Chen, 2008, p. 277). These assets can be used to strengthen the organizational green HRM, which can foster BS. Consequently, firms invest in building the expertise, knowledge, skills, experience, and capabilities to gain competitive advantage through effective implementation of their knowledge management systems; managerial mechanisms, operation processes, managerial philosophies, and organizational culture to be green in all practices (Agyabeng-Mensah and Tang, 2021; Garcia-Perez *et al*., 2020).

Accordingly, the second sub-hypothesis, **H1.2:** can be formulated as follows:

H1.2: ***GSC has a significantly positive effect on BS.***

3- Green Relational Capital (GRC)

GRC has been defined as "*the stocks of a company's interactive relationships with customers, suppliers, network members, and partners about corporate environmental management and green innovation, which enables it to create fortunes and obtain competitive advantages*" (Chen, 2008, p. 278). Hence, GRC aims to survive and remain ahead in the line of competition through strengthening the relationship between all kinds of stakeholders and organizations.

GRC is an intangible resource that emphasises developing and maintaining excellent relationships with stakeholders that may influence the standing of a company within a dynamic and changing environment (Sabbir and Taufique, 2021). In this regard, organizations need to maintain a good relationship with their customers to have a competitive advantage based on a long-term relationship with all stakeholders (Tonial *et al*., 2019).

Consequently, in a highly competitive era, business success is no longer achieved simply by having a healthy financial status or creating innovative products but instead, success is achieved through keeping a good relationship with all kinds of stakeholders (Yong *et al*., 2019). Hence, many organizations realised this core point by going green in HRM to increase their efficiency and competitiveness in a dynamic competitive environment to maintain BS.

Accordingly, the third sub-hypothesis, **H1.3,** can be formulated as follows:

H1.3: ***GRC has a significantly positive effect on BS.***

2.2 Relationship between GIC and GI

Organizations have understood and realised that businesses could no longer survive and sustain themselves in the competitive world without focusing on innovation to bring effectiveness and efficiency to business activities (Ahmed *et al*., 2021). Furthermore, many organizations rely heavily on their employees′ green innovative practices to promote sustainability in the long term (Espaillat *et al*., 2021). GI involves two green activities, which are green product innovation and green process innovation. Green product innovation refers to modified products or services that do not harm the environment. Meanwhile, green process innovation is concerned with updating the production process to reduce the environmental impact, reduce costs, improve the quality and provision of products or services, and incorporate improved techniques in additional supporting activities (Asni and Agustia, 2021; Aboramadan and Karatepe, 2021).

Li *et al*. (2019 p: 135) defined GI as "*The introduction of any new or significantly improved product (good or service), process, organizational change or marketing solution that reduces the use of natural resources (including materials, energy, water and land) and decreases the release of harmful substances across the whole life-cycle of the product*". Thus, GI considers the most effective strategy to minimize environmental pressure and keep economic competitiveness at the same time.

In their study, Li and Du (2021) also defined GI as "*A production, service, process, organizational structure and management or business model innovation, which can reduce the negative impacts of ecological risks, environmental pollution and resource use more effectively than other innovation in production, application or development in life cycle*".

In their study, Delgado-Verde *et al*. (2014) concluded that the GIC positively related to GI, especially green product innovation. In addition, GIC is positively related to GI (Ur Rehman *et al*., 2021; Wang and Juo, 2021; Yusliza *et al*., 2020; Aboelmaged and Hashem, 2019). Moreover, high GSC supports an organizational environment that motivates its employees to learn new knowledge to protect the environment from damage and degradation. Moreover, GIC and GI are interrelated where GIC supports and enhances GI; at the same time, GI may further enhance GIC and which in turn increases competitive advantage and BS (Astuti and Datrini, 2021; Aboramadan and Karatepe, 2021; Yahya *et al*., 2019; Chen, 2008b). However, despite the widely accepted role of skills, expertise, and capabilities of employees in modifying new products and processes that have a minimum harmful effect on the environment, there is still a dearth of studies examining the influence of GIC on GI.

In the light of the above literature, the present study hypothesises that:

Hypothesis 2: ***GIC has a significantly positive effect on GI.***

This central hypothesis can be divided into three sub-hypotheses as follows:

H2.1: ***GHC has a significantly positive effect on GI.***

H2.2*: GSC has a significantly positive effect on GI.*

H2.3*: GRC has a significantly positive effect on GI.*

2.3 Relationship between GI and BS

GI plays a critical role in achieving sustainable development, which ensures economic benefits, ecological benefits, and practical humanities. It has a positive impact on environmental, economic, and strategic performance dimensions and it also has the potential to address the dilemma between consuming available resources and preserving them for the future (Khanra *et al*., 2021; Espaillat *et al*., 2021). In addition, GI aims to modify new products, processes or technology that keep the environment from pollution and natural resources from degradation. It enables organizations to achieve competitive advantage quickly and

ensures maintaining BS in the long term (Ali *et al*., 2021; Khan *et al*., 2021; Li *et al*., 2019). Therefore, it is rational for enterprises to choose GI strategy to attain its long-run objectives through promoting individual awareness of environmental issues and eradicates harmful technologies (Chen *et al*., 2012).

Due to the stakeholders' demand to tackle environmental challenges, Malik *et al*. (2021) showed that many organizations have started to adopt a GI approach that will generate unique and valuable concepts for green products and green processes to comply with environmental regulations on one side and to maintain sustainability on the other side.

In the same vein, Ali *et al*. (2021) argued that GI is highly essential for manufacturing firms to minimize negative impacts on the environment and maintain BS. Consequently, a firm without GI culture will suffer from many problems, especially in implementing employees' green abilities, motivation, and opportunities, because GI considers an effective means to realise energy conservation and reduce carbon emissions (Yusliza *et al*., 2021, Desheng *et al*., 2021; Aboramadan and Karatepe, 2021; Chang and Chen, 2012; Chen, 2008). Because of its importance for both organization and environment, Li *et al*. (2019) argued that GI is considered the most cost-effective way to reduce environmental pressure to attain BS. It aims to achieve cleaner production, improve environmental performance, and promote the comprehensive utilisation of both resources and energy (Fan and Xiao, 2021; Chen, 2008).

Nowadays, research has used an exploration-based GI to help businesses in achieving sustainability and remain competitive. In this way, GI will become the essential requirement for legitimacy (Muisyo and Qin, 2021; Li *et al*., 2019). The issue of sustainability and environmental problems is a significant problem for many countries, especially in developing countries like Egypt which has a large population density and decreased productivity in various industrial sectors (Palguna, 2021). GI plays a vital role in realising environmental performance by promoting the greening of industrial production processes that minimizes the adverse impacts on the environment and coping with intense global competition to attain BS (Arsawan *et al*., 2021; Junsheng *et al*. 2020).

Accordingly, the present study hypothesises that:

Hypothesis 3: ***GI has a significantly positive effect on BS.***

2.4 Mediating Role of GI between GIC and BS

Although many studies have shown that GIC is related to BS (Ababneh, 2021; Yusliza *et al*., 2020), other studies have not established, it is caused by an imbalance investment in intellectual capital elements (Sabbir and Taufique, 2021; Aboramadan and Karatepe, 2021; Rahmawati and Erinos, 2017; Lerro *et al*., 2014). However, scholars suggest that different components of GIC can have an impact on BS. GIC considers the main intangible element that organizations can effectively use to modify green products and processes that enhance and support BS (Adesola *et al*., 2021, Yusoff *et al*., 2019). Therefore, GIC enhances GI and goes green in all products and processes that GIC would be likely to have an additional positive effect on BS. Therefore, GI may serve as a mediator in the relationship between GIC and BS. Therefore, the following hypothesis is plausible:

Hypothesis 4: ***GI mediates the relationship between GIC and BS.***

This central hypothesis can be divided into three sub-hypotheses as follows:

H4.1: ***GI mediates the relationship between GHC and BS.***

H4.2: ***GI mediates the relationship between GSC and BS.***

H4.3: ***GI mediates the relationship between GRC and BS.***

Accordingly, the model of research can be illustrated in figure1.

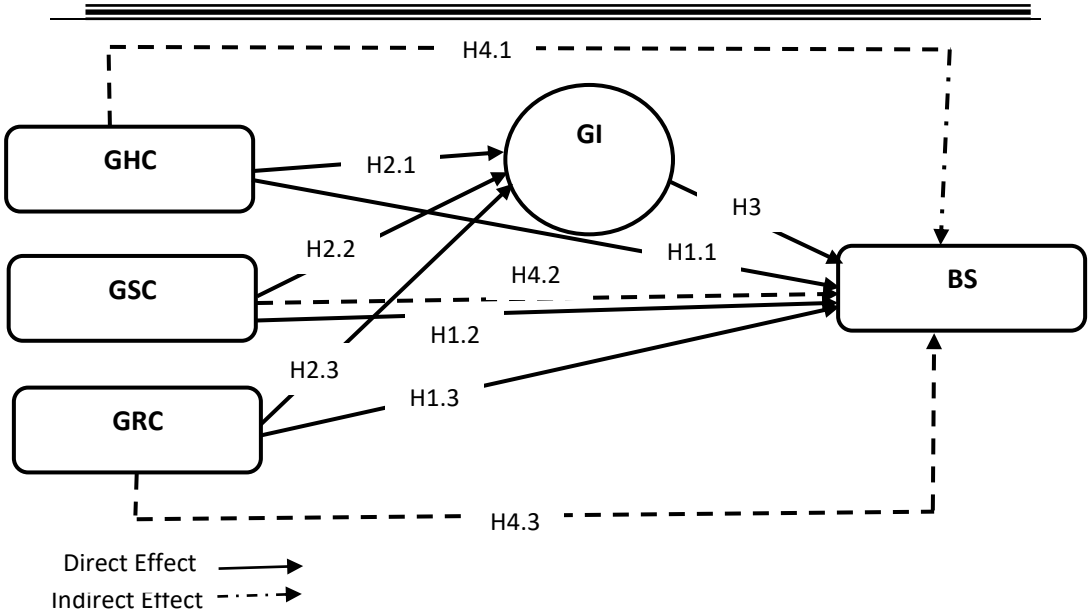

Figure 1 Research Model

3. Methodology

3.1 Research method and participants

This study used a descriptive-analytical approach with a survey questionnaire method. Data were collected during 15/6/2021 to 10/8/2021 from 384 employees who were selected randomly from 720 manufacturing companies working at Damietta port and industrial zone in new Damietta and the corrected questionnaires received were 269 with response rate 70%. The manufacturing companies have been selected because they are the most significant contributor to pollution and environmental issues in Damietta Governorate. The sampling unit was a respondent engaged with implementing the green practices using the random sampling method to distribute the sample size across managerial levels in manufacturing companies. Table 1 represents the demographic characteristics of the sample.

Table 1 Sample characteristics

Variables	Levels	Number	%Percentage
Job level	Upper Management	55	20.45
	Middle Management	127	47.21
	Direct Management	87	32.34
	Total	**269**	**100**
Gender	Male	173	64.31
	Female	96	35.69
	Total	**269**	**100**
Experience years	1 Year Less 3	46	17.10
	3 Year Less 5	101	37.55
	More 5 Years	122	45.35
	Total	**269**	**100**
Educational level	Graduation Level	144	53.53
	Post Graduated	125	46.47
	Total	**269**	**100**
Income level	1500 - Less 3000	32	11.90
	3000 Less 4500	85	31.60
	4500- Less 6000	65	24.16
	More 6000	87	32.34
	Total	**269**	**100**
Industry Type	Fertilizer and chemical	56	20.82
	Food	94	34.94
	Furniture	119	44.24
	Total	**269**	**100**

3.2 Measures

To measure variables, the underlying constructs were adapted from previous studies. All of them were multi-item measures on Likert measure ranging from not agree (1) to completely agree (5) as the following:

1- GIC is comprised of three dimensions named GHC, GSC and GRC. A total of 19 items were used to measure GIC and all items were adapted from previous studies (Ullah et al. 2022; Huang and Kung, 2011; Chen, 2008) as the following:

- 5 items were used for measuring GHC " e.g., *The employees' competence of environmental protection in the firm is better than that of its major competitors*; *Our managers fully support our employees in achieving their goals with respect to environmental protection"*.

- 9 items were used for measuring GSC" e.g., *Investments in environmental protection facilities in the firm are more than those of its major competitors; The competence in the development of green products in the firm is better than that of its major competitors".*
- 5 items for measuring GRC" e.g*., The cooperation relationships about environmental protection of the firm with its upstream suppliers are stable; The cooperation relationships about environmental protection of the firm with its downstream clients or channels are stable; The firm has stable relationships about environmental protection with its strategic partners".*

2- GI was adapted from many sources and comprised of 5 items (Roper & Tapinos, 2016; Chen, 2008; Chen et al., 2006) (e.g., *Our firm uses less or non-polluting/toxic materials; The manufacturing process of the firm effectively reduces the emission of hazardous substances or waste; Our firm chooses the materials of the product that consume the least amount of energy and resources for conducting the product development or design*).

3- BS was measured mainly depending on Chow and Chen (2012) using 22 items distributed on three dimensions namely, Economic Sustainability (ES) with 6 items; Social Sustainability (SS) with 6 Items and Environmental Sustainability (ENS) with 10 items (e.g*., Our firm prioritises employee or community health and safety*; *Our firm has improved compliance with environment; Our firm has achieved sufficient profits*).

The questionnaire was translated from English to Arabic. Later, after finishing the validity, reliability procedures and collecting data, it was translated back to English by another translator.

4. Data Analysis and Results

PLS-SEM was used to test Hypotheses because it is widely used in all business sectors to avoid data normality. Moreover, PLS does not require any distribution assumptions. In addition, a bootstrapping method was employed to determine the significance levels of the loadings, weights, and path coefficients. (Hair *et al*., 2017).

4.1 Measurement Model

Smart PLS 3.3.3 for statistical analysis through structural equation modelling (SEM) was used to test the proposed hypothesis. PLS is considered an appropriate statistical technique for analyzing complex and straightforward theoretical frameworks (Manley et al., 2020). Table 2 shows the outcomes of PLS measurement analysis of validity and reliability tests, factor loadings for items exhibited in table 2 ranged from 0.746 to 0.917 and all of them meet the threshold of 0.60 and items that have factor loadings lower than 0.50 were deleted. Consequently, the results showed that cross loadings of items measuring a particular construct are higher than cross loadings of other items with the same construct, thus confirming discriminant validity. In addition, all the values of CR and AVE are greater than 0.70 and 0.50, respectively (Hair *et al*., 2017). Therefore, data is reliable for further analysis. All measures have a Cronbach alpha of more than 0.80, which means that all measures are validated for this study. To avoid the likelihood of common method bias (CMB), Harman's single factor test was conducted to analyze CMB (Podsakoff et al., 2012). The result of a single factor contribution indicates a value of 38.40 which is below the 50% threshold and represents the absence of CMB in the data. Therefore, the possibility of a significant effect of CMB on estimated results has been ruled out.

Table 2. Internal Consistency and Convergent Validity

Factor	Items	Loadings	Alpha	CR	AVE
Cut off		> 0.5	> 0.6	> 0.7	> 0.5
Green Human Capital	GHC1 GHC2 GHC3 GHC4 GHC5	0.875 0.784 0.891 0.821 0.795	**0.925**	**0.789**	**0.812**
Green Structural Capital	GSC1 GSC2 GSC3 GSC4 GSC5 GSC6 GSC7 GSC8 GSC9	0.817 0.853 0.874 0.901 0.792 0.746 0.867 0.917 0.864	**0.874**	**0.864**	**0.778**
Green Relational Capital	GRC1 GRC2 GRC3 GRC4 GRC5	0.783 0.817 0.881 0.845 0.796	**0.894**	**0.842**	**0.875**
Green Innovation	GI1 GI2 GI3 GI4 GI5	0.761 0.842 0.781 0.872 0.895	**0.846**	**0.796**	**0.867**
Economic Sustainability	ES1 ES2 ES3 ES4 ES5 ES6	0.905 0.871 0.791 0.807 0.841 0.882	**0.872**	**0.801**	**0.786**
Social Sustainability	SS1 SS2 SS3 SS4 SS5 SS6	0.807 0.851 0.798 0.834 0.876 0.905	**0.854**	**0.861**	**0.837**
Environmental Sustainability	ENS1 ENS2 ENS3 ENS4 ENS5 ENS6 ENS7 ENS8 ENS9 ENS10	0.8172 0.807 0.835 0.891 0.914 0.760 0.842 0.871 0.809 0.834	**0.837**	**0.807**	**0.798**

Note: AVE=Average Variance Extracted; CR= Composite Reliability.

In addition, Table 3 presents Descriptive statistics, correlations matrix, and squared root of AVE. In addition, table 3 shows all values of AVE (in bold) for all variables is equal to the square root of the number in this range (0.88-0.91) and all values are greater than coefficient of corelation between variables. As a result, the variables' discriminant validity was preserved and identified for use in the current study model.

Table 3. Descriptive statistics, correlations matrix, and squared root of AVE.

Variables	M	SD	1	2	3	4	5	6	7
1. GHC	3.86	0.15	**0.90**						
2. GSC	3.96	0.22	0.35**	**0.88**					
3. GRC	4.01	0.31	0.28**	0.41**	**0.94**				
4. GI	3.78	0.24	0.56*	0.26*	0.14*	**0.93**			
5. ES	3.65	0.18	0.41**	0.34**	0.23**	0.53**	**0.89**		
6. SS	3.58	0.30	0.18**	0.16*	0.25**	0.36**	0.41**	**0.91**	
7. ENS	3.87	0.10	0.24*	0.30**	0.42**	0.13*	0.61**	0.34**	**0.89**

Note. N = 269; Diagonal values depict the square root of the AVE and indicates the highest in any column or raw.

** = p < 0.01; * = p< 0.05.

Furthermore, the validity of data was measured through the heterotrait–monotrait (HTMT) ratio of correlation. It was discovered that the standardized estimates show a 0.85 value for different constructs, whereas for similar constructs, the value was 0.90. (Henseler et al., 2015). The multicollinearity was measured through the variance inflation factor (VIF), and a value below 5 for all variables proved that multicollinearity was not an issue in the data. Table 4, given below, shows that the data meets the requirements for validity and multicollinearity.

Table 4. The heterotrait-monotrait (HTMT) analysis for discriminant validity.

Variables	VIF	1	2	3	4	5	6	7
1. BS	-	-						
2. GSC	2.185	0.51	-					
3. GRC	1.74	0.37	0.61	-				
4. GI	3.287	0.26	0.29	0.34	-			
5. ES	2.649	0.33	0.51	0.47	0.33	-		
6. SS	3.371	0.42	0.47	0.35	0.30	0.50	-	
7. ENS	2.627	0.38	0.50	0.22	0.23	0.31	0.54	-

Note: Discriminant validity exists if the HTMT < 0.85 (Henseler et al., 2005).

4.2 Results and Hypotheses Testing

Path coefficients, t-values, and standard errors were used to test hypotheses to determine the model significance. Table 5 and figure 2 present details about the tested hypotheses. As per the results, all hypotheses have statistical support. GIC has a significant positive effect on BS (β=0.570, p = 0.001, t- value=6.230). Therefore, **H1** was supported. GHC has a significant positive effect on BS (β=0.205, p = 0.024, t-value=3.346). Therefore, **H1.1** was supported. GSC has a significant positive effect on BS (β=0.256, p = 0.000, t-value=5.724). Therefore, **H1.2** was supported. Lastly, GRC has a significant positive effect on BS (β=0.347, p = 0.015, t-value=6.149). Therefore, **H1.3** was supported.

GHC has a significant positive effect on GI (β=0.604, p = 0.036, t-value=5.147). Therefore, **H2** was supported. GHC has a significant positive effect on GI (β=0.418, p = 0.021, t-value=3.939). Therefore, **H2.1** was supported. In the same vein, GSC has a significant positive effect on GI (β=0.547, p = 0.010, t-value=5.595). Therefore, **H2.2** was supported. Lastly, GRC has a significant positive effect on GI (β=0.478, p = 0.040, t- value=11.539). Therefore, **H2.3** was supported. On the other hand, results referred to GI has a significant positive effect on BS (β=0.198, p = 0.001, t- value=3.648). Therefore, **H3** was supported.

To measure the mediating role of GI in the relationship between GIC and BS, the equation of Barron and Kenny (1986) was used. As a total, results referred to GI mediates the relationship between GIC and BS; the positive effect increased from 0.570 to 0.782 because of GI and is still significant (p = 0.010, t-value=7.215, LL=0.220, UL=0.418). So, we can say that GI plays a partial mediation in the relationship between GIC and BS. Therefore, **H4** was supported. GI mediates the relationship between GHC and BS, the positive effect increased from 0.205 to 0.347 because of GI and still significant (p = 0.050, t-value=9.818, LL=0.372, UL=0.458). So, we can say that GI plays a partial mediation in the relationship between GHC and BS. Therefore, **H4.1** was supported. GI mediates the relationship between GSC and BS; the positive effect increased from 0.256 to 0.364 because of GI and is still significant (p = 0.050, t-value=6.152, LL=0.141, UL=0.287). So, we can say that GI plays a partial mediation in the relationship between GSC and BS.

Therefore, **H4.2** was supported. Lastly, GI mediates the relationship between GRC and BS; the positive effect increased from 0.347 to 0.436 because of GI and is still significant (p = 0.030, t-value=5.517, LL=0.386, UL=0.576). So, we can say that GI plays a partial mediation in the relationship between GRC and BS. Therefore, **H4.3** was supported. A more comprehensive overview of the results is given in Figure 2.

Table 5. Hypotheses Testing

Path	S.Beta	t - value	p-value	95% CI		Total Effect	Decision
				BCILL	BCIUL		
Direct Effect							
H1: *GIC -> BS*	**0.570**	**6. 230**	**0.001**	**0.128**	**0.317**	**-**	**Supported**
H1.1*: GHC -> BS*	0.205	3.346	0.024*	0.123	0.296	-	Supported
H1.2*: GSC -> BS*	0.256	5.724	0.000***	0.216	0.451	-	Supported
H1.3*: GRC -> BS*	0.347	6.149	0.015*	0.157	0.563	-	Supported
H2*: GIC -> GI*	**0.604**	**5.147**	**0.036***	**0.158**	**0.647**		**Supported**
H2.1*: GHC -> GI*	0.418	3.939	0.021*	0.298	0.537	-	Supported
H2.2*: GSC -> GI*	0.547	5.595	0.010**	0.102	0.311	-	Supported
H2.3*: GRC -> GI*	0.478	11.539	0.040*	0.133	0.273	-	Supported
H3*: GI -> BS*	**0.198**	**3.684**	**0.001****	**0.049**	**0.152**		**Supported**
Indirect Effect							
H4*: GIC -> GI -> BS*	**0.212**	**7.215**	**0.010****	**0.220**	**0.418**	**0.782*****	**Supported**
H4.1*: GHC -> GI -> BS*	0.142	9.818	0.050*	0.372	0.548	**0.347***	Partial Mediation
H4.2*: GSC -> GI -> BS*	0.108	6.152	0.001***	0.141	0.287	**0.364****	Partial Mediation
H4.3*: GRC -> GI -> BS*	0.089	5.517	0.030*	0.386	0.576	**0.436****	Partial Mediation

Note: BCI = Bias Confidence Interval; LL = Lower Limit; S. Beta = Standardized Beta; UL = Upper Limit.

*P < 0.05, **P < 0.01, ***P < 0.001.

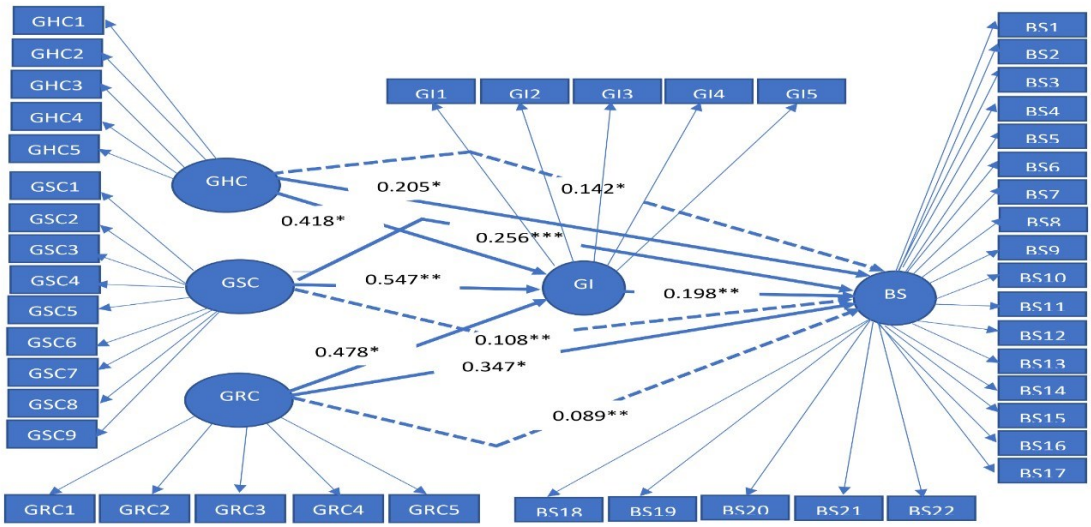

Figure2. Direct and indirect relationships

The mediation effect was tested through variance accounted for (VAF). The criterion value of VAF to decide full mediation is 80%; for partial mediation, it should be between 20% and 80% and less than 20% for no mediation. The results reported in Table 6 shows that the VAF value of 72.15 % proves partial mediation of GI in the relationship of GHC and BS, Hence, H4.1 was supported. Similarly, VAF value 65.33 % proves partial mediation of GI in the relationship between GSC and BS, Hence, H4.2 was supported. Lastly, VAF value 78.23 % proves partial mediation of GI in the relationship between GRC and BS, Hence, H4.1 was supported.

Table 6. VAF estimates for the role of GI as a mediator in the relationship between GIC and BS

IV	DV	MV	Indirect effect	Total effect	VAF (%)
1. GHC	BS	GI	0.142	0.347	72.15
5. GSC	BS	GI	0.108	0.364	65.33
7. GRC	BS	GI	0.089	0.436	78.23

Note: IV = Independent Variable; DV = Dependent Variable = Mediator Variable.

4.1 Predictive relevance and effect size

Referring to Table 7, *Q2* values are calculated for GI (*Q2* =0.185) and BS (*Q2* =0.236). All values were greater than zero; thus, there is an indicate predictive relevance for endogenous latent variables in the PLS path model (Hair et al. 2017). In addition, GIC contributed to 38.4% of the variance in

GI, and GI also explained 28.6% of the variance in BS. Furthermore, according to Cohen (1988), a small level of effect is represented by an f^2 = 0.02, a medium level of the effect by f^2 = 0.15 and a higher level of the effect by f^2 = 0.35. Therefore, it can be inferred from the results of table 7 (f^2 = 0.138 for GIC on GI), (f^2 = 0.271 for GI on BS) indicating that both GIC and GI have a moderate effect on GI and BS respectively.

Table. 7: R^2, f^2, *and* Q^2.

Construc	R^2	Adjusted	f^2	Q^2
GI	0.38	0.378	0.13	0.18
BS	0.28	0.281	0.27	0.23

***P*<0.05, ****P*<0.01.

5. Discussion

As environmental protection has become a priority in many organizations worldwide, this study aimed to examine how GIC contributes towards BS in Egyptian manufacturing firms while considering the mediating role of GI. This thought offers a new outlook for manufacturing companies aiming to improve green innovation through adequate skill inventory for their GIC in maintaining BS.

Hypothesis 1 that assumes a significantly positive effect of GIC on BS is confirmed. Data analysis showed that GIC has a direct effect on BS. In this sense, GIC represents a tacit and intangible resource to attain competitive advantage and then BS. Many petrochemical companies like MOPCO Egypt for manufacturing fertilisers is keen from the beginning and before establishing their factories to evaluate the environmental impact depending on the largest consulting companies specialised in this field. This emphasizes the need to leverage green practices to a higher level by adopting a comprehensive environmental management system including GIC to enable organizations to achieve sustainable performance at the corporate level (Obeidat *et al.*, 2022). Furthermore, this result argues with Chaudhry et al. (2016), who concluded that an organization could keep BS if it has skilled and experienced employees, a firm culture, and efficient management supporting a strong relationship with stakeholders. Apart from these organizational practices, this result aligns with Yusoff et al. (2019), who confirmed that GIC influenced BS in small and medium manufacturing enterprises (SMEs).

Additionally, Hypothesis 2 revealed a significantly effect of GIC on GI. Results Showed that firms tend to adopt GI to a greater extent when they have higher GIC. Specifically, GHC and GSC have a significantly positive effect on GI due to their direct contribution in supporting GI. They are constituting the two primary resources for progression in any organization. The results showed MOPCO had Launched an environmental commitment plan with the Environmental Affairs Agency in Egypt as an initiative role to enhance its leadership in using environmental protection technology. This result was consistent with the study of Ali *et al*. (2021) who showed that Pakistan's firms that having more GHC are adopting more green products and processes in SMEs.

In addition, this result argues with Ababneh (2021), who concluded that when employees receive well-designed green training programs, they engage with environmental initiatives that protect the environment from degradation and pollution. In addition, GRC positively impacts GI because a good relationship with stakeholders ensures that manufacturing firms adopt green products and green processes to keep their image and reputation with stakeholders. This result contradicts past studies which concluded that GRC has an insignificant effect on GI; this may vary due to environmental differences concerning cultural norms, standards, traditions, and principles between the Egyptian environment and foreign ones (Ali *et al*., 2021; Yousaf, 2021).

Furthermore, many studied firms were on a date with training their candidates on the integrated environmental monitoring system by purchasing the latest monitoring systems for the emissions of boilers to link it directly with the national network for monitoring industrial emissions in Egypt. Therefore, continually enriched GIC may lead to modifying green products and processes, whether through exploration or exploitation GI (Ur Rehman, 2021; Aboramadan and Karatepe, 2021). Ultimately, this incessant interaction between GIC and GI may substantially impact BS that appear in improving economic, social, and environmental sustainability. This result implies that firms must consider the green training activities that will qualify their employees with required new knowledge and skills regarding the green initiatives in modifying new products and processes. This result argues with Agyabeng-Mensah and Tang (2021), who concluded that firms are encouraged to invest in the training and education that develop GHC to advance green competitiveness, social performance, and financial performance.

In addition, GRC has a direct impact on GI. Therefore, the firm can gain a competitive advantage over its competitors and then attain BS if it considers and protects the interest of its stakeholders, considers environmental issues, and manages its intellectual capital efficiently (Obeidat *et al.*, 2022; Sabbir and Taufique, 2021; Chaudhry *et al.*, 2016). Investing more in GIC promotes employees to conduct exploitative GI, especially in developing countries like Egypt, where resources are scarce. This type of GI leads to improving existing products and processes to make them more environmentally friendly. In Damietta port, Petrochemical firms have distinguished programs in managing non-hazardous solid waste, hazardous industrial waste and medical waste and trained their employees to work effectively with environmental programs.

Additionally, GIC enhances an exploratory GI by introducing new green products and processes that could reverse negative environmental impacts and positively impact the environment in the future. For example, the Spanish Egyptian Gas Company (SEGAS) for Liquefied Natural Gas Complex uses the new 'cleaner' gas-fired power stations in Spain to make pollution at a minimum level. In addition, SEGAS carried out a major training program for its employees to increase their competencies about environmental protection and motivate its managers to introduce full support for employees in achieving their goals concerning environmental protection.

Moreover, hypothesis 3 is supported in the current study results, which assumes a significantly effect of GI on BS. This result argues with Asni and Agustia (2021), who claimed that GI is a valuable and unique resource, and it contributes to creating a competitive advantage through encouraging firms to recycle waste production into viable products to support BS. In addition, this result confirms with Hao *et al*. (2021) who concluded to GI has better performance in heavy pollution industries and non-high-tech industries.

Lastly, hypothesis 4 is supported in the current study which assumes a mediating role of GI in the relationship between GIC and BS. The findings showed that to build GI, manufacturing firms must pay more attention to GIC. In addition, when treating GI as a mediator in the relationship between GIC and BS, the results confirm that GIC supports BS indirectly by building up the GI. This result argues with prior studies that concluded that GI considers a catalyst factor in maximising the positive effect of GIC on BS (Tjahjadi *et al*., 20212; Waqas *et al*., 2021; Syafri *et al*., 2021; Aboramadan and Karatepe, 2021).

6. Theoretical and Managerial Implications

The results have many significant theoretical and managerial implications. They have contributed to the existing knowledge by investigating the relationship between GIC and SB through mediating GI. This relationship had to be studied to maximize the impact of GIC on BS in Egyptian manufacturing companies. On the other hand, Egypt is consuming more energy and natural resources, resulting in 6% CO2 emissions. Therefore, all organizations must qualify their employees with green skills to decrease CO2 emissions through designing green products and processes. This result is consistent with the recommendations of the climate conference in Sharm El-Sheikh COP 27.

This present study is a valuable addition to the literature on GIC and GI towards BS. The results showed that GIC could only grow when an organization is actively involved in GI. Furthermore, there is an interrelationship between GIC and GI on BS. Hence, the mediation of GI in this relationship suggests a comprehensive framework to study the impact of GIS on BS.

Most manufacturing firms are facing various environmental challenges. Therefore, this research has opened many doors for new researchers to conduct their research in any other sector besides the manufacturing sector and compare their findings with this study. The results have postulated GIC as a critical practice to build GI and foster BS. Then GIC represents a tacit resource and dynamic capability continually evolving in interaction with GI to attain BS. Thus, manufacturing firms are required to reinforce knowledge, capabilities, expertise, understanding, intelligence, vision, obligation, and skills of their employees regarding environmental safety and to properly deal with environmental issues through training their employees to reach BS.

Furthermore, manufacturing firms are also required to provide opportunities for their employees to implement what they have learned during the training. Consequently, enriching the skills and abilities of employees reinforces GI, which in turn will foster BS. Further, this study can facilitate managers in their effort to build GI as it has provided empirical evidence related to the contribution of GIC towards BS. Additionally, the findings also aid managers in identifying and focusing on the organization's culture, competencies, patents, trademarks, exclusive rights, corporate image, and managerial capabilities regarding GI to foster it, which supports BS.

7. Limitations and Future Directions

While the study presented here contributes to new knowledge, it is not free from shortcomings. It has some limitations. **First**, the sample was taken from the manufacturing sector of Damietta governorate, and single-source data collection was followed, which may involve some biased results. Therefore, future studies may consider the service sector and other governorates in Egypt to study the current research framework to compare. In addition, the present study has considered one mediating variable, namely GI. Therefore, future studies may consider other mediating variables that can build BS. In this context, it is also interesting to study the moderating variables between the relationship of GIC and BS, such as green self-efficacy or green behaviour.

Secondly, this study did not differentiate between exploitative and exploratory GI. This differentiation may be related to BS in their ways and may differ in how they play their mediating roles. Future research could, therefore, further differentiate between different GI types in their relationship with BS. **Thirdly,** this study dealt with BS as one unit and did not divide it into its three dimensions (economic sustainable, social, and environmentally sustainable). So, future research must deal with this issue to determine which dimension is more influenced by GIC and GI. Therefore, further research should broaden the knowledge on the relationships between these variables and explain these relationships more fully. **Finally**, this study only considered the current state of the large manufacturing Egyptian firms and does not examine either the short or long-term effects of GIC on BS. Future research would benefit from a longitudinal approach that traces the development of GIC practices and investigates how the relationship between variables changes over time.

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العلاقة بين رأس المال الفكري الأخضر واستدامة الأعمال في الشركات الصناعية المصرية: الدور الوسيط للابتكار الأخضر

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الغرض- تهدف هذه الدراسة بحث تأثير رأس المال الفكري الأخضر على استدامة الأعمال من خلال الدور الوسيط للابتكار الأخضر في الشركات الصناعية المصرية.

المنهجية - تم جمع البيانات من ٢٦٩ موظفًا يعملون في الشركات الصناعية بميناء دمياط والمنطقة الصناعية بدمياط الجديدة. وباستخدام طريقة PLS-SEM تم قياس الدور الوسيط للابتكار الأخضر في العلاقة بين رأس المال الفكري الأخضر واستدامة الأعمال.

النتائج - تتمثل النتيجة الرئيسية للدراسة في وجود تأثير معنوي طردي لرأس المال الفكري الأخضر على كل من الابتكار الأخضر واستدامة الأعمال، وأن الابتكار الأخضر يلعب دور الوساطة الجزئية بين رأس المال الفكري الأخضر واستدامة الأعمال، حيث أشارت النتائج إلى وجود تحسناً ملحوظاً في مستوى الابتكار الأخضر عندما تستثمر الشركات الصناعية بشكل واضح في رأس المال الفكري الأخضر، ومن ثم يكون للابتكار الأخضر تأثير كبير على استدامة الأعمال. علاوة على ذلك، فإن رأس المال الفكري الأخضر له تأثير مباشر على استدامة الأعمال.

الأصالة / القيمة – تتمثل المساهمة الفعلية لتلك الدراسة في قياس أثر رأس المال الفكري الأخضر على استدامة الأعمال الشركات الصناعية في مصر في ضوء وساطة الابتكار الأخضر اعتماداً على كل من نظرية الموارد ونظرية رأس المال الفكري. في ضوء ما توصلت إليه الدراسة من نتائج، تم اقتراح العديد من التوصيات لتعظيم تأثير رأس المال الفكري الأخضر على استدامة الأعمال.

الكلمات المفتاحية: استدامة الأعمال؛ رأس المال الفكري الأخضر رأس المال البشري الأخضر؛ رأس المال الهيكلي الأخضر رأس المال الترابطي الأخضر الابتكار الأخضر الاستدامة الاقتصادية؛ الاستدامة الاجتماعية؛ الاستدامة البيئية.