Journal of Engineering, Project, and Production Management
2023, 13(1), 65-75

Nexus between Big Data and Green Intellectual Capital on Project Sustainability

Jamshid Ali Turi[1], Mirza Hamza Naeem Mughal[2], Muhammad Waris Ali Khan[3], and Asadullah Khan[4]

[1]Assistant Professor, College of Business Administration, University of Tabuk, Kingdom of Saudi Arabia. E-mail: jamshidturi@gmail.com

[2]Student, Bahria Business School, Bahria University Islamabad, Pakistan. E-mail: hamza_mughal2@hotmail.com

[3]Associate Professor, Faculty of Business and Law, The British University in Dubai, UAE. E-mail: waris.khan@buid.ac.ae (corresponding author).

[4]Assistant Professor, Department of Business Management, Karakoram International University, Gilgit, Pakistan. E-mail: asad@kiu.edu.pk

Production Management
Received April 7, 2022; revised July 21, 2022; October 8, 2022; accepted October 10, 2022
Available online November 21, 2022

Abstract: Green Intellectual Capital (GIC) refers to environmentally friendly management styles for gaining a competitive advantage. In this study, the impact of GIC was assessed on the project's sustainability while big data was taken as a moderating variable. Data was collected from the manufacturing industry and analyzed using structural equation modeling. Results indicated that GIC has a significant effect on project sustainability. In the same way, big data moderates the relationship between the GIC and project sustainability, except for the relational capital construct. The finding of the study recommends that GIC, with the support of big data, can be helpful for the completion of sustainable manufacturing projects. Moreover, the study recommends that elements of the relational capital construct need to be explored in-depth to assess their role in project sustainability. In the same way, the GIC may also need to be tested and applied in other industries and countries for the delivery of value to customers.

Keywords: Green intellectual capability, green relational capital, green human capital, green structural capital, big data, project sustainability.

DOI 10.32738/JEPPM-2023-0007

1. Introduction

Green Intellectual Capital (GIC) is the collection of intangible assets including, but not limited to, skill sets, norms, routines, learning, human assets, and structural and relational sets of activities and processes. GIC is a crucial factor in the long-term survival of a company (Ullah et al., 2021). Formally, Chen (2008) explored that GIC is the collection of intangible knowledge, relationships, capabilities, and assets of any organization to retain, sustain, and develop the company's green environment for its long-term commitment and survival. GIC has been tested in different contexts and sectors and has proved its vitality and validity for sustainability. In the Malaysian business market and China's service industries, GIC has sustained productivity (Bueno et al., 2004). In the same way, in European countries, GIC is focused and laws regarding nature and the environment carry claws to incorporate GIC practices into industrial processes and products. However, the literature is silent on GIC's application in the manufacturing sector, especially in developing economies (Chang and Chen, 2012; Hair et al., 2013). Developing economies are moving or even shifting towards industrial economies besides keeping their agrarian status, and there is a chance that this transition may disturb the natural environment, resources, and even future energy resources (Bontis, 1998; Huang, 2011). At the same time, developing economies are showing good potential for growth. They have attracted skilled workers, with the help of advanced technology, and developed economies are bolstering their economies (Kelava, 2016; Sheikh, 2021). Besides this, studies have surfaced the limitations associated with the manufacturing industry, their project sustainability, and GIC. Likewise, Big Data has proven its potential validity and capabilities in certain industrial sectors. Therefore, stronger relationships between big data capabilities and manufacturing are expected. Therefore, this research focused on filling the gap by studying the impact of the GIC on the project's sustainability with the moderating role of big data capabilities. Likewise, the study focused on searching for answers to the following questions:

RQ1: What is the impact of big data as moderated on the relationship between green human capital (GHC) and project sustainability?

RQ2: What is the impact of big data as moderated on the relationship between green relational capital (GRC) and project sustainability?

RQ3: What is the impact of big data as moderated on the relationship between green structural capital (GSC) and project sustainability?

2. Literature Review

Green intellectual capital is the collection of organizational intangible skills, learning, experiences, routines, and information. GIC has been tested in various fields and industries and it has contributed to the policies, practices, and routines and has shifted management and knowledge workers' inclinations toward environmentalism, naturalism, and futurism. A GIC is a composite construct. GHC, GSC, and GRC are the major components of it.

2.1 Green Human Capital (GHC) and Project Sustainability

GHC is a term related to an employee's aptitude. It refers to the devotion, innovation, attitude, skills, and competence of an employee toward a sustainable environment and green innovation. In other words, it is the summation of the employee's attitude, competencies, experiences, commitments, creativity, and knowledge of environmental conservation, preservation, protection, promotion, and sustainment. In the era of industrialization and urbanization, it has become the social responsibility of organizations to foster environmental awareness among their knowledge workers (Bontis, 1998; Chen, 2008). Organizations need to promote undertakings that need to be environmentally friendly, more effective, and efficient. It can be easily done if the top management trains its employees (Elwira et al., 2020). Their skillfulness will lead to a reduction in waste, optimization of the processes, a reduction in individual, organizational, and social losses, and a reduction in the carbon footprint. Similarly, moving to a paperless environment, where meetings are conducted virtually and files are shared electronically, can add to the employees' attitude toward environmental protection and sustainability (Aarseth et al., 2017; Higgins, 2014).

According to Vos and Heijden (2017), the long-term viability of any company is based on the dedication and skills of its employees. If the project he is doing is stable or sustainable, then ultimately the organization will get business, thus making the business sustainable (C. L. Huang et al., 2011). Therefore, many organizations in the world have started practising GHC due to its vast benefits. Many authors discussed GHC. One of the authors said that most of the growing economies in the world have started focusing on developing green skills among their employees (Yusoff et al., 2018). Companies should need to work on GHC in their functioning to enhance the sustainability of the projects they do. Organizations that invest in human capital gain better performance in their projects (Wang et al., 2011). This indicates the optimal influence of GHC, so there should be a plan that helps ensure the effective skills and abilities of the employees and can support green innovation. This leads to our first hypothesis of the research, which is:

H1: Green human capital affects project sustainability.

2.2 Green Structural Capital (GSC) and Project Sustainability

GSC refers to the stock of capabilities, knowledge, commitment, management systems, managerial philosophies, organizational culture, company images, patents, copyrights, and trademarks on environmental preservation, conservation, promotion, protection, sustainment, green innovation, green consumerism within a system (Wang et al., 2011). It is the company's own identity that includes the company's brand, copyrights, image, organization's traditions, patents, self-commitment, and ability towards green innovation and environmental protection in the process of the company's trade. Environmentally friendly logos, slogans, structures, and artifacts show that organizations care about the environment and work to protect and improve it (Yong et al., 2021). Through the adaptation of green structural practices in their processes and policies, organizations construct their good image and can gain above-average returns. In contrast, a lack of GSC can badly affect organizational performance due to an increase in the wastage of human skills, money, materials, and machinery (Cheng, 2020; Huang, 2011).

Integration of new technologies can also be considered as a part of GSC, as it enhances the company's performance and can also put them in line with green innovation. Chen (2008) said that green innovation plays a crucial role in the organization's overall sustainability (Yusliza et al., 2020). It covers sustainable supply for the project operations, financial performance, sustainable project governance, developing strength of ties among the project team, and developing an oriented environment for the smooth execution of the project. (Rahmawati and Erinos, 2017). In the same way, relational capital believes in organization-wide management and a relational approach; therefore, every knowledgeable worker ensured with the right skills, attitude, motivations, and role identity, which promotes a proactive approach to managing projects' operation and leads to a reduction of waste, cost reduction, ameliorated environment, and project sustainability (Yusoff et al., 2018; Cahyono and Hakim, 2020). In contrast, a lack of GSC can badly affect the company's overall growth and performance as it may lose its customers (Cahyono and Hakim, 2020).

In the same way, the public is more environmentally conscious; they are coming back to their basics, to the life they were living centuries ago (Henseler et al., 2015). So, a change in branding and giving the organization's overall look and feel a new look makes the organization show its commitment to environmental sustainability and can also help grasp new customers, ultimately increasing projects and giving new business to the organization (Baharum and Pitt, 2009; Hair et al., 2013). So, it can be said that this process of self-renewal makes them sustainable in emerging economies and competitive environments. Rahmawati and Erinos (2017) found evidence to support the optimal impact of GSC on financial performance. Furthermore, the renewal process improves the organization's performance on future projects and goals (Higgins, 2014; Huang, 2011). Integration of new technologies can also be considered as a part of GSC, as it enhances the company's performance and can also be put in line with green innovation. Chen (2008) said that green innovation plays a crucial role in the organization's overall sustainability. A lack of GSC can badly affect the

organization's overall growth and performance as it may lose its customers. The above discussion leads to the following.

H2: Green structural capital (GSC) affects project sustainability.

2.3 Green Relational Capital and Project Sustainability

GRC focuses on the emergence and development of internal and external relations. Through GRC, organizations develop their internationalization process (Huang, 2011). It is the sum of all knowledge, skills, and learning that promotes the process of conducting environmental management to gain a competitive advantage. According to Chen (2008), GRC is related to an organization's interactions with key stakeholders (Malik et al., 2020). This is one of the important intangible assets that an organization has when it comes to managing its business environment (Kelava, 2016). It's built on relationships between the company and its customers and partners and other members of the business community, to get a competitive advantage of GRC can have on the environment and green innovation (Kelava, 2016). This deficiency may have an impact on the company's projects as it decreases its sustainability (Jabbour et al., 2019; Maryam Ghasemaghaei, 2018).

A decrease in project sustainability can decrease the company's performance, and hence, the company may lose business (Gupta, 2016). The reason for this lacking factor of GRC implementation is that the stakeholders are reluctant to implement it as it increases the costs, but in the long run, it can benefit their business and they can be able to compete in the competitive market (Tortorella et al., 2016). Most of the emerging organizations are focusing on GRC, and these companies create relationships with the contractors to guarantee sustainability in their projects that will last for a long period and work with environmental sustainability in parallel (Yusliza et al., 2020). Nowadays, buyers prefer not to buy commodities that do not follow today's standards and are not in line with their needs. (Yu and Huo, 2019) said that the GRC had a substantial effect on the organization's performance. The research's third hypothesis is:

H3: Green Relational Capital (GRC) affects project sustainability.

2.4 Moderating role of Big Data Capabilities

Technology has invaded and disrupted learning and working mechanisms. It has penetrated project operations and processes and has added to the vitalities, capabilities, and productivity of individuals and organizations (Yusoff et al., 2018). Information technology runs and operates on big data. All multinational organizations' decisions are based on data. They are supported by the data. Otherwise, they are competing in the technology-engaged era (Cahyono and Hakim, 2020). In the same way, the employees' GIC capabilities will also be different while using and based on big data. Through big data, employees can judge the emerging trends and demands in the business environment better (Wang et al., 2011). Big data algorithms help in analyzing and data cleansing and data engineering, which helps keep in context the social, economic, and environmental demands synchronized with the organizational resources (Chen, 2008). These data analysis, cleansing, and engineering processes minimize costs, efforts, waste, and variation, and promote consistency, constancy, adaptability, and flexibility (Malik et al., 2020).

In the same way, big data helps in defining flexible and adaptable working conditions, which smoothens relational capital, and skills, and reduce cost and wastage. Furthermore, big data capabilities play a vital role in a company's GSC. It is for this purpose that companies, with the help of big data capabilities, can ensure effective GSC along with their attitudes and beliefs. Organizational performance increases along with an increase in business sustainability in emerging economies (Bueno et al., 2004; Higgins, 2014). Likewise, big data enhances human analytical skills, competencies, capacities, and capabilities. Therefore, organizations are promoting big data practices inside their operations and projects. These findings and arguments lead us to the following hypothesis:

H4: Big data capabilities moderate the relationship between green relational capital and project sustainability.

H5: Big data capabilities moderate the relationship between green human capital and project sustainability.

H6: Big data capabilities moderate the relationship between green structural capital and project sustainability.

2.5 Theoretical Framework

The present study adopts institutional theory (the theory relates to the establishment of routines and development of social behaviour of organizations or individuals for the benefit of the environment) to determine the role of big data as the moderating factor between project sustainability and Green Intellectual Capital (GIC). The institute theory states the more detailed and vigorous features of social architecture in organizational studies. The theory serves as the standing operating procedures by which the routines, schemes, standards, and organizational structure may be carried out (Carvalho et al., 2017). With a focus on organizational legitimacy, many other features of the theory will also be considered. As Markus et al. (2019) said, to achieve organizational legitimacy, both structural and procedural isomorphism will be used. Therefore, it forces organizations to embrace green intellectual capital practices. Organizations that use GIC practices for their project execution catch more consumers (Yip and Bocken, 2018). This practice can help make their business more sustainable and enhance their performance. The clear guidelines gave confidence to the organizations in developing best practices for a sustainable environment and making it a habit (Lim and Wang, 2019).

In the same way, the knowledge management theories can be applied to the study, which primarily focuses on organizational structure, organizational culture, routines, and flow/management of the information inside the organization (Gürlek and Çemberci, 2020). Their basic premise is to uplift the organizational standard and performance so that they can sustain, maintain and develop their selves, besides responding to customers' needs and requirements. Knowledge management theories can be divided into two major perspectives. The organizational ecological part believes in developing the internal capacity, and capability of the organization. It focuses more on the change and development of human assets, their founding, growth, and transformation of organizational capital and assets (Azam, 2015; Fernando et al., 2018). Moreover, it postulates that organizations are supposed to change themselves with the change in the dynamics of the market,

social and environmental ecology, and most probably change in the customer's needs, requirements, and tastes for their maintainability and sustainability (Henri, 2004).

In the same way, techno-centric theory proclaims that organizations should deploy technology for smoother and more transparent process handling. Organizations need to develop processes, which can facilitate and promote knowledge, and sharing of information. People, processes, and technology need to be organized coherently so that they can contribute to and complement one another (Berberoglu, 2018). Based on the cited theories, recommendations, and literature the study came with the research model, given in Figure 1.

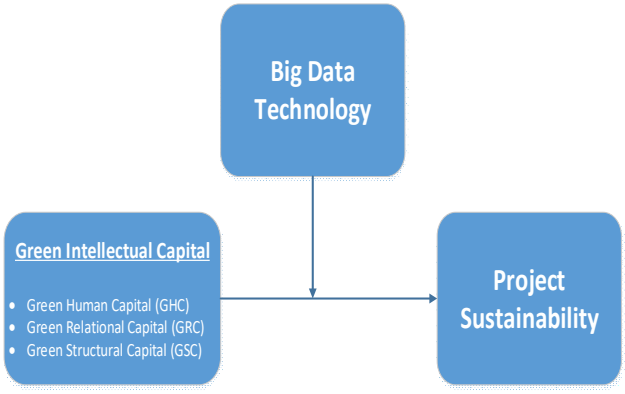


Fig. 1. The research model of the study

3. Methodology

The research methodology directs the techniques to be used to achieve the desired results and outlines the appropriate processes to be followed in analysing the impact of green intellectual capital on project sustainability with the moderating role of big data. It includes research design and methodology, study specifications, sampling details, and questionnaires to be used in this study to get the relevant data. For the current study, SPSS and SMART-PLS were selected for the data analysis. For the initial descriptive analysis, SPSS was utilised, as SPSS is considered best for summarizing and presenting demographics concisely and concretely. Similarly, SMART-PLS was selected for the inferential analysis due to its versatility, robustness, and its capability for handling normal and abnormal data. Moreover, SMART-PLS applies a comprehensive two-stage approach, where measurement and structural model were assessed in detail and lead toward inferences and results in a concrete way (Ismaeel and Mohamed, 2022).

3.1 Research Design

Collecting data from a large number of respondents using a qualitative research design makes it difficult for the researcher to handle the data. Therefore, to achieve the desired goals and accomplish the main objectives of the research, a quantitative research design will be used. This study is based on numerical data, which makes a quantitative approach more appropriate for studying the relationship among the variables. This study is based on assessing the nexus between big data and green intellectual capital and their impact on sustainable businesses. To collect the required data and get valid results, project-based manufacturing organizations were approached. It will help in simplifying and understanding the results as the selected sample will represent the entire manufacturing project-based organizations in Pakistan.

The unit of analysis is a significant characteristic of research because the features that are to be analysed in the study depend on it. The respondents of the questionnaire for this research will be the employees of project-based manufacturing organizations. The questionnaires will be directly filled in by the targeted audience working in these associations to get the appropriate data as per their working environment.

3.2 Data Collection Plan

In this research, a quantitative approach has been adopted for collecting the data. The questionnaires are designed and distributed among the study's participants. The questionnaire includes close-ended questions. The commonly used five-point Likert scale has been used to rank the priority of the answers to the questions that have been asked by the respondents. This scale ranges from 1 to 5, indicating values from strongly disagree to strongly agree.

3.3 Sample Method and Technique

For this study, a non-probability random sampling technique has been used. It is regarded as the most feasible technique because the researcher will select the samples that are available easily. In this technique, the simplest and most used methodology has been adopted, known as convenience sampling. For a population of 550 (manufacturing project-based organizations), a sample size of approximately 227 is sufficient. This is verified through the Rao Soft Sampling Calculator. However, the overall number of respondents for the study was 272. The details are given in Table 1.

Table 1. Measuring instrument of the study

.	Variable type	Items	Source
Big data technology	Moderator	4	(Gupta, 2016), (Maryam Ghasemaghaei, 2018) & (Wang, 1996)
Green intellectual capital	Independent	9	(Yong et al., 2019)
Project sustainability	Dependent	4	(Zhu and Fu, 2013) (Zhang et al., 2020)

4. Results and Discussion

Data analysis is carried out using two different software packages, namely, Smart-PLS 3.2.9 and SPSS 23. The two-step technique has been used. The first step is to access the measurement model for the validity and reliability of the study, and the second step is the structural model to access hypothesis testing.

4.1 Sample Characteristics

For a strong understanding of the participants of the study, questions have been asked regarding the demographics of the participants. The demographics are required by the researchers, and they are different in different research. Demographics in this study include age, gender, qualification, work experience, and the working

organization. The questionnaire was distributed among the managerial-level employees of manufacturing industries.

The individuals who filled out the questionnaire had the following characteristics:

4.2 Participant's Demographics

Gender was asked of participants, as this study aims to have gender equality and there shouldn't be any bias among the participants. These fields in the questionnaire help to show male and female participants. Looking at Table 2, it has been observed that male participants are approximately three times more than female participants. So, we can assume that in manufacturing organizations, female employees make up 25% of the workforce, whereas male employees make up the other 75% of the workforce.

Table 2. Gender frequency

Gender	Frequency	Percentage
Male	205	75.36
Female	67	24.64
Total	272	100

In getting the responses, the qualification information of participants is of crucial importance. The more educated a person is, the more likely he or she is to provide correct answers to questions. important attention has also been given to the qualification of individuals. Looking at Table 3, it can be observed that participants of the questionnaire with bachelor's qualifications have a weightage of approximately 43%, whereas those with master's qualifications secure approximately 55% of the weightage. Participants with PhD qualifications also participated in giving responses, but they are only about 2% in participation.

Table 3. Qualification level of participants

Qualification	Frequency	Percentage
Bachelors	117	43.01
Masters	150	55.15
PhD	5	1.84
Total	272	100

Work experience is evaluated; the more experience a participant has, the better he understands the questionnaire. Experience in relevant fields helps in making this research work a success and helps in making the right decisions. This important demographic helps in contributing to the knowledge management domain and also impacts the study. In general, experience is given more importance than qualifications. The reason behind this fact is that an experienced resource has a higher maturity level than a new resource because an experienced person knows how to tackle various situations and sometimes an experienced resource also saves the project from disasters. Table 4 shows the working experience of the participants who responded to the questionnaire. It can be observed that only 0.75% of participants have an experience of more than 10 years, whereas participants with an experience of 3 to 5 years have gained the highest weightage, i.e., 57.3%. So, it can be concluded that the majority of the participants had a very good maturity level and responded seriously to the questionnaire.

Table 4. Experience of participants

Experience (Years)	Frequency	Percentage
0-2	73	27.34
3-5	153	57.30
5-10	39	14.61
10+	2	0.75
Total	272	100

The designation of the individual is also a very important demographic. Sometimes it is given more importance than work experience. Individuals with higher designations have greater visibility into the process than those with lower designations. Table 5 shows the designation by contribution to the study. It can be seen that manufacturers' lead and engineers' have more weightage than other designated participants.

Table 5. Designation of participants

Designation	Frequency	Percentage
Administration	19	6.99
Project Manager	44	16.18
Manufacturing Lead	63	23.16
Engineer	67	24.63
Technical	37	13.60
Installer	9	3.31
Software	33	12.13
Total	272	100

4.3 Descriptive Statistics

Table 6 shows the mean, and standard deviation (SD), values of the gathered data for the research. The mean in this table represents the average of the variable, and SD represents the deviation from the mean value. As the data collection process is carried out using a closed-ended technique, measured through a Likert Scale of 5 points. So, the minimum value will be 1, and the maximum value will be 5. Moreover, the mean of the measuring items was higher than the SD, which indicates that more of the respondents affirm the impact of the GIC on PS in the presence of the BD.

Table 6. Descriptive statistics

Variable	**Mean**	**Standard Deviation**
GHC	3.9119	0.87499
GRC	3.5597	0.71245
GSC	3.9811	0.72329
BD	3.8255	0.66068
PS	4.0472	0.84361

4.4 The Measurement Model

The core purpose of implementing structural equation modeling (SEM) is to check the data for validity and reliability. Validity contains discriminant and convergent

validity, whereas reliability contains internal consistency reliability.

4.5 Reliability and Convergent Validity Analysis

Reliability is the testing of items on a scale repeatedly and getting reliable results. To access the research model, internal consistency reliability, convergent validity, and discriminant validity were examined. Outer loading is used to test the validity of indicators. Factor loading is also treated as outer loading (Wang and Wang, 2019), and the value should be above 0.7. To measure the internal consistency, Cronbach's alpha (CA) and composite reliability (CR) are calculated. For a reliable latent construct (Kelava, 2016), the value for CA and CR should be more than 0.7. Similarly, the value of the average variance extract (AVE) should be more than 0.50, to check the convergence of the variables. Table 7 shows all the values, i.e., CA, composite reliability, and average variance extracted related to this study. The table also shows the related factor values and items. Looking at the values in the table, it can be observed that only green relational capital values are near threshold levels. Moreover, the results are also supported by the SMART-PLS algorithm, given in Figure 2

Table 7. Construct reliability

Constructs /Items	FL	CA	CR	AVE
BD		0.900	0.922	0.705
BD1	0.789			
BD2	0.881			
BD3	0.902			
BD4	0.866			
GHC		0.876		
GHC1	0.836		0.964	0.794
GHC2	0.891			
GHC3	0.867			
GRC		0.815	0.858	0.509
GRC1	0.842			
GRC2	0.586			
GRC3	0.931			
GSC		0.867		
GSC1	0.919			
GSC2	0.803			
GSC3	0.866		0.918	0.556
PS		0.761		
PS1	0.762			
PS2	0.947			
PS3	0.898			
PS4	0.898			

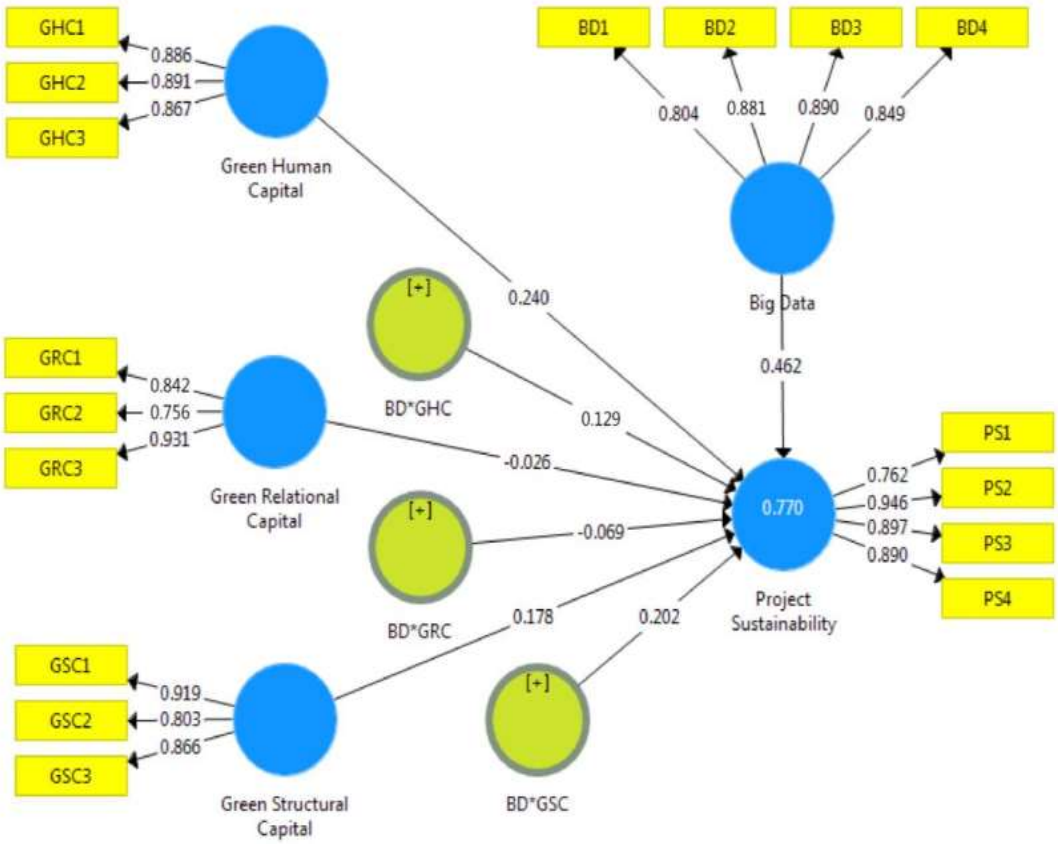


Fig. 2. SMART-PLS algorithm for the measurement model

4.6 Discriminant Validity Analysis

To check the discriminant validity, Fornell Lacker was applied to confirm the discriminant validity of the constructs. Table 8 shows all the values of variables concerning their self and other constructs. The theory says that the value concerning itself should be greater than the other variables. The highlighted values in the table are the square root values of AVE in each latent variable, and they are available on the diagonal. All the values on the diagonal should be greater than the other correlation values among the latent variables, and the values below the diagonal show the correlations between latent variables. Looking at the table, it can be seen that the Green Relational Capital correlation value is smaller than the other latent variables.

Table 8. Fornell lacker - discriminant validity

Constructs	BD	GHC	GRC	GSC	PS
BD	0.829				
GHC	0.148	0.892			
GRC	0.181	0.127	0.724		
GSC	0.328	-0.154	0.133	0.756	
PS	0.259	0.158	0.351	0.336	0.746

The distinctiveness between latent constructs is tested using Heterotrait Monotrait (HTMT), proposed by (Henseler et al., 2015), as shown in Table 9. Researchers suggested that the ratio should be less than 0.85, else the results may face collinearity issues. The table clearly shows that discriminant validity can be considered established.

Table 9. HTMT ratio – discriminant validity

Constructs	BD	GRC	GHC	GSC	PS
BD					
GRC	0.211				
GHC	0.203	0.142			
GSC	0.323	0.064	0.149		
PS	0.249	0.192	0.371	0.388	

4.7 Measurement Model Diagram

Figure 2 shows the final measurement model of this research study. The values on the arrow lines are the outer loading values. Values closer to 1 are considered to have greater reliability.

4.8 Structural Model

The second part of the measuring model in SMART-PLS is to assess the structural model of the study. In structural model assessment, research focuses to assess the values of the effect of the variance level R^2, the represents the effect size through F^2, and the predictive relevance through Q^2a.

Table 9 shows all the related values with their reference values. It can be seen in the table that R-square falls within a substantial range as the value is greater than 0.7. Here, F-square shows a nearly moderate effect. It can also be observed that the value of Green Relational Capital has a very weak effect. The inner VIF shows that there are no multi-collinearity issues among the variables. The Q-square also shows predictive relevance, as its values were found more than Zero (0). Hypothesis acceptance and rejection can be computed after bootstrapping the model, as shown in Figure 3. Scholars (Vinzi et al., 2009) said that bootstrapping can be interpreted as a resampling technique. The T value depicts the difference between the two sample sets, the higher value of T indicates the groups are different. Looking at the value of P, which should always be less than 0.01 for acceptance, it can be observed that BD*GRC is not significant, which means that the moderating effect of BD produces a negative effect. Table 10 shows the P, T, and OS/ Beta values for each hypothesis.

Table 10. Structural model assessment

R-Square	Endogenous variables	R Square	R Square Adjusted	0.26: substantial, 0.13: moderate, 0.02: weak (Hair et al., 2017)
	PS	0.276	0.273	
Effect size (F-Square)	Exogenous Variables	EL	PS	0.26: substantial, 0.13: medium effect, 0.02: weak effect (Hair et al., 2017)
	GHC		0.008	
	GSC		0.031	
	GRC	0.021	0.112	
	BD	0.101	0.067	
Collinearity (Inner VIF)	Exogenous Variables	EL	PS	VIF <= 5.0 (Hair et al., 2017)
	GHC		1.175	
	GSC		1.175	
	GRC	1.028	1.162	
	BD	1.038	1.169	
Predictive Relevance (Q-Square)	Endogenous Variables	CCR	CCC	Value larger than 0 indicates predictive relevance (Hair et al., 2017)
	PS	0.138	0.363	

4.9 The Goodness of fit Test

For the robust assessment, the Goodness of Fit test was also applied. In SMART-PLS, Standardized Mean Squire Residual (SRMR) was applied to assess the value for the goodness of fit. According to the research, it measures the absolute values, therefore, if its value is Zero (0), the model is considered a perfect fit. Moreover, if its value is 0.8, it is considered a good fit for the model. Similarly, Root Mean Square Residual Covariance (RMStheta) is the second measure for the assessment of Goodness of fit. Its values should be equal to or less than 0.8. Table 11 indicate the values for SRMR and RMS-Theta, and both values assure the model of fitness.

Table 11. The goodness of the fit test

Criterion	Value
SRMR	0.57
RMStheta	0.100

4.10 Hypothesis Testing

The study concluded the proposed hypothesis in the structural analysis and measurement of the model. In Table 12, the values for accepting and rejecting the hypothesis are given, and they are also supported by Figure 3. In the hypothesis analysis, the Beta value should be greater than 0.10 for the significant impact. Moreover, there should be no negative tabulated value in LL and UL. Similarly, the P-value should be less than 0.005 and the t-value should be greater than 1.96. According to the criteria given, all hypothesis was accepted except for the H2, where the Study found that GRC has no significant impact on the PS.

Furthermore, in the bootstrapping where the model was tested for 5000 samples, the model indicates that all the t-values are greater than the cut-off values. Similarly, all the mean values are also falling in the acceptable range, except for the beta value of GRC; therefore, all hypotheses were accepted except H2. The data proclaims that overall GIC has a significant impact on PS and BD can be a good moderator to be integrated with GIC to reap the benefits of the PS.

5. Discussion

The study attempted to address the impacts of the GIC on PS in the presence of the BD. According to the results, the study found that GHC and GSC have significant impacts on PS. These findings have also been supported by previous studies (Amores-Salvadó et al., 2021; Elwira et al., 2020). However, in the current study, GRC does not have a significant direct impact on PS, although, in many previous studies, GRC has been considered as an impacting and contributing factor in PS. The reason may be that BD is a new born baby field in Pakistan. GCI may not have been recognized in the holistic form in Pakistan's manufacturing sector. Moreover, BD has not matured enough, the industries have not proceeded toward Big Data Technology adaptation. Therefore, in our study, the study/respondent data didn't support the hypothesized stance (M. Ali et al., 2021; Haider and Kayani, 2020). Moreover, the study found a moderated, significant and positive effect of BD on PS. The findings imply that BD and GCI can develop a good impact on the practices and processes in the PS.

Table 12. Hypothesis acceptance/ rejection

Hypotheses	OS/ Beta	LL	UL	T	P	Decision
H1: GHC -> PS	0.284	0.148	0.403	4.433	0.000	significant direct effect
H2: GRC -> PS	-0.221	0.075	0.363	0.986	0.203	insignificant direct effect
H3: PSC -> PS	0.120	0.003	0.050	4.325	0.000	significant direct effect
H4: GHC -> BD -> PS	0.148	0.003	0.095	2.056	0.001	significant moderation effect
H5: GRC -> BD -> PS	0.199	0.068	0.295	3.305	0.001	significant moderation effect
H6: GSC -> BD -> PS	0.183	0.738	0.377	4.929	0.000	significant moderation effect

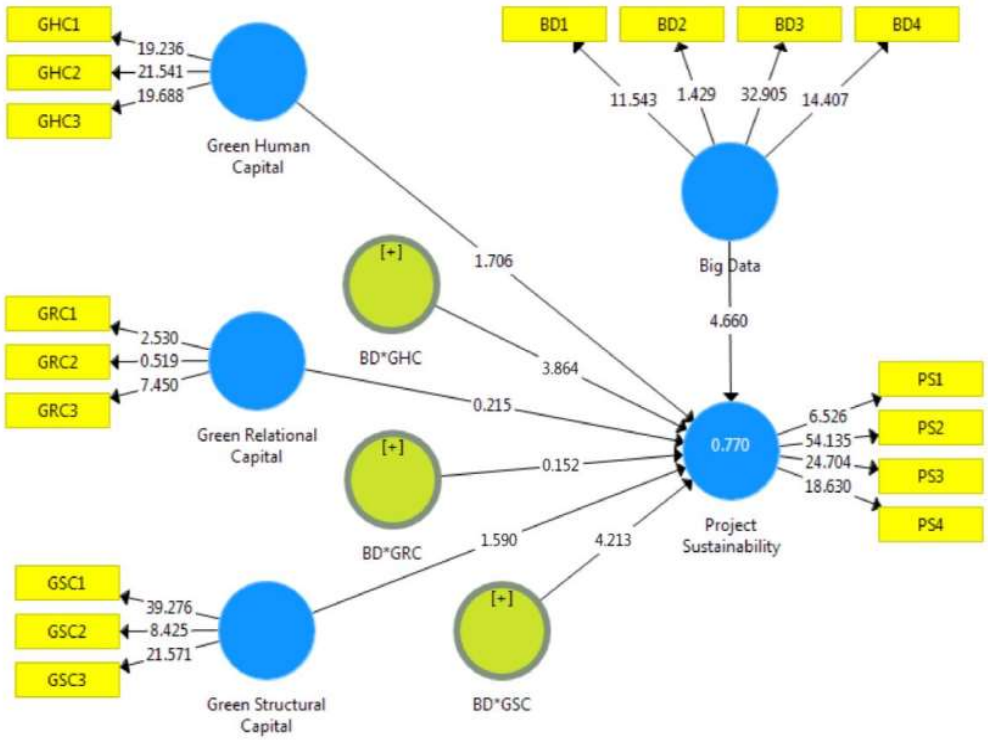


Fig. 3. Model after bootstrapping

6. Theoretical Implication

This study highlights that the green method of capital resource utilization may be very advantageous to an organization's financial stability. Moreover, integration, or the moderating role of big data, can also be very beneficial because it can speed up the process by helping in collecting past data and making trends for the optimization of the processes, and practices, and taking informed decisions. Based on experience integrated with technology, decisions can be taken easily and more accurately. This research can help to add to institutional theory because institutional theory helps to maintain norms, culture, structure, schedules, and traditions besides introducing the latest technological tools, methods, models, and practices in the form of big data technologies and their support for learning and development (Carvalho et al., 2017). The integration of big data with Green Intellectual Capital can be very beneficial for project sustainability, institutional theory can help in making up for this norm and tradition of using Intellectual Capital in a green manner with big data technology integration.

Similarly, the study also added to the knowledge management theory, that organizational knowledge, which may be indigenous, tacit, or explicit, can be handled best if they are supported by the latest models and methods of big data tools. Although, the study did not decline the use of old traditional practices, however, it recommends the data analytical tools and their capability for project sustainability. Additionally, techno-centric theory, which previously focused was hard technologies but has been expanded towards the soft aspects of the technologies' accommodation, assimilation, and applications.

6.1 Managerial Implication

According to the managerial point of view, a well-managed project can only be carried out if the project is planned properly, the right decisions are made at the right time, and this can all be done with vast experience in the field a better understanding of the project. Another aspect of best managerial practice is that less effort can have maximum benefit. All of this can be done using this research study. This study focused on the integration of past data using big data technology. Big data helps in combining the results of past decisions with their effects on projects and combining these two aspects creates an analysis report that can speed up the process of doing work. The study also highlights the importance of GHC, GRC, and GSC to any organization and its goals. Better employees through GHC practices can help grow employees and their skills, ultimately giving growth to the organization. Then GRC helps to create better relationships between customers and organizations or suppliers and organizations. GRC can give confidence to both parties concerned and help them grow together. Then the GSC practice is done to show the customers how their trusted company is focused on their self-improvement. That can help to create customer loyalty. Finally, the association of big data Technology with GIC has had a huge impact on project sustainability and helped grow the company. So, policymakers of the organization should make policies, invest in technology, and adopt new ways of working that can be very beneficial for the company to grow.

7. Limitations

This study must have limitations because there is always a change in the environment from one place to another. This research is carried out in the manufacturing industry sector, so there can be room to study the research variables in pharmaceutical, IT organizations, or any other industry. Moreover, the study used big data as a moderator, blockchain technology, a decision support system and Artificial Intelligence (AI) could also be used as a moderator. So, several future works can be extracted just from this study, and this is the strength of this research that it can benefit others and can open new avenues of research. Moreover, GIC's role in green project management may give new horizons, new philosophies, and directions to the research and practices, which carries more values for socio-economic development, sustainability, and prosperity.

Acknowledgement

The authors would like to express their gratitude to all registered professional members of the Pakistan Engineering Council for their contributions to the current research

Author Contributions

Jamshid Ali Turi contributes to conceptualization, methodology, investigation, draft preparation, manuscript editing, visualization, and supervision. Mirza Hamza Naeem Mughal contributes to conceptualization, methodology, software, validation, analysis, investigation, data collection, and draft preparation. Muhammad Waris Ali Khan contributes to the investigation, draft preparation, manuscript editing, and visualization. Asadullah Khan contributes to methodology, software, validation, and manuscript editing.

Funding

There is no financial support used in the execution of the research and preparation of the manuscript.

Institutional Review Board Statement

Not applicable.

References

Aarseth, W., Ahola, T., Aaltonen, K., Økland, A., and Andersen, B. (2017). Project sustainability strategies: A systematic literature review. *International Journal of Project Management*, 1071-1083.

Azapagic, A., and Perdan, S. (2000). Indicators of Sustainable Development for Industry: A General Framework. *Process Safety and Environmental Protection*, 243-261.

Bontis, N. (1998). Intellectual capital: an exploratory study that develops measures and models. *Management Decision.*

Bueno, E., Salmador, M. P., and Rodríguez, Ó. (2004). The role of social capital in today's economy: Empirical evidence and proposal of a new model of intellectual capital. *Journal of Intellectual Capital*.

Cahyono, B., and Hakim, A. (2020). Green Intellectual Capital and Competitive Advantage: The Moderating Effect of Islamic Business Ethics. *Proceedings of the 3rd Asia Pacific International Conference of Management and Business Science* (AICMBS 2019), 78-84.

Carvalho, A. D., Cunha, S. K., Lima, L. F., and Carstens, D. D. (2017). The role and contributions of sociological institutional theory to the sociotechnical approach to

innovation theory. *RAI Revista de Administração e Inovação,* 250-259.

Chen, Y.-S. (2008). The Positive Effect of Green Intellectual Capital on Competitive Advantages of Firms. *Journal of Business Ethics, 271-286.*

Cheng, M. L. (2020). Can joint-contract functions promote PPP project sustainability performance? A moderated mediation model. *Engineering, Construction and Architectural Management.* Emerald Publishing Limited.

Comin, D., and Nanda, R. (2019). Financial Development and Technology Diffusion. *IMF Economic Review*, 395-419.

Elwira, G.-G., Marta, K.-J., and Bartlomiej, J. (2020). Can elements of intellectual capital improve business sustainability?—the perspective of managers of SMEs in Poland. *Sustainability.*

Fernando, G.-B., Przychodzen, W., and Przychodzen, J. (2016). Corporate Sustainability and Shareholder Wealth—Evidence from British Companies and Lessons from the Crisis. *Economic and Business Aspects of Sustainability.*

Foroudi, P., Gupta, S., and Melewar, T. (2017). Corporate Logo: History, Definition, and Components. *International Studies of Management and Organization*, 176-196.

Gupta, M. and. (2016). Toward the development of a big data analytics capability. *Information and Management,* 1049-1064.

Hair, J. F., Ringle, C. M., and Sarstedt, M. (2013). Editorial - Partial Least Squares Structural Equation Modeling: Rigorous Applications, Better Results and Higher Acceptance. *Long Range Planning*, 1-12.

Henseler, J., Ringle, C. M., and Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling. *Journal of the Academy of Marketing Science volume*, 115-135.

Herazo, B., Lizarralde, G., and Paquin, R. (2012). Sustainable Development in the Building Sector: A Canadian Case Study on the Alignment of Strategic and Tactical Management. *Project Management Journal.*

Higgins, J. (2014). Bringing HR and Finance Together with Analytics. *Human Capital Management Institute - HR Magazine*, 11-13.

Huang, C. L. (2011). Environmental consciousness and intellectual capital management: Evidence from Taiwan's manufacturing industry. *Management Decision,* 1405-1425.

Jabbour, A. B., Luiz, J. V., Luiz, O. R., Jabbour, C. J., Ndubisi, N. O., Oliveira, J. H., and Junior, F. H. (2019). Circular economy business models and operations management. *Journal of Cleaner Production*, 1525-1539.

Kelava, A. (2016). A Review of Confirmatory Factor Analysis for Applied Research. *Journal of Educational and Behavioral Statistics.*

Li, G., Lim, M. K., and Wang, Z. (2019). Stakeholders, green manufacturing, and practice performance: empirical evidence from Chinese fashion businesses. *Annals of Operations Research,* 961-982.

Malik, S. Y., Cao, Y., Mughal, Y. H., Kundi, G. M., Mughal, M. H., and Ramayah, T. (2020). Pathways towards Sustainability in Organizations: Empirical Evidence on the Role of Green Human Resource Management Practices and Green *Intellectual Capital. Economic and Business Aspects of Sustainability*.

Markus, S., Moritz, A., and Philipp, P. (2019). nstitutional isomorphism, entrepreneurship and effectiveness: the adoption and implementation of quality management in teaching and learning in Germany. *Tert Educ Manag*, 115-129.

Maryam Ghasemaghaei, S. E. (2018). Data analytics competency for improving firm decision making performance. *The Journal of Strategic Information Systems,* 101-113.

Rahmawati, and Erinos NR. (2017). Green Intellectual Capital and Financial Performance of Corporate Manufacture In Indonesia. *International Journal of Business and Management Invention*, 75-81.

Santis, F. D., and Presti, C. (2018). The relationship between intellectual capital and big data: a review. *Meditari Accountancy Research*, 361-380.

Tortorella, G. L., Vergara , L. L., and Ferreira, E. P. (2016). Lean manufacturing implementation: an assessment method with regards to socio-technical and ergonomics practices adoption. *The International Journal of Advanced Manufacturing Technology*, 3407-3418.

Ullah, H., Wang, Z., Bashir, S., Khan, A. R., Riaz, M., and Syed, N. (2021). Nexus between IT capability and green intellectual capital on sustainable businesses: evidence from emerging economies. *Environmental Science and Pollution Research.*

Vinzi, V. E., Chin, W. W., Henseler, J., and Wang, H. (2009). Editorial: Perspectives on Partial Least Squares. *Springer Handbooks of Computational Statistics.*

Visconti, R. M., and Morea, D. (2019). Big Data for the Sustainability of Healthcare Project Financing. *New Project Financing and Eco-Efficiency Models for Investment Sustainability.*

Vos, A. D., and Heijden, B. I. (2017). Current thinking on contemporary careers: the key roles of sustainable HRM and sustainability of careers. *Current Opinion in Environmental Sustainability,* 41-50.

Wang, C.-N., Chang, Y.-L., Huang, Q.-H., and Wang, C.-H. (2011). Assessment on intellectual capital management for Taiwanese pharmaceutical industry: Using GRA and MPI. *African Journal of Business Management*, 2950-2958.

Wang, J., and Wang, X. (2019). *Structural Equation Modeling: Applications Using Mplus*. John Wiley and Sons.

Wang, R. Y. (1996). Beyond Accuracy: What Data Quality Means to Data Consumers. *Journal of Management Information Systems.*

Wang, Z., Mahmood, M. R., Ullah, H., Hanif, I., Abbas, Q., and Mohsin, M. (2020). Multidimensional Perspective of Firms' IT Capability Between Digital Business Strategy and Firms' Efficiency: A Case of Chinese SMEs. *SAGE Open*.

Yip, A. W., and Bocken, N. M. (2018). Sustainable business model archetypes for the banking industry. *Journal of Cleaner Production*, 150-169.

Yong, J. Y., Yusliza, M.-Y., Ramayah, T., Jabbour, C. J., Sehnem, S., and Mani, V. (2019). Pathways towards sustainability in manufacturing organizations: Empirical evidence on the role of green human resource management. *Business Strategy and the Environment,* 212-228.

Yu, Y., and Huo, B. (2019). The impact of environmental orientation on supplier green management and financial performance: The moderating role of relational capital. *Journal of Cleaner Production*, 628-639.

Yusliza, M.-Y., Yong, J. Y., Tanveer, M. I., Ramayah, T., Faezah, J. N., and Muhammad, Z. (2020). A structural model of the impact of green intellectual capital on

sustainable performance. *Journal of Cleaner Production.*

Yusoff, Y. M., Omar, M. K., and Zaman, M. D. (2018). Practice of green intellectual capital. Evidence from Malaysian manufacturing sector. *Proceedings of the IOP Conference Series: Materials Science and Engineering.* IOP Publishing.

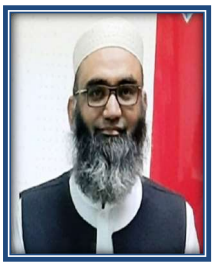
Zhang, M. F., Dawson, J. F., and Kline, R. B. (2020). Evaluating the Use of Covariance-Based Structural Equation Modelling with Reflective Measurement in Organizational and Management Research: A Review and Recommendations for Best Practice. *British Journal of Management,* 257-272.

Zhu, S., and Fu, X. (2013). Drivers of Export Upgrading. *World Development,* 221-233.

Dr Jamshid Ali Turi is an Assistant professor at the Bahria Business School, Bahria University, Pakistan. He holds a PhD in Technology Management from the University of Malaysia Phanag, Malaysia. He is an active researcher, consultant, and educationist and has been rendering his services in the education and development sectors for the last 10 years. He has published more than 40 research papers and has presented at 11 national and international conferences.

Mirza Hamza Naeem Mughal is a postgraduate student at the Bahria Business School, Bahria University, Pakistan. He holds a master's degree in project management and is an industry professional with areas of expertise in Big Data Analytics and sustainable project management.

Dr Muhammad Waris Ali Khan is a professional engineer, certified Project Management Professional (PMP) and Associate Professor in the Faculty of Business and Law, The British University in Dubai, UAE. His research interests include project management & governance, sustainability and renewable energy projects.



Dr Asadullah Khan is serving as an Assistant Professor at the Department of Business Management, Karakoram International University Gilgit, Pakistan. He has done PhD in Project Management from Universiti Malaysia Pahang, Malaysia. His areas of interest are project management, public sector projects, change management and organizational behavior.