



Green Human and Operational Capital on Operational Efficiency: The Role of Green Intellectual Capital

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ABSTRACT: This study investigates the relationship between green human capital, green operational capital, green intellectual capital, and organisational operational efficiency. It also investigates the function of green intellectual capital in moderating these interactions. Green human capital relates to individuals' environmental knowledge and abilities, whereas green operational capital refers to the physical resources and technologies that support sustainable operations. Green intellectual capital refers to an organisation's collective environmental knowledge, innovative thinking, and capacities. The study emphasises the interdependence of these variables and their impact on operational efficiency. Green intellectual capital, it is discovered, mediates the linkages between green human capital and operational efficiency, as well as green operational capital and operational efficiency. The findings highlight the necessity of cultivating a sustainable culture and investing in developing green resources and competencies to improve operational efficiency. This study adds to the body of knowledge on green management and offers useful insights for organisations seeking to establish sustainable operational practices and competitive advantages.

KEYWORDS: Green Human capital, green operational capital, green intellectual capital, operational efficiency.

INTRODUCTION

Organisations increasingly recognise the necessity of incorporating green practices into their operations in this era of sustainable development and environmental concern (Roscoe et al., 2019). Green human and operational capital is critical to operational efficiency and long-term performance (Costa & Matias, 2020; Haldorai et al., 2022). Green intellectual capital is critical in enabling organisations to achieve and maintain operational efficiency while minimising their environmental effect (Cole et al., 2019; Tze San et al., 2022).

Organisations investing in green human capital focus on improving employee knowledge and abilities in sustainable practices, environmental regulations, and green technologies (Amrutha & Geetha, 2020; Malik et al., 2020; Mousa & Othman, 2020). Organisations may develop an environment of environmental responsibility and innovation by providing staff with the appropriate competence (Piwowar-Sulej, 2021). Green human capital improves operational efficiency by empowering people to explore, analyse, and adopt environmentally friendly practices across the value chain (Nejati et al., 2017; Zaid et al., 2018). As a result, resource consumption, waste generation, and carbon emissions are minimised, ultimately improving operating efficiency (Kjaer et al., 2019; Zhao et al., 2017).

The physical and technological resources that organisations have to support their operations are referred to as operational capital (Roxas, 2021). Environmentally friendly infrastructure, energy-efficient equipment, and green technology are examples of operational capital in green operations (Xia et al., 2021). Green operational capital enables businesses to optimise resource utilisation, streamline operations, and reduce environmental impact (Bag & Gupta, 2020; Javaid et al., 2022). For example, implementing energy-efficient machinery or using renewable energy sources can dramatically reduce energy usage and associated expenses, improving operational efficiency (Chel & Kaushik, 2018).

The role of green intellectual capital in mediating the interaction between green human capital and operational capital on operational efficiency, on the other hand, remains unexplored. Understanding how green intellectual capital influences the use of green human and operational capital to drive operational efficiency is critical for organisations aiming for long-term success (Chuang & Huang, 2018; Pedro et al., 2018; Saeed et al., 2019; Yong et al., 2022).



Despite increased awareness of the importance of green practices in organisations, there needs to be more understanding of the role of green intellectual capital in mediating the interaction between green human capital, operational capital, and operational efficiency. While earlier research has looked at the individual effects of green human capital and operational capital on operational efficiency, the specific processes by which green intellectual capital influences these connections have received less attention. A large research vacuum exists in understanding how organisations may successfully harness their green knowledge, skills, and capacities to optimise the utilisation of green resources and promote operational efficiency.

This study attempts to add to the existing literature by investigating the function of green intellectual capital as a moderator in the interaction between green human capital, operational capital, and operational efficiency. This research will provide unique insights into how organisations improve their environmental performance while maintaining operational efficiency by investigating the interconnections and consequences of these variables. This study emphasises the need to build and use specific knowledge and capacities connected to sustainable practises by concentrating on the distinctive elements of green intellectual capital. The originality of this study lies in its comprehensive examination of the interplay between green human capital, operational capital, and the mediating role of green intellectual capital in illuminating the pathways by which organisations can effectively achieve their green and operational goals.

LITERATURE REVIEW

Green human capital refers to an organisation's employees' knowledge, skills, and competencies related to environmental sustainability (Mousa & Othman, 2020). The physical resources and technologies supporting ecologically sustainable operations are called green operational capital (Haldorai et al., 2022). Green intellectual capital refers to an organisation's collective knowledge and capacities related to environmental sustainability (Boon et al., 2018). The interaction of these three variables is critical in driving operational efficiency (Nisar et al., 2021). Green people capital fosters green practice uptake and implementation, whereas green operational capital provides the resources required for execution (Huo et al., 2022). Green intellectual capital informs decision-making, creates a culture of sustainability, and aids in developing and implementing green practices and technology (Masri & Jaaron, 2017). The combination of these components allows organisations to optimise resource utilisation, decrease waste, increase productivity, and reduce environmental impact, resulting in increased operational efficiency (Adepoju et al., 2022; Anwar et al., 2020). Organisations can gain a competitive advantage while supporting environmental sustainability by investing in the development of green human and operational capital and utilising their green intellectual capital (Kim et al., 2019).

Green human capital, green operational capital, and green intellectual capital are all interconnected components that help businesses achieve operational efficiency and competitive advantage by focusing on environmental sustainability (Makhloufi et al., 2022; Porter & Kramer, 2019). Green human capital uses individuals' knowledge and abilities to drive the adoption of ecologically sustainable practices, whereas green operational capital offers the physical resources and technologies required for their execution (Singh et al., 2020). Green intellectual capital informs decision-making, creates a culture of sustainability, and allows for creating and implementing green practices and technology (Secundo et al., 2020). Combining these three components helps organisations optimise resource utilisation, decrease waste, increase productivity, and reduce environmental impact, resulting in increased operational efficiency (Kristensen & Mosgaard, 2020). Organisations can achieve a competitive advantage in the marketplace while supporting environmental sustainability by investing in the development of green human and operational capital and utilising their green intellectual capital (Yusliza et al., 2020). This comprehensive approach to incorporating environmental factors into organisational operations emphasises the significance of matching information, resources, and decision-making processes to achieve long-term performance (Yong et al., 2019). Organisations can drive positive environmental outcomes while improving operational efficiency and gaining a competitive advantage in an increasingly environmentally conscious business landscape by recognising the interrelationships between green human capital, green operational capital, and green intellectual capital. Based on the literature review and previous research findings, the hypotheses proposed for this study are as follows:

Hypothesis 1: Green human capital relates on green intellectual capital

Hypothesis 2: Green human capital relates on operational efficiency

Hypothesis 3: Green operational capital relates on green intellectual capital

Hypothesis 4: Green operational capital relates on operational efficiency

Hypothesis 5: Green intellectual capital relates on operational efficiency



Hypothesis 6: Green intellectual capital mediates the relationship between green human capital and operational efficiency

Hypothesis 7: Green intellectual capital mediates the relationship between green operational capital and operational efficiency

METHODOLOGY

This study takes a quantitative approach and employs a cross-sectional research design. The research sample will be drawn randomly from diverse organisations in the manufactur industry in Serang Regency. Surveys will be conducted using a questionnaire to assess green human capital, green operational capital, green intellectual capital, and operational efficiency. The acquired data will be analysed statistically using regression analysis to investigate the correlations between these factors. The role of green intellectual capital in mediating the linkages between green human capital, green operational capital, and operational efficiency can also be investigated using mediation analysis. The study instrument's validity and reliability will be assessed. Measurement scale using a Likert scale of 1-5 with 200 questionnaires distributed to participants via Email and WhatsApp in the form of a Google Form, out of which 175 questionnaires were returned and 128 questionnaires were completed and subsequently analyzed further.

FINDINGS AND DISCUSSION

Assessment of the structural model

After confirming the model's validity (refer to Table 1), the analysis used 128 responses to evaluate the structural model and determine the significance of the path coefficients. Figure 1 and Table 1 illustrate the regression weights of the structural model.

Table 1. Confirmatory factor analysis with reliability and validity statistic

Construct	Items	Outer Loading	α	rho_A	CR	AVE
Green Human Capital	GHC1=I am well-versed in the current environmental issues	0.927	0.983	0.986	0.985	0.866
	GHC2=I actively participate in environmental projects at work or in my community	0.950				
	GHC3=I have the knowledge and expertise to adopt environmentally sustainable methods	0.929				
	GHC4=I have obtained environmental sustainability education and training	0.924				
	GHC5=I am constantly looking for information on the most recent environmental study	0.960				
	GHC6=I take the lead in creating or supporting environmental activities	0.916				
	GHC7=Through responsible business methods, I contribute to long-term economic and social development	0.915				
	GHC8=I see the good influence of environmental activities on increasing community quality of life	0.941				
	GHC9=I regularly participate in environmental efforts and educate others	0.931				
	GHC10=In my daily existence, I pursue environmentally responsible behaviour	0.914				
Green Operational Capital	GOC1=Our daily activities actively incorporate sustainable principles	0.849	0.936	0.936	0.945	0.635



	GOC2=We place a high priority on energy efficiency and work to lower our energy usage	0.803				
	GOC3=Recycling and waste minimisation are essential components of our operational procedures	0.771				
	GOC4=We are dedicated to reducing water use and implementing sustainable water management techniques	0.820				
	GOC5=Our operations are guided by two essential principles: responsible sourcing and resource conservation	0.785				
	GOC6=We prioritise green transportation strategies and advance green logistics	0.751				
	GOC7=We employ green technology to reduce our environmental impact and invest in them	0.854				
	GOC8=Our operational decision-making places a high focus on environmental regulation compliance	0.798				
	GOC9=We are always looking for ways to enhance environmental performance and operational sustainability	0.752				
	GOC10=Our business procedures follow the guidelines of a circular economy	0.773				
Green Intellectual Capital	GIC1=I am knowledgeable about sustainability and environmental issues	0.771	0.95	0.96	0.955	0.678
	GIC2=I constantly research new green technologies and techniques to keep up with them	0.846				
	GIC3=I use my knowledge and abilities to support sustainable solutions in the workplace	0.867				
	GIC4=I actively participate in seminars, conferences, and conversations on environmental and sustainability concerns	0.745				
	GIC5=I've completed specialised coursework or training in sustainability and the environment	0.816				
	GIC6=I participate in research and development efforts aimed at finding long-term solutions	0.857				
	GIC7=I actively share my expertise and experience in environmental and sustainable business methods with coworkers and business partners	0.752				
	GIC8=I contribute to the creation of workplace sustainable practices and environmental policies	0.835				
	GIC9=I locate and apply chances for sustainable innovation within the company	0.863				
	GIC10=My awareness of and contribution to sustainability and the environment must be consistently improved	0.868				
Operational Efficiency	OEFF1=We continuously review and enhance our operational procedures to increase effectiveness	0.935	0.978	0.978	0.981	0.838



OEFF2=We track and analyse key performance indicators (KPIs) to gauge and evaluate our operational effectiveness	0.850
OEFF3=To reduce waste and increase production, we have applied lean manufacturing techniques	0.959
OEFF4=To restructure our business and eliminate inefficiencies, we prioritise continuous improvement projects	0.918
OEFF5=We use technology and automation to increase operational effectiveness and decrease the need for manual labour	0.840
OEFF6=We have put energy-saving measures in place to cut operational expenses and maximise resource usage	0.953
OEFF7=We regularly solicit input from stakeholders and employees to pinpoint opportunities for increasing operational efficiency	0.940
OEFF8=We have set clear operational goals and targets to promote improvements in performance and efficiency	0.845
OEFF9=We regularly conduct training and development programs to boost personnel skills and expertise for increased operational efficiency	0.953
OEFF10=To find opportunities for more improvement, we compare our operational effectiveness to best practices in the industry	0.949

Table 2. Fornell-Larcker Criterion

*) Construct	GHC	GIC	GOC	OEFF
Green Human Capital	0.931			
Green Intellectual Capital	0.436	0.823		
Green Operational Capital	0.423	0.587	0.797	
Operational Efficiency	0.512	0.677	0.589	0.915

*) GHC=Green Human Capital; GOC=Green Operational Capital; GIC=Green Intellectual Capital; OEFF=Operational Efficiency

Table 3. Heterotrait-Monotrait Ratio (HTMT)

*) Construct	GHC	GIC	GOC	OEFF
Green Human Capital				
Green Intellectual Capital	0.404			
Green Operational Capital	0.435	0.588		
Operational Efficiency	0.515	0.632	0.613	

*) GHC=Green Human Capital; GOC=Green Operational Capital; GIC=Green Intellectual Capital; OEFF=Operational Efficiency

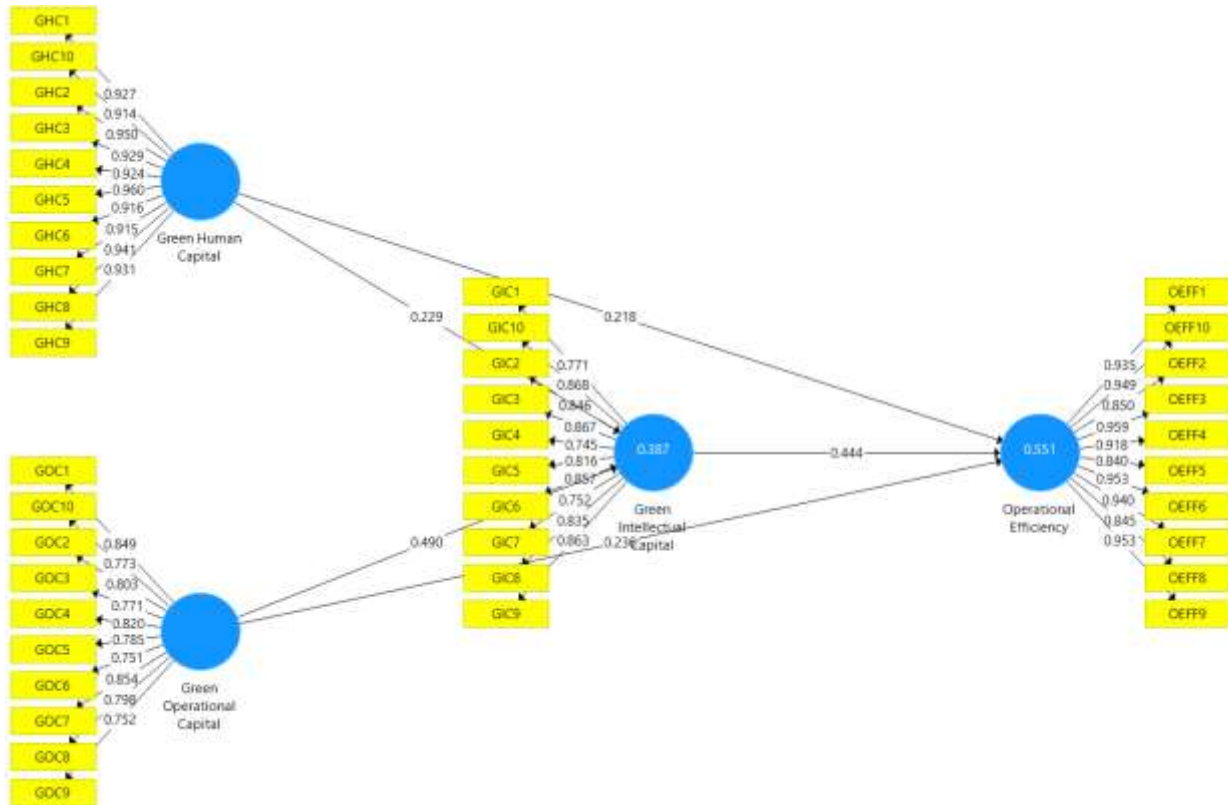


Figure 1. PLS Algorithm

Inner Model Test

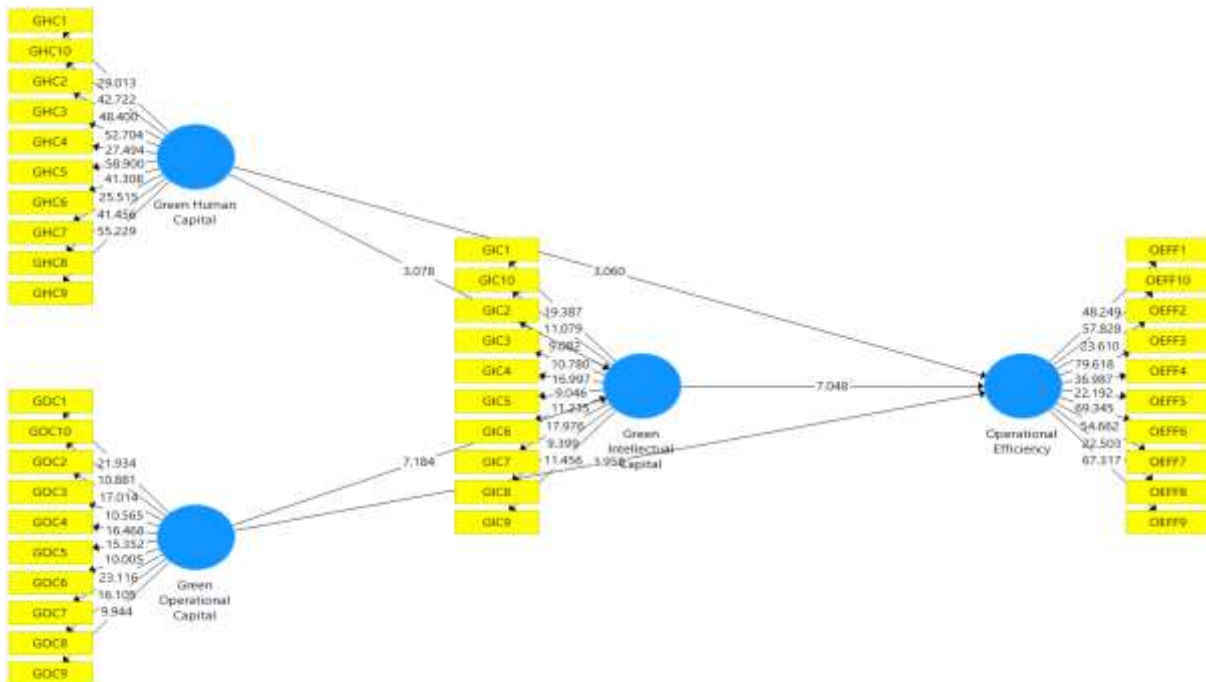


Figure 2. Bootstrapping Analysis



Direct relationship

Table 4. Path Analysis

Hypothesis	Construct *)	Original Sample	Standard Deviation	T Statistics	P Values	Remark
H1	GHC -> GIC	0.229	0.074	3.078	0.002	Accepted
H2	GHC -> OEFF	0.218	0.071	3.06	0.002	Accepted
H3	GOC -> GIC	0.490	0.068	7.184	0.000	Accepted
H4	GOC-> OFF	0.236	0.06	3.958	0.000	Accepted
H5	GIC -> OEFF	0.444	0.063	7.048	0.000	Accepted

*) GHC=Green Human Capital; GOC=Green Operational Capital; GIC=Green Intellectual Capital; OEFF=Operational Efficiency

Indirect relationship

Table 5. Mediation test

Hypothesis	Construct *)	Original Sample	Standard Deviation	T Statistics	P Values	Remark
H6	GHC -> GIC -> OEFF	0.101	0.034	2.979	0.003	Accepted
H7	GOC -> GIC -> OEFF	0.217	0.038	5.760	0.000	Accepted

*) GHC=Green Human Capital; GOC=Green Operational Capital; GIC=Green Intellectual Capital; OEFF=Operational Efficiency

The creation and accumulation of green intellectual capital within organisations is significantly influenced by green human capital (H1 accepted). Employees with environmental knowledge and skills contribute to creating and spreading environmentally friendly knowledge. Their knowledge promotes the acquisition, creation, and utilisation of green intellectual capital, encompassing the organisation's collective knowledge, environmental awareness, and sustainable practises capabilities. Green human capital and intellectual capital have a symbiotic relationship, with efforts in building green human capital leading to increased green intellectual capital. Green human capital development may help organisations utilise their knowledge and skills to generate sustainable innovation and earn a competitive advantage.

Green human capital has a favourable impact on organisational operational efficiency (H2 accepted). Employees with environmental sustainability knowledge and skills promote implementing ecologically friendly practices, resulting in greater resource utilisation, waste reduction, and energy efficiency. They help to spread sustainable practices throughout operational processes, resulting in cost savings and increased productivity. Furthermore, green human capital develops a sustainable culture by pushing employees to engage in ecologically responsible behaviours and fostering a collaborative work atmosphere. Organisations that invest in their employees' green knowledge and skills are more likely to achieve improved operational efficiency while lowering their environmental impact.

Green operational capital significantly influences the growth and accumulation of green intellectual capital within organisations (H3 Accepted). Organisations support the production and utilisation of green intellectual capital by investing in environmentally friendly infrastructure and technologies. Employees' knowledge and expertise in environmental sustainability are enhanced by the availability of resources and technologies that promote sustainable practices. Green operational capital also helps build and disseminate green intellectual capital by allowing for innovation and implementing ecologically friendly solutions. Green operational and intellectual capital have a mutually reinforcing relationship, as investments in green operational capital improve the organisation's ability to produce and exploit green intellectual capital. Green operational capital can help organisations strengthen their knowledge base, improve environmental performance, and acquire a competitive advantage.

Green operational capital has a favourable impact on organisational operational efficiency (H4 Accepted). Investing in environmentally friendly infrastructure, energy-efficient equipment, and sustainable technologies helps to optimise resource



utilisation, reduce waste, and reduce environmental impact. Green practices improve operational efficiency by streamlining operations, lowering costs, and encouraging sustainable resource management. Furthermore, green operational capital promotes a sustainable culture by fostering staff participation and creativity. Overall, including green operational capital enables organisations to balance environmental stewardship and operational efficiency, resulting in long-term success and competitiveness.

Green intellectual capital has a favourable impact on organisational operational efficiency (H5 Accepted). It includes the organisation's collective environmental knowledge, innovative thinking, and environmental awareness. By harnessing this knowledge and skills, organisations can discover and implement environmentally friendly measures that improve operational efficiency. Green intellectual capital promotes decision-making processes aligned with sustainability goals and fosters a culture of sustainability, promoting employee engagement and motivation. Organisations with high levels of green intellectual capital are better positioned to optimise resource utilisation, streamline processes, and improve operational efficiency while encouraging environmental sustainability.

Green intellectual capital bridges the gap between green human capital and operational efficiency (H6 Accepted). Employees with green human capital help to implement sustainable practices, while green intellectual capital helps them translate their knowledge and abilities into tangible solutions for operational efficiency. Green intellectual capital drives decision-making processes, promotes knowledge sharing and builds an organisational culture of sustainability. Organisations can improve operational efficiency and generate long-term competitive advantages by using green human and intellectual capital.

Green intellectual capital serves as a bridge between green operational capital and organisational and operational efficiency (H7 Accepted). It helps decision-making processes and makes environmentally friendly solutions easier to execute. Organisations can use their green operational resources to optimise operational processes and achieve higher levels of efficiency by using green intellectual capital. Furthermore, green intellectual capital develops a culture of sustainability by encouraging staff engagement and knowledge exchange. Developing and deploying green intellectual capital is critical for organisations seeking long-term operational efficiency.

CONCLUSION

The study's findings emphasise the importance of green human capital, green operational capital, green intellectual capital, and their interrelationships in defining organisational operational efficiency. By integrating these components, organisations can adopt and implement ecologically friendly practices, optimise resource utilisation, and minimise waste. Green intellectual capital serves as a bridge, allowing knowledge and skills connected to environmental sustainability to be translated into practical solutions for operational efficiency. This study adds to our understanding of how organisations might use their green resources and capabilities to achieve long-term operational efficiency and acquire a competitive advantage.

This study's conclusions have various ramifications for both theory and practice. The discovery of green intellectual capital's mediating role emphasises the necessity of cultivating a culture of sustainability, supporting information sharing, and stimulating innovation inside organisations. Through training, education, and adopting sustainable technology, organisations should invest in developing green human capital, operational capital, and intellectual capital. By combining these components, organisations can improve operational efficiency and contribute to environmental sustainability.

This study has certain drawbacks. The study was done in a specific business or context, which may restrict the findings' generalizability. Furthermore, the study relied on self-reported data, which is vulnerable to response bias. Future studies should examine a broader range of industries and use objective operational efficiency measures. Furthermore, the study did not investigate any potential mediating or moderating variables that could alter the link between the variables under consideration. Additional elements that may influence the relationship between green human capital, green operational capital, green intellectual capital, and operational efficiency should be investigated in future research.

Several directions for future research can be suggested based on the constraints revealed. Longitudinal studies on the long-term effects of green human capital, green operational capital, and green intellectual capital on operational efficiency might be done. Furthermore, qualitative research approaches could be used to understand better the mechanisms through which these variables interact and affect operational efficiency. Further examination into the role of organisational culture, leadership, and other contextual factors in creating the relationships under investigation may also yield useful insights. Finally, comparative studies across industries



and nations would contribute to a better understanding of the links between green capital and operational efficiency in various circumstances.

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