
Doctoral

Engineering

2020

A Framework for Sustainable Procurement Practice in the Irish Construction Industry

Duga Jamus Ewuga

Technological University Dublin, djewuga@yahoo.com

Follow this and additional works at: <https://arrow.tudublin.ie/engdoc>



Part of the [Construction Engineering and Management Commons](#), and the [Other Civil and Environmental Engineering Commons](#)

Recommended Citation

Ewuga, D. (2020). A Framework for Sustainable Procurement Practice in the Irish Construction Industry. Technological University Dublin. DOI: 10.21427/0GPG-F264

This Theses, Ph.D is brought to you for free and open access by the Engineering at ARROW@TU Dublin. It has been accepted for inclusion in Doctoral by an authorized administrator of ARROW@TU Dublin. For more information, please contact arrow.admin@tudublin.ie, aisling.coyne@tudublin.ie, gerard.connolly@tudublin.ie.



This work is licensed under a [Creative Commons Attribution-Noncommercial-Share Alike 4.0 License](#)

A FRAMEWORK FOR SUSTAINABLE PROCUREMENT PRACTICE IN THE IRISH CONSTRUCTION INDUSTRY

By

Duga Jamus Ewuga

(B.Tech (Hons) QS, MSc Const Mgt, MSc QS (Mech and Elect), MNIQS, RQS)

A Doctoral Thesis presented as part of the requirement for the award of

DOCTOR OF PHILOSOPHY

In the School of Surveying and Construction Management



College of Engineering and Built Environment

TECHNOLOGICAL UNIVERSITY DUBLIN

Supervisors: Dr Mark Mulville

Dr Alan Hore

December 2020

ABSTRACT

The Architectural, Engineering and Construction (AEC) sector has been called upon to develop innovative strategies to drive sustainability. Despite the efforts and commitments made, their performance is still observed to be low, this has been linked to the low level of understanding of practitioners. Also noted was the lack of interest by firms due to the uncertainty of the benefits of committing to long term investments. Nevertheless, academic literature and reports have stated that firms nowadays utilise their procurement mechanism to drive their sustainability practice. However, there is a gap in understanding how construction firms adopt and embed sustainability in their procurement process. Data was collected through the mixed-methods approach, and the single embedded case study strategy was used to understand an organisation's sustainable procurement practice from the organisational and project level. Different statistical methods were used in analysing the data obtained. The findings revealed that construction-contracting firms have developed various policies and strategies aimed at promoting their sustainable procurement practice. These strategies were found to include investment in their core capabilities, development of long-term relationships and close collaboration with their supply chains. The adoption and utilisation of digital technology tools and resources were also found to have added value to the firm operations. However, it was noted that the level of collaboration within the firm in terms of sharing of information was quite challenging. Therefore, firms will have to develop strategies that will enable them to provide real-time data to disclose their sustainability performance. The study contributed to knowledge by unveiling the internal organisational strategies of large firms in driving sustainable procurement. Also, the study developed and validated a framework that will aid construction firms in disclosing and implementing their sustainable procurement strategy. Disclosing sustainability performance of construction firms enable their clients and the public to be aware of their contribution towards the sustainable development objectives.

DEDICATION

This doctoral thesis is dedicated to:

To my wife Longdi Ewuga, my daughter Akatki Abigail Ewuga and my son Ombili Barnabas Ewuga, for their sacrifice and love showed to me during the period of my study.

I love you.

To my parents Baba Christopher Ewuga and Mama Esther Pwachom Ewuga for the sacrifice they made in my upbringing. I remain forever grateful.

Finally, I dedicate this work to the martyred and those who have lost their lives or are in captivity, especially in Nigeria and Africa for the sake of Christ.

DECLARATION PAGE

I certify that this report which I now submit for examination for the award of a DOCTOR OF PHILOSOPHY (PhD), is entirely my own work and has not been taken from the work of others, save and to the extent that such work has been cited and acknowledged within the text of my work.

This thesis was prepared according to the regulations for graduate study by the research of the Technological University Dublin and has not been submitted in whole or in part for another award in any other third-level institution.

The work reported on in this thesis conforms to the principles and requirements of the TU Dublin guidelines for ethics in research.

TU Dublin has permission to keep, lend or copy this thesis in whole or in part, on condition that any such use of the material of the thesis is duly acknowledged.

Signature _____ Date _____

ACKNOWLEDGEMENT

Undertaking a doctoral study requires a lot of determination and discipline, but an individual can never attain the required goals without motivation and support from mentors, friends and family. In this doctoral journey, I have been supported and motivated by so many people.

My gratitude first goes to my heavenly father, God almighty the maker of heaven and earth that has given me the opportunity and good health for undertaking this study. I am forever grateful and remain faithful to his ways and instructions. Secondly, my gratitude and indebtedness go to Technological University Dublin for the Fiosraigh Scholar funding award that enabled me to undertake this study. It was valuable, and I remain forever grateful.

This PhD work would not have been completed without the mentorship, commitment, and guidance of my supervisors, Dr Mark Mulville and Dr Alan Hore. Mark has been a wonderful supervisor always willing to help and has positively motivated me in the whole process. Alan went beyond the supervision to help me survive in Ireland. I remained highly indebted to them. My gratitude also goes to Prof Lloyd Scott for starting up the PhD work with me. Also, not forgetting Prof Jacqueline Glass who examined my confirmation report and gave a positive feedback that shaped the work, her contribution is highly appreciated and acknowledged. My acknowledgement goes to the staff members of the TU Dublin graduate research school, Bolton Street Library staff, and Staff of the Writing Centre for their assistance and support throughout my study.

Furthermore, I will like to thank the following for their numerous support and assistance, Dr Marek Rebow, Dr Barry McAuley, Rev Fr. Alan Hilliard, Rev Philip Gotep, Mr Tom Dunne, Mr Bill Murphy, Mr Donald McCarthy, Mr Paul Carmody, Mr Pat Lucey, Mr Derek Gormley, Mr Charles Mitchell, Mark (printing room), Dr Philip Adu, Prof Libby

Schweber, Prof Victor Dugga, Chief Peter Buba, Alan Gorman, Brian Haverty, Sarah Casey, David Frazer, Allen Chimamba, Cormac FitzPatrick, David Tracey, John McCarthy, Dr Adekunle Oyegoke, Dr Chris Piwuna, Late Dr Titus Kassem, Paul Stack, Dr Tariya Yusuf, Dr Emmanuel Itodo, Prof Natasha Anigbogu, Prof Fred Job, Prof Shehu Bustani, Assoc Prof, Evelyn Allu-Kangkum, Prof Paul Pam Lomak, Mr and Mrs Patrick Alerk and family, Mr Chris Choji, Mama K.G Matta, Dr & Mrs Jurbe Molwus, Suzanne Greene, Mr and Mrs Ali Maina, Engr Habila Mormi, Qs Joshua Mwangwat, Ian Clarke, Pastor Paul Carley, Ewa Olugbo, Nanyen Abene, Mrs Linda Mchivga and Prince and Mrs Abdul Omogbai.

To my friends and colleagues Lorna Corley, Rakshit Muddu, Ahlam Alanbouri, Antonello Durante, Jeffrey Sa'ad, Shiyao Kuang, Catherine Byrne, Williams Gadimoh, Dr Louis Nwachio, Dr Oluwasegun Seriki, Dr Michael Adesi, Arc David Gyang, Qs Ali William Yoms, Rev. Fr Jacob Peter Shanet, Rev. Fr Joseph Davou, Salome Pam, Dr Samuel Wapwera, Dr Adamu Pam, Arc Abimiku Yunnana, Engr Alex Plagnan, Engr Nanman Daze, QS Suleiman Yusuf, Mr Paul Ochieng, Finance John Ayuba, Mrs Roseline Ikilama, Clifford Enyitta, Dr Godfrey Dannang, and Mr and Mrs Gheorghe Buga.

This acknowledgement would not be complete without appreciating and thanking my wife Longdi for her sacrifice and prayers for my success. To my daughter Akatiki Abigail and son Ombili Barnabas for the pains, they had to go through in my absence. My brother Dr Ovyo Ewuga (FWACP) for playing a father figure to my kids I say thank you. To my sisters Manyi, Ashello, and brothers Abene, and Ulu, I say thank you for your prayers. To my in-laws, nieces, and nephews, I thank you all. To the Dugga Ekiri family, I am grateful. Finally, to my parents, I say a big thank you for their prayers, discipline and sacrifice for providing the foundation for my education. GOD BLESS.

"We are like dwarfs sitting on the shoulders of giants. We see more, and things that are more distant, than they did, not because our sight is superior or because we are taller than they, but because they raise us up, and by their great stature add to ours."

John of Salisbury-1159

ABBREVIATION LIST

ACA: Accelerated Capital Allowance

AEC: Architectural, Engineering and Construction

BER: Building Energy Rating

BREEAM: Building Research Establishment Environmental Assessment Method

BWPE: BIM-Based Whole-Life Performance Estimator

CCS: Constructors Considerate Scheme

CDP: Competitive Dialogue Procedure

CIPS: Chartered Institute of Procurement and Supply

CMR: Construction Management at Risk

DB: Design-Build

DBB: Design-Bid-Build

DJSI: Dow Jones Sustainability Index

EEM: Environmental Efficiency Model

EMS: Environmental Management System

EPBD: Energy Performance of Building Directive

EPC: Energy Performance Certificate

EU: European Union

FSC: Forest Stewardship Council

GDP: Gross Domestic Product

GHG: Greenhouse Gas

GHGE: Greenhouse Gas Emission

GIS: Geographical Information System

GRI: Global Reporting Initiative

GSCM: Green Supply Chain Management

HRI: Home Renovation Incentive

IBS: Industrialised Building System

IER: Independent Environmental Representative

IISD: International Institute for Sustainable Development

IOT: Internet of Things

ISO: International Organization for Standardization

LCCE: Life Cycle Cost and Efficiency

LCII: Life Cycle Impact Index

LEED: Leadership in Energy and Environmental Design

PFI: Private Finance Initiative

PMO: Project Management Organisation

PR: Public Relations

QSE: Quality Safety and Environmental

RFMP: Recency, Frequency, And Monetary Value and Product Model

SEAI: Sustainable Energy Authority of Ireland

SME: Small and Medium Enterprise

SSCM: Sustainable Supply Chain Management

TBL: Triple Bottom Line

UK: United Kingdom

UNEP: United Nations Environment Programme

US: United States

WCED: World Economic Commission on Environment and Development

Table of Contents

ABSTRACT.....	ii
DEDICATION	iii
DECLARATION PAGE.....	iv
ACKNOWLEDGEMENT	v
ABBREVIATION LIST	viii
Table of Contents	xi
List of Tables	xvii
List of Figures	xix
1.0 Introduction.....	1
1.2 Background of the Study.....	1
1.3 Research Problem and Justification	6
1.4 Research Questions	8
1.5 Aim and Objectives of the Study	9
1.6 Research Scope and Limitation.....	12
1.7 Contribution to Knowledge.....	14
1.8 Structure of the Thesis	16
CHAPTER TWO	19
LITERATURE REVIEW	19
2.0 Introduction.....	19
2.1 Sustainable Development: Meaning, Context and Discussions.....	21
2.1.1 The Triple Bottom Line (TBL)	26
2.2 AEC Sector in the Republic of Ireland	31
2.3 Sustainable Development in the Republic of Ireland.....	34
2.4 Sustainable Construction Practice and Adoption in the AEC sector	38
2.4.1 Implementing Sustainable Construction	43
2.4.2 Level of Adoption and Practice of Sustainable Construction	47
2.4.2.1 Organisational practice perspective	47
2.4.2.2 Adoption from the Stakeholders Perspective	51
2.4.2.3. Adoption based on Geographical location perspective	53
2.4.2.4 Impact of government policies, regulations, and laws	54
2.4.2.5 Adoption from the Size of firm Perspective	58
2.5 Construction Supply Chain Management	63
2.5.1 Sustainable Supply Chain Management.....	66
2.5.2. Supply Chain Integration.....	72
2.5.3 Suppliers Development	76

2.6 Sustainable Procurement Practice	81
2.6.1 An In-depth Overview	81
2.6.2 Implementing Sustainable Procurement.....	85
2.7 Frameworks for Sustainable Procurement	91
2.8 Sustainable Delivery Process	102
2.8.1 Delivery Routes	103
2.9 Collaboration and Integration of Team Members.....	108
2.10 Role of Digitisation in Sustainable Procurement.....	115
2.10.1 Areas of Digital Technology Application in the AEC Sector	117
2.10.2 Examples of Application of Digital Technologies in Driving Sustainable Practice	119
2.11 Underpinning Theory	125
2.11 Summary of Literature Review	129
CHAPTER 3	131
METHODOLOGY.....	131
3.0 Introduction	131
3.1 The Research Process	132
3.2 Research Philosophy	135
3.3 Approach to theory development	144
3.4 Methodological choice	150
3.5 Strategy (ies).....	153
3.6 Time horizon	158
3.7 Techniques and procedures	159
3.8 Why the Case Study Approach?.....	160
3.8.1 The Case Study Research Design.....	162
3.8.1.1 The Study's Question	163
3.8.1.2 The Study Proposition	163
3.8.1.3 Unit of Analysis	164
3.8.1.4 Justification of the Single Case Study	165
3.8.1.5 Case Selection.....	166
3.8.1.6 An Overview of the Case Study	168
3.8.1.7 Sampling Population/Design Approach	169
3.8.1.8 Data Collection Procedure	173
a. Documents.....	173
b. Questionnaire Survey	174
c. Interviews	176

3.9 Pilot Study.....	179
3.10 Response Rate from Questionnaire Survey	180
3.11 The technique for Data Analysis.....	181
a. Descriptive Statistics.....	181
b. Chi-Square Statistics (X^2).....	182
c. Relative Importance Index (RII).....	183
d. Principal Component Analysis (PCA)	183
e. Importance Performance Analysis (IPA)	185
3.12 Quality and Assessment Criteria of Research Design	190
a. Construct Validity	190
b. Internal Validity	191
c. External Validity	191
d. Reliability.....	192
e. Addressing Biases	192
3.13 Ethical Consideration.....	194
CHAPTER 4	196
SURVEY RESULTS AND ANALYSIS	196
4.0 Introduction.....	196
4.1 General Background of Respondents.....	196
4.2 Level of Adoption/Performance of Sustainable Procurement	201
4.2.1 Compliance with Organisations Sustainability Policies.....	201
4.2.2 Impact of Drivers to Sustainable Practice	206
4.2.3 Analysis of Sustainable Procurement Strategies	210
4.3 Influencing Supply Chains by Main Contracting firms	224
4.4 Level of Adoption of Digital Technology.....	229
4.4.1. General Level of Adoption of Digital technologies	229
4.4.2. Utilisation and Potential of Digital Technology in Sustainable Procurement	232
4.5 Chapter Summary	238
CHAPTER 5	240
CASE STUDY- ORGANISATIONAL LEVEL.....	240
5.0 Introduction.....	240
5.1 Structure of the Findings.....	241
5.2 Implementation within the firm	242
5.2.1 Collaboration within the firm	243
5.2.2 Implementing Government and External Stakeholders Requirements	249

5.2.3 Collaborating and Implementing Client's Requirements	254
5.3 Influencing Supply Chains	261
5.3.1 Selection and Appointment of Supply Chains	261
5.3.2 Collaborating with Supply Chains	262
a. Level of Trust and Long-Term Relationship	265
b. Instigating competition amongst the Supply Chains	270
c. Suppliers Development	273
5.4 Utilisation of Digital Technology	276
CHAPTER 6	284
CASE STUDY- PROJECT LEVEL	284
6.0 Introduction	284
6.1 Background of the Case study	285
6.2 PROJECT A-FINDINGS	288
6.2.1 Implementation within the Main Contractor's Team.....	288
6.2.1.1 Collaboration Within the Contractor's Team.....	288
6.2.1.2 Addressing Government Regulations and External Stakeholders' Requirements	293
6.2.1.3 Collaborating and Implementing Client's Requirements	294
6.2.2. Influencing Supply Chains	299
6.2.2.1 Collaboration at Planning and Delivery Phase	299
6.2.2.2 Supply Chain Assessment Mechanism	309
6.2.3 Utilisation of Digital Technologies	314
6.3 PROJECT B-FINDINGS	320
6.3.1 Implementation within the Main Contractor's Team	320
6.3.1.1 Collaboration Within the Contractor's Team.....	320
6.3.1.2 Addressing Government Regulations and External Stakeholders' Requirements	326
6.3.1.3 Collaborating and Implementing Client's Requirements	327
6.3.2. Influencing Supply Chains	330
6.3.2.1 Collaboration at Planning and Delivery Phase	330
6.3.2.2 Supply Chain Assessment Mechanism	341
6.3.3 Utilisation of Digital Technologies	345
6.4 Chapter Summary	349
CHAPTER 7	351
DISCUSSION OF FINDINGS	351
7.0 Introduction	351
7.1 Strategy Development.....	351

7.2 Sustainable Construction Practice and Implementation within the Firm.....	357
7.2.1 Collaboration within the firm	357
7.2.2 Implementing Government and External Stakeholders Requirements ...	360
7.2.3 Collaborating and Implementing Client's Requirements	362
7.3 Supply Chain Management Practice	367
7.3.1 Sustainable Supply Chain Management Practice	367
7.3.2 Long-Term Relationship	369
7.3.3 Supply Chains Improvement Mechanism	373
7.4 Utilisation of Digital Technologies.....	378
7.4.1 The Current Level of Adoption and Utilisation of Digital Technology..	378
7.4.2 Potential and Future Area of Growth	381
7.5 Implications and limitation of the findings	383
7.6 Chapter Summary	386
CHAPTER 8	388
FRAMEWORK DEVELOPMENT	388
8.0 Introduction.....	388
8.1 Reflection on the Conceptual Framework	388
8.2 The IDEF0 Framework Technique and Processes.....	392
8.3.1 Features of the Framework.....	396
8.3.2 Actors in the framework.....	398
8.3.3 Sustainable Procurement Framework (SPF)	399
8.3.3.1 Implementing Sustainable Procurement (A-0)	403
8.3.3.2 Develop Organisational Resources and Policy (A0)	407
8.4 The IGOE Diagram.....	423
CHAPTER 9	425
VALIDATION OF FRAMEWORK.....	425
9.1 Introduction.....	425
9.2 Background to the Validation Approach	425
9.3 Method of Validation	426
9.4 Background of Participants.....	428
9.5 Response of Participants on the Framework.....	429
9.6 Results of Evaluation Questionnaire.....	431
9.7 Summary of the Chapter	434
CHAPTER 10	435
CONCLUSION AND RECOMMENDATION.....	435
10.0 Introduction.....	435

10.1 Conclusion	435
10.2 Contribution to Knowledge and Impact of Study	443
10.3 Limitation of the Study	444
10.4 Recommendation for Implementation by Practitioners	445
10.5 Recommendation for further study	447
APPENDICES	496
Appendix A: Questionnaire survey instrument.....	496
Appendix B: Framework validation Instrument	509
Appendix C: Tables of Statistical Results.....	511
Appendix D: Codes and Themes from NVivo 24.....	524
LIST OF PUBLICATIONS	528
LIST OF EMPLOYABILITY AND DISCIPLINE SPECIFIC SKILLS TRAINING	529

List of Tables

Table 1: Implementation Strategy	11
Table 2: Seven Sustainability Revolutions	28
Table 3: Key Issues on Sustainable Construction	40
Table 4: Factors driving the implementation of sustainable construction TBL in the AEC sector	62
Table 5: Summary of some Selected Frameworks.....	99
Table 6: Implementation Strategies	106
Table 7: Summary of Studies on Application of Digital Technologies in Sustainable Procurement	124
Table 8: Summary of the Research Process.....	134
Table 9: Deduction, Induction and Abduction: From Reason to Research	149
Table 10: Addressing Biases.....	194
Table 11: Role in the Organisation	197
Table 12: Nature of Work Undertaking	200
Table 13: Organisation's Policy Development based on turnover	202
Table 14: Organisation's Policy Development based on the Nature of Work Undertaking	202
Table 15: Level of Compliance in Embedding Sustainable Procurement	203
Table 16: Level Compliance Based on Annual Turn-over	204
Table 17: Level Compliance Based on Nature of Work Undertaking.....	204
Table 18: Chi-Square Test on the Level Compliance Based on Annual Turn-over	205
Table 19: Chi-Square Test on the Level Compliance Based on Nature of Work Undertaking.....	206
Table 20: Level of Impact of Drivers to Sustainable Practice	208
Table 21: Reliability Statistics for Level of Importance.....	212
Table 22: KMO and Bartlett's Test	213
Table 23: Total Variance Explained	214
Table 24: Pattern Matrix and Communalities	216
Table 25: Importance-Performance Analysis -Supplemental Capabilities	218
Table 26: Importance-Performance Analysis -Enabling Capabilities.....	221
Table 27: Importance-Performance Analysis -Core Capabilities	222
Table 28: Phase of Engaging Supply Chains	224
Table 29 Long-term Relationship with Supply Chains.....	226

Table 30: Mechanism for Improving Supply Chain Performance	228
Table 31: Level of Utilisation of Digital Technology on Sustainable Procurement Practice.....	234
Table 32: Level of Importance in Utilising Digital Technology in Sustainable Procurement Practice	237
Table 33: Project Characteristics	287
Table 34: Mapping Process for Sustainable Procurement Framework.....	400
Table 35: Node Index for Sustainable Procurement Process	406
Table 36: Participants Information	428
Table 37: Evaluation Questionnaire.....	433

List of Figures

Figure 1: Structure of The Thesis	18
Figure 2: Focus of Literature review.....	20
Figure 3: Summary of Development in Driving Sustainability Agenda.....	24
Figure 4: Venn Diagram Showing the Relationship between the Three Pillars Of Sustainability.....	27
Figure 5: Seven Sustainability Revolution	30
Figure 6: Output in Investment in Building in the ROI.....	31
Figure 7: Employment in Construction in ROI 2012-2020	32
Figure 8: Factors influencing Demand in EFB.	42
Figure 9: Physical Boundaries in the Built Environment	46
Figure 10: Current level of Sustainable Construction.....	49
Figure 11: Power-Interest Matrix.....	52
Figure 12: The Two School of Thoughts for Achieving SCM	74
Figure 13: Supplier’s Development Improvement.....	78
Figure 14: Ways of Improving Sustainable Procurement Practice	88
Figure 15: An Alternative Perspective on the Construction System	89
Figure 16: Integrating sustainability into the procurement process.....	92
Figure 17 BS 8903 Sustainable Procurement framework (BS 8903:2010)	95
Figure 18: ROI GPP policy design and implementation.....	97
Figure 19: A typology model of green embedded project-based organizations	111
Figure 20: Collaboration Key Elements.....	113
Figure 21: Application of Digital Technologies (DT) for Sustainable Procurement....	119
Figure 22: Conceptual Framework	128
Figure 23: The Abductive Reasoning Process	147
Figure 24: Research Approach Adopted for the Study	160
Figure 25: Mixed Methods: Two Nested Arrangement	166
Figure 26: Sampling Design Adopted for the Study.....	172
Figure 27: Stages in Analysing Interviews	178
Figure 28: Original Importance-Performance Analysis.....	186
Figure 29: Revised IPA.....	189
Figure 30: Organisation years in business	198
Figure 31: Based on Annual Turn-over	199
Figure 32: Based on Number of Employees	199

Figure 33: Level of Clarity of Sustainability requirements	209
Figure 34: Sustainability Requirements in the Selection of Supply Chains	210
Figure 35: Scree Plot.....	215
Figure 36: IPA Graph with Empirical Means and Diagonal line.....	223
Figure 37: Gaps for the 22 Elements of Sustainability Delivery Strategies	223
Figure 38: Impact of Digital Technology in the Procurement Process.....	230
Figure 39: Level of Compliance by Supply chains in adopting Digital Technology ...	231
Figure 40: Areas of Application of Digital Technology	232
Figure 41: Case Study Layout.....	240
Figure 42: Structure of Findings	242
Figure 43: Summary at Organisational Level	283
Figure 44: Drivers to Disclosing Sustainability Performance	355
Figure 45: Collaborating and Implementing Client's Requirements.....	364
Figure 46: Utilisation of Organisational Human Resources	365
Figure 47: IDEF0 Diagram	393
Figure 48: Decomposition and Hierarchy of an IDEF0 Model adapted from	395
Figure 49: A Summary of the IDEF0 Process	397
Figure 50: Context Diagram-Implementing Sustainable Procurement.....	405
Figure 51: Develop Organisational Resources and Policy/A0.....	409
Figure 52: Develop Policies and Strategies	413
Figure 53: Develop Human Development Strategies	416
Figure 54: Develop Supply Management Strategy	419
Figure 55: Develop Digital Technology Strategy	422
Figure 56: IGOE diagram for Implementing Sustainable Procurement	423
Figure 57: Summary of Key Findings.....	437
Figure 58: Recommendation for Implementation of Framework	446

CHAPTER ONE

1.0 Introduction

This chapter provides a background of the study and the research problem and justification. The chapter also sets out the research question (s), the aim and objectives of the study, research scope and limitations and a summary of the structure of the thesis is presented.

1.2 Background of the Study

The Architectural, Engineering and Construction (AEC), sectors have a significant role to play in helping to deliver on the sustainable development objectives. These objectives are tripartite of environmental, economic, and social. These three objectives are popularly referred to as the triple bottom line (TBL) (Elkington, 1994, 1997). The United Nations (UN), in 2005, set up goals and targets to drive the implementation of the TBL (Caradonna, 2014; United Nations Development Programme, 2019). The first goals and targets ended in 2015 popularly known as the millennium development goals (MDGs), while the second goals and targets which are referred to as the sustainable development goals (SDGs) are expected to end in 2030. The concept of sustainable development or sustainability has been argued to be an ideological concept with different meanings for different people (Yolles & Fink, 2014). In the AEC sector, sustainable construction is defined as a process where the construction industry together with its product ‘built environment’, among many sectors of the economy and human activity, can contribute to the sustainability of the earth including its human and non-human inhabitants (Kibert, 2007). This contribution addresses the main ethical dilemma posed by sustainable development, namely the obligations of the world’s contemporary population to a future generation (Kibert, 2007). The World Economic Forum reported that the AEC sector accounts for about 6% of the global Gross Domestic Product (GDP) and employs over 100 million people worldwide (World Economic Forum, 2016b). Also, in developed

countries, the sector accounts for about 5% of total GDP, while in developing countries it tends to account for more than 8% of the GDP (McKinsey Global Institute, 2017). Furthermore, McKinsey Global Institute (2017), estimated that about 10 trillion dollars (€8.9 trillion) is spent annually on construction-related goods and services globally, and the sector employs about 7% of the world's working-age population.

Additionally, the sector has been noted to be the largest global consumer of raw materials and accounts for about 25-40% of the world's total carbon emission (World Economic Forum, 2016b). In an effort in driving sustainability, global business leaders and civil society have made declarations to lead their companies or organisations towards achieving the sustainability goals/objectives (Business and Sustainable Development Commission, 2017). Although, a report by Ethical Corporation in 2018 and a more recent report in 2019 by the United Nations Global Compact and Accenture Strategy reveals that many business enterprises are still struggling in meeting the required targets of the sustainable development objectives (Ethical Corporation, 2018; United Nations Global Compact & Accenture Strategy, 2019). Some of the reasons observed are the uncertainty on the benefits to be derived in committing to long term investments, which makes it crucial for enterprises to showcase their sustainability impact on the business bottom line (Business and Sustainable Development Commission, 2017; Ethical Corporation, 2018; United Nations Global Compact & Accenture Strategy, 2019).

Nowadays, it has been found out that, business enterprises drive sustainability in their organisations through their procurement mechanism. Sustainable procurement in construction is the process or mechanism where organisations or firms collaborate with their various supply chains and relevant stakeholders in delivering the sustainability goals in a project (Berry & McCarthy, 2011). The organisation's procurement mechanism can be used to help ensure that all members of the supply chain meet the organisation's sustainability requirements (Bratt et al., 2013; Grob & Benn, 2014; Perera et al., 2007).

Utilising the procurement mechanism can enhance sustainability performance and innovation that can, in turn, lead to close collaboration amongst the various team members (Carvalho & Rabechini, 2017; Sanchez et al., 2014; United Nations Environment Programme, 2017; Zhu et al., 2007). Sustainability performance is defined as the harmonisation of economic, environmental, and social objectives in the delivery of an organisation core business activities (Elkington, 1997; Jeurissen, 2000)

Furthermore, the procurement of good and services in an organisation accounts for about 70% of an organisation revenue; as a result, a small reduction in cost can have a significant impact on profit (Chartered Institute of Procurement & Supply, 2018). At the sectoral level, construction firms have been noted to have made commitments in driving and implementing sustainable procurement (Berry & McCarthy, 2011; Meehan & Bryde, 2011; Zuo et al., 2012). These commitments are through their organisational policies and mission statements where sustainability is positioned as a primary focus. However, the level of adoption and achievement of sustainability objectives in the AEC sector is said to be low (Linesight, 2018b; McKinsey Global Institute, 2017; Russell et al., 2018; World Economic Forum, 2016b). Equally, the report of Corporate Sustainability Assessment (RobecoSAM AG) shows the need for construction firms to disclose their sustainability practices (RobecoSAM, 2019).

The complex set-up of the construction industry, and the uniqueness of construction projects that are made up of various actors and supply chains, have been identified as potential contributory factors to the slow and low-level sustainability performance of the sector (Ageron et al., 2012; Papadonikolaki, 2018; Ruparathna & Hewage, 2015a; Russell et al., 2018). Additionally, the cyclical nature of the AEC sector discourages large firms to invest in machinery or productions due to fear of economic uncertainty (Linesight, 2018b; McKinsey Global Institute, 2017). In terms of the adoption of sustainability in the AEC sector, Upstill-Goddard *et al.* (2016), argued that most small and medium-sized

firms are always reactive to the adoption of sustainability. Such challenges could be likely because of firms not identifying or understanding the benefits to be derived from implementing such practice (Mulligan et al., 2014; Ruparathna & Hewage, 2015a; Upstill-Goddard et al., 2016). Several benefits such as improved corporate image, competitive advantage, value for money, improved process flow and productivity, improvement in environmental quality and increased compliance with customer's expectations were found to be realised by firms (Berry & McCarthy, 2011; Department for Environment Food and Rural Affairs, 2013; Oladapo et al., 2014). However, Meehan and Bryde (2011) revealed that the organisation's sustainability policies are rarely reflected in their sustainable procurement practices. Therefore, implementing an effective and successful sustainable procurement practice requires close collaboration of all the team members (Fellows, 2006; Korkmaz & Singh, 2011; Woo et al., 2016). Several studies have been carried out in the AEC sector on how they can drive the adoption and implementation of sustainability practices. These studies identified that the low level of understanding of practitioners on issues of sustainability is one of the barriers affecting the adoption and implementation of sustainability in the AEC sector (Adetunji et al., 2003; Akotia et al., 2016; Chang, Zuo, et al., 2016; Higham et al., 2016; Opoku & Ahmed, 2013). They also identify that firms with large financial turnover are motivated in adopting sustainability practices (Adetunji et al., 2003; Boyd & Schweber, 2012; Chang, Zuo, et al., 2016; Upstill-Goddard et al., 2016). Such motivation, as explained by the authors, is seen in the firm's willingness to invest in innovative practices that will enhance their corporate image and gaining a competitive advantage.

The leadership quality in an organisation is another motivating factor. This can be driven by aligning organisation's policies with workers values, doing this has been proven to enhance the sustainability performance of the firm (Eilers et al., 2016; Kannan, 2021; Meehan & Bryde, 2011; Opoku & Fortune, 2015; Qi et al., 2010; Rickaby & Glass, 2017).

Other factors are the engagement of stakeholders that are external to the projects because of the influence they exert (Sfakianaki, 2015; Wu et al., 2017; Yusof et al., 2016). Engagement of the various stakeholders can be through education and creating awareness on the benefits and impact of the project (Kashyap & Parida, 2017; Lim et al., 2015). Lastly, the adoption and utilisation of digital technologies have been proven to have the potential of yielding high sustainability performance (Papadonikolaki, 2016; Papadonikolaki et al., 2015). Li et al. (2013) contended that the managerial and technological capabilities of a firm are related to the firms' performance.

There is no contradiction that the drive for sustainability has changed the focus of procurement practice from short-term cost minimisation to a long term value creation and delivery (Walker et al., 2008). In the delivery of value in the AEC sector, the main-contracting firm is noted to be a major driver in the implementation of sustainable procurement (Riley et al., 2003). This is necessary because main-contracting firms take responsibility for the behaviour of their supply chains (Lin & Tseng, 2016; Sancha, Gimenez, et al., 2016; Wu & Barnes, 2016). Also, implementation of a successful sustainable procurement requires close collaboration with their supply chains and the relevant stakeholders because sustainability cannot be attained in isolation but rather through the collaboration of supply chain players and the relevant stakeholders (Kibert, 2007; Pero et al., 2017). Despite the position of the main contracting firm in driving sustainable procurement, there seems to be a paucity of studies on how they collaborate with the various actors and their supply chains in the implementation of their sustainable procurement.

Different frameworks have been proposed in different academic pieces of literature and reports (Aktin & Gergin, 2016; British Standard Institution (BSI), 2010; Environmental Protection Agency, 2014), but arguably the frameworks were quite generic and focused on the public sector procurement practice. On the other hand, Grob and Benn (2014) and

Walker et al. (2012) noted that there is a dearth in the application of theories in explaining sustainable procurement practices of an organisation. Equally, Hoejmoose and Adrien-Kirby (2012) noted that most studies on sustainable procurement are quite descriptive and fail to contribute to theory.

Therefore, there is a need to understand how main construction-contracting firms implement their sustainable procurement practice. This is necessary because it is argued that most construction firms only seek to gain a competitive advantage and legitimacy rather than truly implementing sustainability or complying with government regulations (Rietbergen et al., 2015; Russell et al., 2018; Upstill-Goddard et al., 2015). To have a good understanding on how construction firms implement their sustainable procurement, there is a need to focus on the practice of large construction- contracting firms. Chang et al. (2016), argued that learning from large construction-contracting firms could be beneficial to knowledge because their practice is often regarded as the benchmark of the learning model for other firms. Hence, there is a need to understand how large construction-contracting firms in the Republic of Ireland implement their sustainable procurement.

1.3 Research Problem and Justification

The attainment of the TBL in driving sustainable development objectives in the AEC sector is through the interactions of the sector with other numerous sectors. These interactions are in providing built and infrastructural facilities that create value for the various sectors operation (World Economic Forum, 2016b). The Society of Chartered Surveyors Ireland (SCSI) (2015), reported that there had been a significant sign of growth in the construction industry in the Republic of Ireland from 2012. This growth is experienced after a lack of activity because of the recession that happens from 2008 (Linesight, 2020; SCSI & PwC, 2017). For example, the sector reported an output of circa €17.5 billion in 2017, which represents an increase of 17% over the 2016 level

(Linesight, 2018a). While in 2019 investment in building and construction grew by an estimated 11% with circa €27 billion (Linesight, 2020). However, a decrease of about 35% is expected in 2020 as a result of the pandemic that affected public and private investment (Linesight, 2020). Such decrease is expected to see construction turnover at €18 billion which represents 5.4% of the total projected GDP for 2020 of €331 billion (Linesight, 2020) With regards to employment, the industry was reported to have employed about 140,000 people in 2017 compared to under 95,000 employed in 2016 (SCSI & PwC, 2017). Furthermore, there is an expected growth in the population in the Republic of Ireland of an additional one million people from the current four million, seven hundred and ninety-two thousand, five hundred (4,792,500). The government observed that the population growth would lead to demand for transportation, buildings and other infrastructural facilities (Government of Ireland, 2018a).

Additionally, the government, in its efforts to meet the SDGs set up an implementation plan that will guide the delivery of the 17 SDGs (Government of Ireland, 2018b). The plan identifies four strategic priorities to guide the implementation. The priority is by creating public awareness on SDGs, followed by participation through engaging stakeholders; third priority for implementation is supporting and encouraging communities and organisation towards meeting the SDGs. The fourth priority is policy alignment through developing national policy that aligns with the SDGs and identifying policy coherence (Government of Ireland, 2018b).

The procurement mechanism is a process where organisations collaborate with the various actors in project to realise the project objectives (Love et al., 1998). While sustainable procurement is a process where organisations collaborate with the various actors in achieving the various sustainability goals (Berry & McCarthy, 2011). Therefore, the full realisation of the SDGs in Ireland will require the AEC sector to adopt and implement an effective sustainable procurement practice. Sustainable procurement have the benefits

of encouraging innovation and reducing the harmful impact of pollution and waste. An effective sustainable procurement practice is the first step required to achieve the sustainable development objectives (Kralik & Chrzan, 2020). Adopting such practice requires construction firms to demonstrate to their clients and stakeholders that they are committed to delivering sustainable products while also educating them on how this can be achieved and not just engaged in public relations (Myers, 2005). This effort can only be accomplished if construction firms can fully identify the benefits that would be gained in undertaking such practices (Business and Sustainable Development Commission, 2017; Ethical Corporation, 2018; Upstill-Goddard et al., 2016). If such benefits cannot be identified, arguably, then construction firms will merely be using sustainability practices as a form of public relations to gain legitimacy and competitive advantage. Therefore, there is a need to explore how leading construction-contracting firms in the Republic of Ireland addresses sustainability issues in their procurement processes. This is to identify areas of improvement that will motivate them to adopt and implement sustainability practices fully. Leading construction-contracting firms can significantly contribute to supporting the 2030 SDGs targets. This is because, in 2017, there was a combined economic output of more than €6.7 billion from leading construction-contracting firms in the Republic of Ireland (The Journal, 2018). This economic output is an indication of how important the AEC sector is in achieving the SDGs. Also, learning from leading construction-contracting firms could be vital in driving the adoption of sustainability in the AEC sector (Riley et al., 2003). Based on their performance, large contracting firms are often regarded as the benchmark and present a learning model for others (Chang, Zuo, et al., 2016).

1.4 Research Questions

The study raised the following research questions to address the research problem

Central Research Question: How do Irish construction-contracting firms embed sustainability in their procurement practices?

Sub-Questions

1. How do contracting firms implement sustainable procurement practice in their organisation?
2. How do construction firms influence their supply chains in driving sustainable construction practices?
3. What is the current level of digital technologies application in driving successful sustainable procurement practice?
4. How have government policies and regulations promote sustainable procurement?

1.5 Aim and Objectives of the Study

The study aims to develop a sustainable procurement framework that will enhance sustainable procurement practice in the Irish construction sector.

The following objectives are set out to help achieve the aim of the study:

1. To critically review existing literature in relation to the existing literature on the current level of sustainable construction practices in the Irish construction industry and globally.
2. To evaluate the current level of adoption/performance of sustainable procurement practice amongst Irish construction contracting firms.
3. To determine if and how construction contracting firms in Ireland influence their supply chains in adopting sustainable construction practice.

4. To assess the current levels of, and potential for the adoption of digital technologies by construction-contracting firms at the procurement phase of a project to help achieve sustainability goals.
5. To develop and validate a sustainable procurement framework that will guide firms in the implementation of sustainable procurement.

In addressing the research objectives, several tools and strategies are employed. Table 1 presents the implementation strategy of how each objective will be addressed. The four major tools and strategies utilised are literature in the form of peer-reviewed academic papers, and industry reports. Also, documents from the organisation studied, questionnaire surveys, and interviews will be used in the collection of data.

Table 1:Implementation Strategy

Objectives	Literature Review	Documents Analysis	Interviews	Questionnaire
Objective 1: Sustainable Construction Practice Globally and Irish Context	✓			
Objective 2: Evaluate the current level of adoption and performance		✓	✓	✓
Objective 3: How contracting firms influence their supply chains		✓	✓	✓
Objective 4: Existing levels and potential for adopting digital technologies	✓	✓	✓	✓
Objective 5: Development and validation of a framework	✓	✓	✓	✓

1.6 Research Scope and Limitation

The research focuses on sustainable procurement practices of construction-contracting firms in the Republic of Ireland, and it is limited to the top fifty leading construction-contracting firms listed by the construction industry federation in 2018 according to their annual financial turnover. The European Commission (European Commission, 2020), categorized businesses as either large, medium or small enterprise based on their annual turnover or staff headcount. Large business has a turnover of over €50 million and a staff head count of over 250. While medium size business has a turnover of less than €50 million and a staff head count of less than 250. Finally, small size business has a turnover of less than €10 million and a total head count of less than 50 person. Although focusing on only the top fifty construction contracting firms could make the findings limited. It is limited because it is not wholly representative of the population of construction enterprises in the Republic of Ireland or other global construction sectors (Government of Ireland, 2019c; Karim et al., 2006; Oyegoke et al., 2010). The Project Ireland 2040 report shows that about fifty thousand, six hundred and seventy-three (50,673) construction enterprises are registered in the Republic of Ireland (Government of Ireland, 2019c). Out of the total number, about 95% are micro-sized, while less than 5% are medium, and less than 1% are large-sized (Government of Ireland, 2019c).

However, despite such a limitation focusing on the top fifty construction-contracting firms will provide an in-depth understanding of their organisational strategies. Unveiling such strategies will provide a foundation for future research around the sustainable procurement practice of construction-contracting firms.

Additionally, learning from the top fifty construction-contracting firms is necessary because as mentioned earlier that, large contracting firms are often regarded as the benchmark and present a learning model for others (Chang, Zuo, et al., 2016). Therefore, the top fifty construction-contracting firms selected based on their annual financial

turnover will provide an opportunity of unveiling their organisational strategies in driving sustainable procurement practice. This is because, firms with high financial turnover are most of the time motivated in adopting sustainability practices compared to smaller firms (Adetunji et al., 2003; Boyd & Schweber, 2012; Chang, Zuo, et al., 2016; Upstill-Goddard et al., 2016). Also, leading contracting firms have a unique role in driving sustainable procurement because of their structural dominance in influencing their supply chains (Adetunji et al., 2008; London, 2008).

Secondly, utilising the purposive (judgemental) sampling technique provides the opportunity of getting the best information through focusing on a relatively small number of participants based on their known attributes (Denscombe, 2014). As noted by Denscombe (2014), such attributes are based on the relevance of the issues investigated and the knowledge or experience of the participants..

Lastly, the essence of the study is not to generalise findings but rather to provide an inference of best explanation (abduction), therefore, examining the sustainable procurement practice of the top fifty firms becomes adequate and relevant. Furthermore, the study is also limited in terms of theoretical focus because it focuses only on the internal operations and strategies of the firms in driving their sustainable procurement practice. Utilising the case study strategy that provides the ability to look at a sub-units that are situated within a larger case (Baxter & Jack, 2008). Examining such sub-units requires an in-depth analysis that might lead to resources and time constraint. Therefore, the cross-sectional study provides a snapshot of construction-contracting firms sustainability practice. Saunders et al. (2015) explained that a cross-sectional study compared to a longitudinal study seeks to describe the incidence of a phenomenon or explain how factors are related in different organisations in a short period. While on the other hand, longitudinal study has the advantage of studying change and development in an organisation for a long time. So, external factors such as managing risk and

uncertainties, interdependencies and social relationships are not considered. Also, the influence of external stakeholders' in the implementation of sustainable procurement is not deeply considered. Therefore, the results of the study are expected to provide an in-depth understanding that will provide the foundation for future research.

1.7 Contribution to Knowledge

The study contributed to knowledge by unveiling the sustainable procurement practice of large construction-contracting firms in the Republic of Ireland. One of the study's main contributions was demonstrating how the firms utilise their organisational human resources to promote sustainable procurement practice. Such utilisation was done by providing training formally and informally through continual professional development and on-the-job. The formal training focuses on the understanding of the organisation's sustainability policies and management procedures. In comparison, the informal training, workers are assigned responsibilities and tasks during the execution of projects. Such a strategy provides an opportunity for knowledge sharing amongst team members and enhances teamwork.

Secondly, the study contributed by showing the organisational strategies utilised by firms in collaborating with their supply chains. Such collaboration was found very significant because the study revealed that long years of working relationships between the main contracting firms do not guarantee a successful project outcome in project delivery.

Another contribution was that despite firms possessing and utilising different digital technology tools and resources, their applications mainly were around their everyday operations. Therefore, for firms to disclose their sustainability performance, there is the need to develop policies and strategies to enable them to have a central database that will make real-time data available to all actors.

Methodologically, the study demonstrated how the single case study approach could be utilised in understanding internal organisations strategies. It contributed significantly by demonstrating how the single case study provided the opportunity of using multiple data collection techniques. In addition, it provided further clarification and a deeper understanding of earlier arguments about the choice of either multiple or single case studies. This contribution further supports the argument of Dubois and Gadde (2002), which explained that certain disadvantages counter any benefits gained by increasing the number of cases. This is because as the number of cases increases in breadth, a significant reduction in the depth of analysis will be experienced (Dubois & Gadde, 2002; Eisenhardt, 1989; Upstill-Goddard et al., 2016).

Another contribution to knowledge made by the study is the development of a sustainable procurement framework. The framework is intended to guide construction firms in planning and implementing sustainable procurement. Planning and implementing sustainable procurement using the framework developed will enable firms in disclosing their sustainability performance to their clients and relevant stakeholders. In addition, the framework developed could be beneficial to both policymakers and practitioners in large and medium companies by enabling them to develop long-term strategies in driving sustainable procurement.

These contributions add to the existing academic literature that has created a better understanding of the implementation of sustainability at both individual and organisational levels. Earlier studies by different authors address sustainable procurement more from a descriptive perspective (Eilers et al., 2016; Hoejmose & Adrien-Kirby, 2012; Rickaby & Glass, 2017; Terouhid & Ries, 2016). This study contributed to the existing literature by adding to knowledge the internal organisational strategies of construction-contracting firms in the Republic of Ireland.

1.8 Structure of the Thesis

The thesis is divided into eleven chapters. A summary of the various chapter is presented below and in figure 1.

Chapter 1: This chapter presents the background of the study, problem statement and justification, the research questions and aim and objectives of the study. The research scope and limitation of the study is also presented in this chapter.

Chapter 2: This chapter is a review of the relevant literature and studies that relate to sustainability practices in the AEC sector. It also provides a review of sustainable procurement and the application of digital technologies in supporting sustainable procurement practices. The construction industry practices in the Republic of Ireland is also reviewed in this chapter. The chapter further provided a summary of the gaps found in previous studies.

Chapter 3: The methodology aspect of the research is presented in this chapter. The chapter provides an overview and theories of research and the various philosophical assumptions adopted in the research. The various research strategies and techniques adopted in research are also discussed. The choice of the researcher's philosophical assumptions, strategies and other techniques guiding the study is also discussed in this chapter.

Chapter 4: This chapter reports the findings on the questionnaire survey, the various statistical analysis used and explanations.

Chapter 5: Findings on case study phase 1 is reported in this chapter. The findings of the case study at the organisational level are reported.

Chapter 6: The chapter is on findings on case study phase 2. The findings at the project level, where two completed projects were studied are reported.

Chapter 7: Discussion of results chapter triangulates the results in chapters 4,5, and 6. It discusses the results and shows how each of the research questions and study objectives is achieved.

Chapter 8: The chapter presents the processes used in the development of the framework. Also, the framework developed is presented in this chapter.

Chapter 9: The validation procedure is reported in this chapter.

Chapter 10: The chapter presents the conclusion and recommendations for further study of the work.

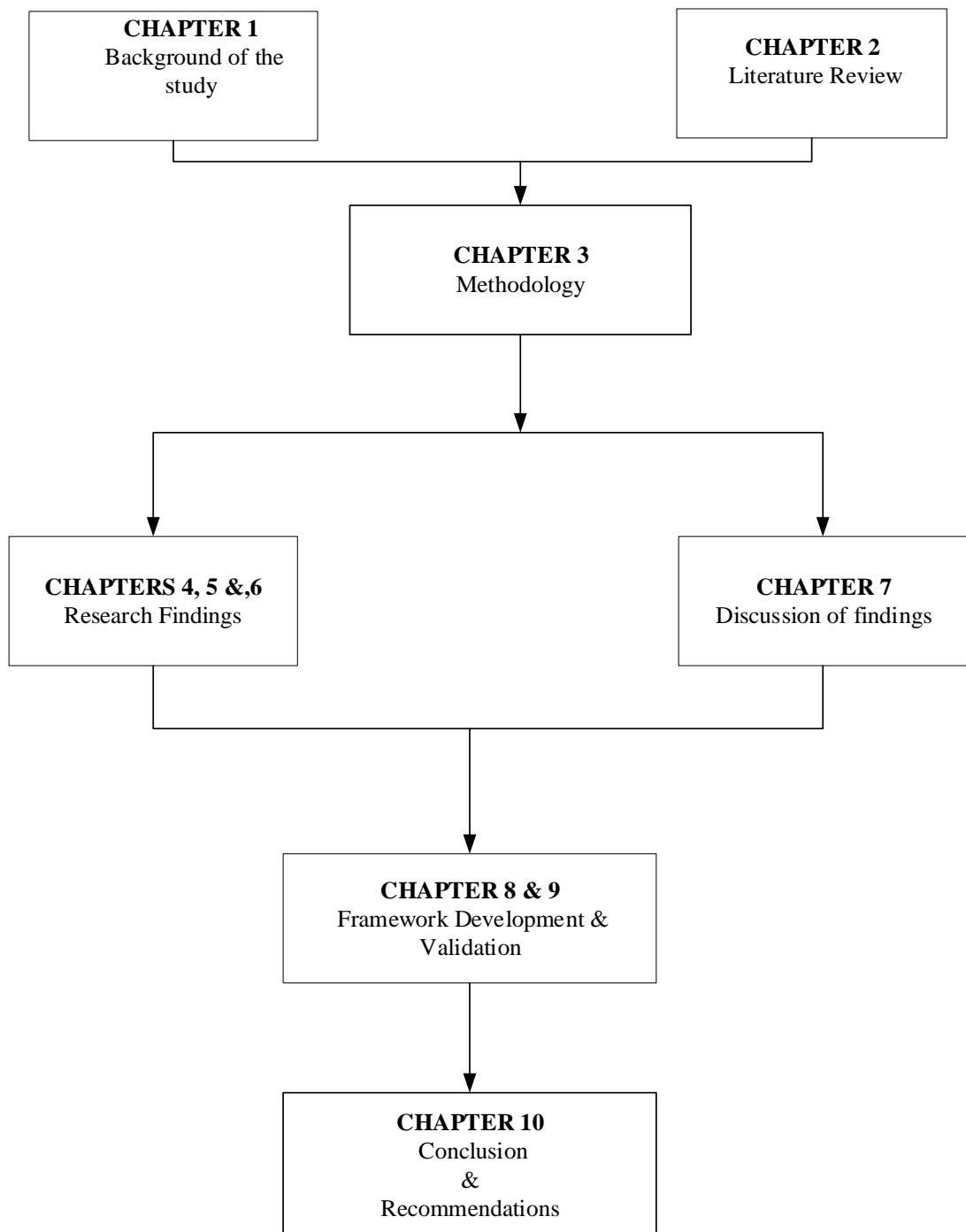


Figure 1: Structure of The Thesis

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

The chapter sets out to lay the foundation in addressing the research question on how construction-contracting firms embed sustainability in their procurement processes. The chapter first provides a background on sustainable development and presents a review of relevant literature on sustainable development as it relates to the Architectural, Engineering, and Construction (AEC) sector. Also, pieces of literature in sustainable construction, sustainable procurement, and utilisation of digital technologies were critically reviewed. The chapter focuses on different aspects that drives understanding on sustainable construction practice and sustainable procurement practice as shown in figure 2. The literature review is divided into eleven sections starting from 2.1. Sections 2.1 to 2.10 discusses the various topics shown and mentioned earlier. While section 2.11 provides a summary of the literature review and the gaps identified in the study. Such a review is important because there is a need to understand the current level of adoption and implementation of sustainable construction and procurement practice.

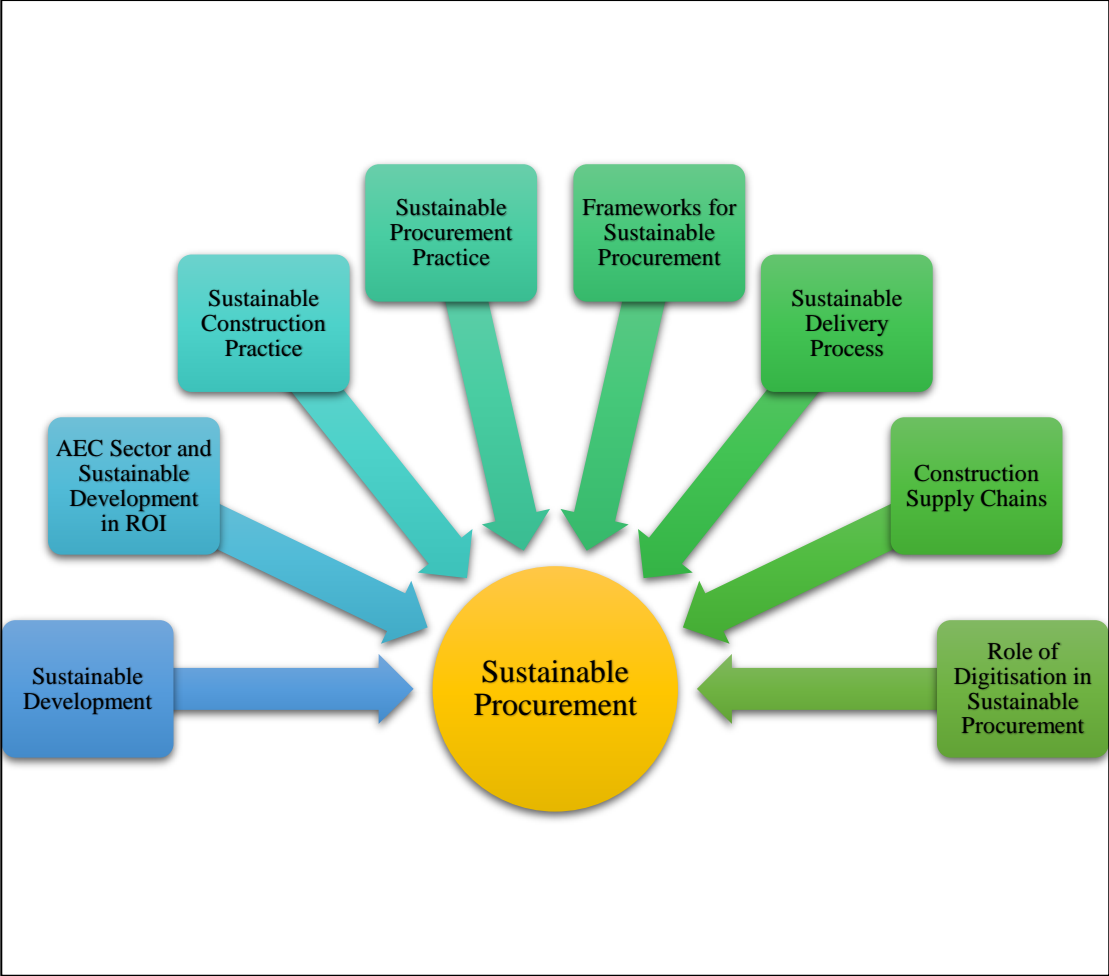


Figure 2: Focus of Literature review

2.1 Sustainable Development: Meaning, Context and Discussions

Debates and concerns on sustainable development can be traced back to Thomas Malthus (1766-1834) and Williams Stanley Jevons (1835-82) and other eighteenth and nineteenth-century thinkers who showed concern about the rise in demand of earth resources to meet the rise in population (Baker, 2006; Hill & Bowen, 1997; Kuper, 2014). These struggles and agitations on how human activities affect the earth resources continued to the point that the World Commission on Environment and Development (WCED) in 1987 published its report known as Our Common Future. The report is popularly known as the Brundtland Report that addressed issues relating to the social, economic and ecological dimensions of development (Baker, 2006; Brandon & Lombardi, 2010). Sustainable development, as defined in the Brundtland report is, *“the development that meets the needs of the present, without compromising the ability of future generations to meet their own needs.* Building on this, the Sustainable Development Commission explained that

“The concept of sustainable development can be interpreted in many different ways, but at its core is an approach to development that looks to balance different, and often competing, needs against an awareness of the environmental, social and economic limitations we face as a society”

(Sustainable Development Commission, 2016).

The Cambridge Dictionary (CD) defines sustainability as the ability for an enterprise to continue at a particular level for a period. Therefore, in this context, sustainable development can be considered as relating to how the AEC sector addresses the TBL in driving their organisational goals and project objectives.

The terms sustainable development and sustainability have been used interchangeably with the term green design or the green environment. For instance, Cole (1999) noted that

environmentally progressive building practice is currently described using a variety of different tags: green design; ecological design; and sustainable design. The term green can be explained to be a quick and inexpensive step to make the world less unsustainable by the deployment of tactics that reduce the environmental impact of human activity, agricultural and industrial production in our built environment (Yanarella et al., 2009). On the other hand, sustainability implies undertaking the necessary changes in our economic, social, and urban process to achieve a dynamic virtuous and balanced relationship with nature. The main objective of building green is to minimize environmental impact. At the same time, sustainability is a continuous process or a non-stop development depending on the building practices that embrace the environmental, social and economic aspect of the society (Doan et al., 2017). Sustainable development can be argued to represent a new environmental approach that is aimed at promoting a form of development that is contained within the ecological carrying capacity of the planet, which is socially just and economically inclusive (Baker, 2006). Therefore, the term sustainability and sustainable development shall be used in this study. To guide the study, after reviewing several definitions of sustainability from different sources, the study coined a single definition on what the term sustainability would mean in the context of the study. Therefore, sustainability is defined as a continuous process of improving the methods of development by considering the environment, society, and economic resources.

In driving the adoption of sustainability practice globally, the United Nations Global Compact revealed that about 13,456 organisations in the different sectors of the economy in 162 countries have a voluntary partner with them in disclosing their sustainability performance (United Nations Global Compact, 2019). One of the ways of deriving the benefits of adopting sustainable development in an organisation is through the adoption of innovative practices. The United Nations Environmental Programme (UNEP)

suggested that the culture of innovation cuts across sectors and that the key features of an innovative culture are creativity, openness and participation (United Nations Environment Programme, 2019). In addition, many international organisations and agencies like the European Union (EU), the United Nations Environmental Programme (UNEP) and the World Bank had developed policies and regulations that sought to embrace the practice of sustainable development (Baker, 2006; Gough & Scott, 2003). Gough and Scott (2003), and Baker (2006) further reported that national governments, sub-national regional and local authorities, as well as groups of the civil society and economic actors, have all made declaratory and practical commitments to the goals of achieving sustainable development. In May 2019 the Republic of Ireland became the second country after the UK to declare a climate emergency. In their action plan report, the government of Ireland stated that the declaration of the emergency provides a strong foundation for the climate action plan that is committed to achieving a net-zero carbon energy system objective for Irish society. Besides the plan is to help create a resilient, vibrant and sustainable country (Government of Ireland, 2019a). This approach by the government of the Republic of Ireland will have a significant impact on the AEC sector.

Furthermore, the United Nations (UN) in 2005 endorsed a tripartite Venn diagram that illustrates the interconnectedness of the “three Es”: environment, economic and (social) equity. It is generally believed that Edward Barbier first developed the Venn diagram (the TBL discussed in detail in section 2.1.2) illustrating the concept of sustainability in 1987 (Barbier, 1987). In setting out this approach, the UN in 2005 set sustainability goals and targets. The first goals and targets had eight goals which were popularly known as the Millennium Development Goals (MDGs). These goals ended in 2015, the second goals and targets, which is the Sustainable Development Goals (SDGs) is expected to end in 2030. The SDGs has seventeen goals, 169 targets, and 230 indicators (Caradonna, 2014; United Nations Development Programme, 2019). These goals are expected to address the

global challenges, which include poverty, inequality, climate, environmental degradation, prosperity, and peace and justice (Caradonna, 2014; United Nations Development Programme, 2019).

Additionally, the UN in reducing the negative impact of the greenhouse gas emission (GHG) under the UN Framework Convention on Climate Change (UNFCCC) also known as COP21, produced a report known as the Paris Climate Agreement. The agreement was adopted in December 2015 and signed by 196 countries (IPCC, 2018; United Nations Framework Convention on Climate Change, 2015). Under the agreement, each country is expected to make proactive plans and regularly report their effort and contribution towards mitigating global warming. A summary of some the development made in driving the sustainability is shown in figure 3.

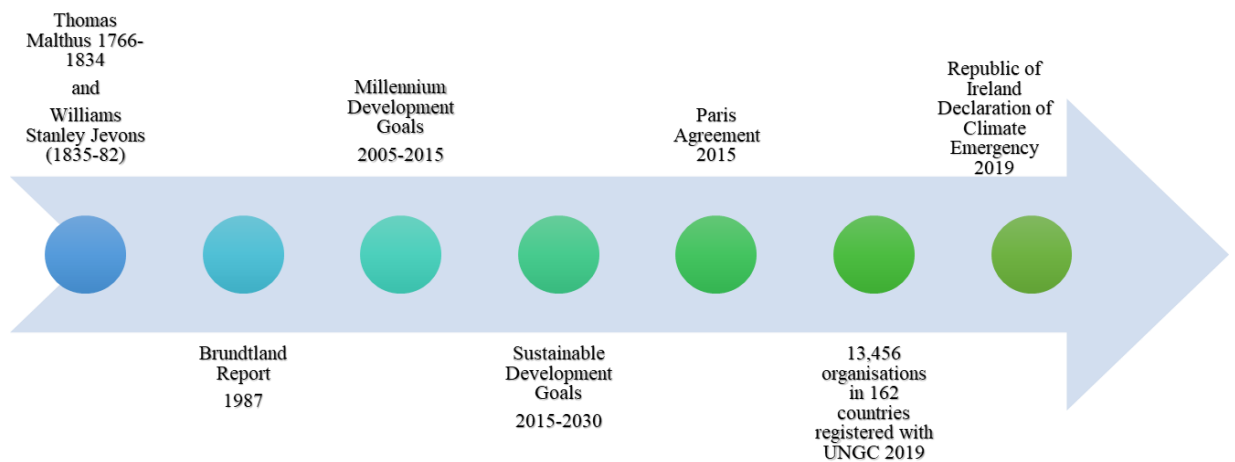


Figure 3: Summary of Development in Driving Sustainability Agenda

It is necessary, for the AEC sector to adopt innovative practices concerning sustainable construction. This is because it was shown in section 1.2 and 1.3 on the contribution of the sector in terms of the global economy and its impact on the environment. Such economy impact indicates that the AEC sector accounts for about 6% of global GDP. Also, the Financial Stability Board's Taskforce on Climate-related Financial Disclosures (TCFD) has identified the materials and building sector as one of the sectors having a significant exposure to climate risks and the highest likelihood of climate-related financial impact (Task Force on Climate-related Financial Disclosures (TCFD), 2017). However, it has been noted that the AEC sector has been slow in adopting innovative practices that could enhance their performance (World Economic Forum, 2016b). This slowness is likely to be due to the cyclical nature of the AEC sector that discourages firms from investing in innovative practices (Linesight, 2018b; McKinsey Global Institute, 2017). Also, the unwillingness of some small and medium-sized firms in the adoption of sustainability in the AEC sector (Upstill-Goddard et al., 2016), As the level of awareness in the society develops on the need of embracing sustainability practice; there was the challenge of measuring the sustainability performance and activities of organisations. In addressing this challenge, John Elkington developed the concept of the Triple Bottom Line (TBL) in 1994. The TBL is an accounting framework that measures organisations sustainability (social, economic and environmental) performance (Elkington, 1997). Slaper and Hall (2011) explained that the TBL differs from the traditional reporting framework that shows only the profit aspect of an organisation without showing the social and environmental performance. The next section is on the Triple Bottom Line (TBL).

2.1.1 The Triple Bottom Line (TBL)

To aid business enterprises to assess and examine their sustainability performance, John Elkington, developed the concept of the triple bottom line. Just as it was discussed in section 2.1 on the strategies developed by the UN on the goals and targets of meeting the MDGs and SDGs, the TBL developed by John Elkington focuses more on business enterprises. It is an accounting framework that enables organisations to assess their performance not only from the profit perspective but from the social and environmental perspective (Elkington, 1997, 2004). It simultaneously considers and balances the economic, environmental and social goals from a microeconomic standpoint that will enable organisations to develop strategies of meeting the three primary goals of sustainability (Elkington, 2004). In addition, Adams et al. (2004) argued that the TBL concept has helped in articulating the philosophy of sustainability in a language accessible to corporations and their shareholders. Citing the definition of Andrew Savitz, Slaper and Hall (2011) explained that the TBL

“captures the essence of sustainability by measuring the impact of an organisation's activities on the environment ... including both its profitability and shareholder values and its social, human and environmental capital”.

Slaper and Hall (2011) further observed that there is an increase in the number of profit and non-profit organisations globally in adopting TBL sustainability framework in evaluating their performance. Evaluating their performance helps them to create value in their practice while gaining a competitive advantage.

A business is said to be sustainable when it can meet the “triple bottom line” target (Jeurissen, 2000). The TBL target is realised through economic prosperity, environmental quality and social justice. Jeurissen (2000) further argued that the TBL are interrelated, interdependent, and partly in conflict, as shown in figure 4.

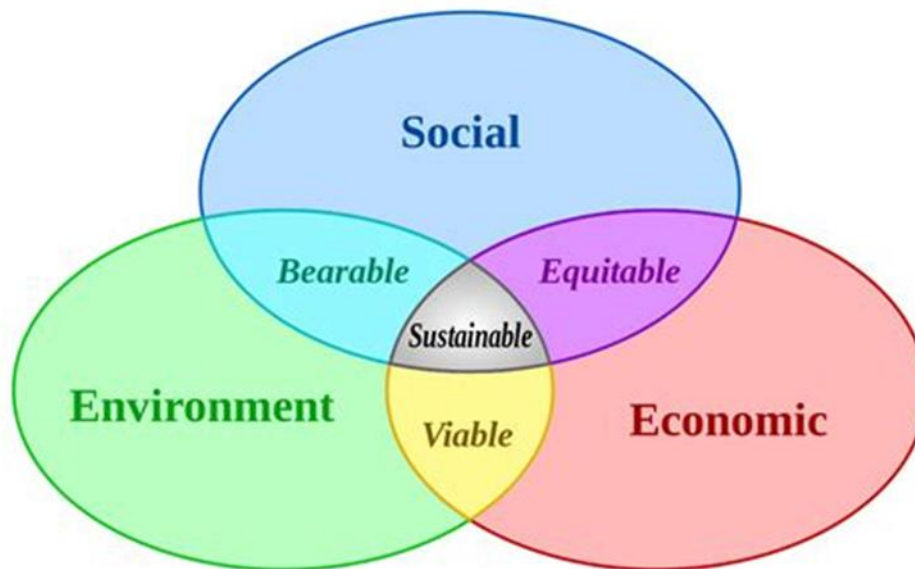


Figure 4: Venn Diagram Showing the Relationship between the Three Pillars Of Sustainability (*Elkington, 1997; Jeurissen, 2000*)

Although measuring the social aspect of the TBL has been challenging in the AEC sector (Edum-Fotwe & Price, 2009). Nevertheless, it is argued that organisations that pay attention in delivering effective environmental management are expected to improve its organisation image through gaining a competitive advantage in the market, and improving relations with the society due to better environmental performance (To et al., 2015). Equally, Lim and Loosemore (2017), suggests that socially responsible firms are likely to increase their turnover, improve public image, enhance employee loyalty, and attract talented persons.

The TBL suggests that at the intersection of social, environmental, and economic performance, there are activities that organisations can engage, which not only positively affect the natural environment and society but also result in the long-term economic benefits and competitive advantage for the firm (Carter & Rogers, 2008). For a business enterprise to gain a competitive advantage while adopting sustainable development practice, Elkington (1997) argued that such business enterprise would have to change

from their traditional way (old paradigm) to a more innovative way (new paradigm). He argued that such changes would be dependant on seven closely linked revolutions.

The seven sustainability revolution, as argued by Elkington (1997), will see the organisation changing their practice and behaviour from the old paradigm to the new paradigm. As shown on Table 2, the seven revolutions that will impact business enterprises are markets (compliance to competition), values (hard to soft), transparency (closed to open), life cycle technology (product to function), partnership (subversion to symbiosis), time (wider to longer), and corporate governance (exclusive to inclusive).

Table 2: Seven Sustainability Revolutions (Elkington, 1997)

Revolutions	Old Paradigm	New Paradigm
Markets	Compliance	Competition
Values	Hard	Soft
Transparency	Closed	Open
Life-cycle technology	Product further	Function
Partnership	Subversion	Symbiosis
Time	Wider	Longer
Corporate governance	Exclusive	Inclusive

Furthermore, figure 5 explained how the new paradigm would have an impact on business enterprises. The market will be determined by the client requiring detail information about their products, which will make businesses to understand their clients or customers requirements. While values will influence the behaviour of businesses towards the environment and society. The third revolution, which is transparency, will see business disclosing their sustainability performance which could be either voluntarily, or involuntarily, or mandatory. The fourth revolution, life-cycle technology will see

attention paid to the performance and function of the product rather than sales. The partnership is the fifth revolution, that will see businesses partnering and engaging with their stakeholders and the community. While the sixth revolution, time will require businesses to develop long -term strategies than short -term. The seventh revolution, corporate partnership, is driven by the whole six revolutions. Corporate governance will see the transformation of corporate organisation's structures. This transformation has been noted in the AEC sector where firms are restructuring their organisation structure and changing their working culture in order to gain a competitive advantage (Berry & McCarthy, 2011; Boyd & Schweber, 2012). Therefore, the impact of this seven revolution in the AEC sector will need to be understood and their influence on driving sustainable procurement.

Having provided background on sustainable development and their link to the AEC sector, the next section provides background and in-depth understanding of the AEC sector in the Republic of Ireland. Also, the section provides an insight into sustainable development in the Republic of Ireland

Market	<ul style="list-style-type: none"> •Product information rather than sales pitch •Green consumerism (Clients opinion about products) z
Values	<ul style="list-style-type: none"> •Behaviour and values towards the environment and society
Transparency	<ul style="list-style-type: none"> • Organisation’s activities and thinking under intense scrutiny •Impact on value systems and advancement of information technologies •Disclosure of activities (voluntary, involuntary, or mandatory through laws)
Life-Cycle Technology	<ul style="list-style-type: none"> •Focusing on function and performance of products rather than sales •Paying attention from extraction of raw materials right through to recycling and disposal (cradle to grave)
Partnership	<ul style="list-style-type: none"> •Stakeholders holders and community engagement •Community and Stakeholders requirements
Time	<ul style="list-style-type: none"> •Long-term planning and strategies rather than short term.
Corporate Governance	<ul style="list-style-type: none"> •Driven by the six revolution (time, values, transparency, life-cycle, partnership, and time) •Transformation of corporate organisation’s structures

Figure 5: Seven Sustainability Revolution (Elkington,1997)

2.2 AEC Sector in the Republic of Ireland

The construction sector in the Republic of Ireland has been experiencing a significant growth with an output of approximately €17.5 billion in 2017, which represents an increase of 17% over the 2016 level (Linesight, 2018a). In addition, the Central office of Statistics reported that there is a 7.4% increase in the volume of building and construction in the first quarter of 2018. This they explained represents an increase of 5.6%, 5.5% and 1.1% respectively in the volume of residential building work, non-residential building work and civil engineering work (Central Statistics Office, 2018). Most of the construction projects undertaken centres on new office development and office fit-outs, primarily in the Greater Dublin Area. Also, in 2019 the investment in building and construction grew by an estimated 11% with circa €27 billion in 2019 (Linesight, 2020). However, as shown in figure 6 a decrease of about 35% is expected in 2020 as a result of the pandemic that affected public and private investment (Linesight, 2020). Such decrease is expected to see construction turnover at €18 billion which represents 5.4% of the total projected GDP for 2020 of €331 billion (Linesight, 2020).

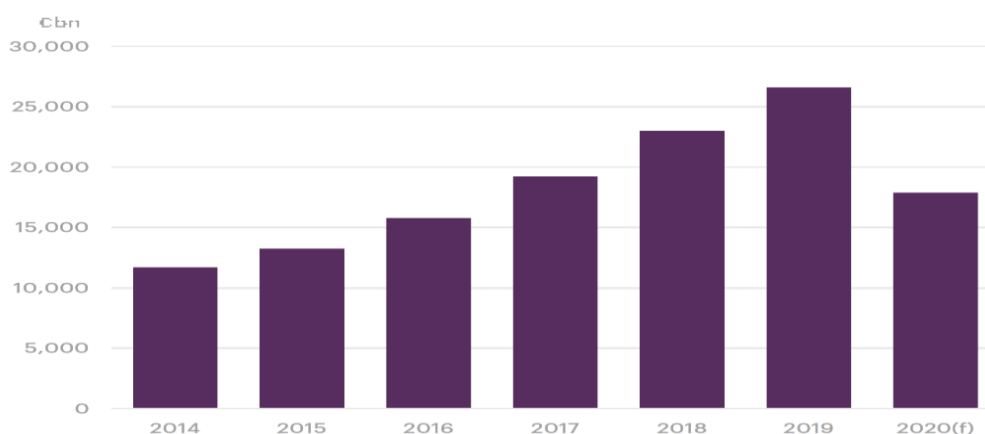


Figure 6: Output in Investment in Building in the ROI Source: (Linesight, 2020).

Additionally, with regards to employment, It is reported that about 140,000 people were employed in the industry compared to under 95,000 employed in 2016, which was the lowest point (SCSI & PwC, 2017). Increase in employment rate in the sector was further experienced upto 2019. But a decrease was experienced due to the pandemic in 2020 as shown in figure 7. Linesight (2020), explained that as of 6th September 2020, 10,023 construction workers remained on the pandemic unemployment payments compared with 52,118 on the 3rd of May 2020.

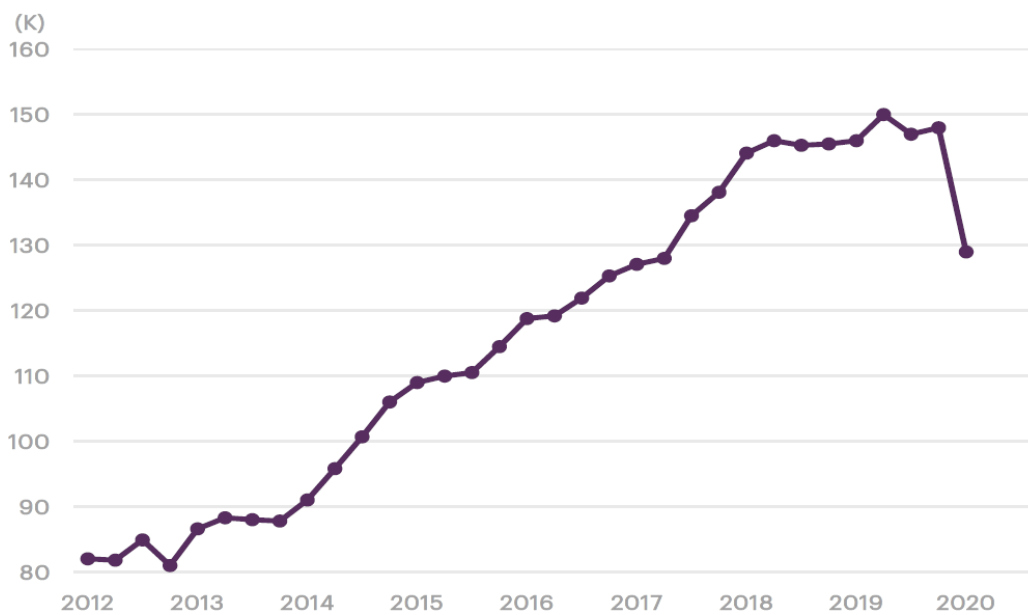


Figure 7: Employment in Construction in ROI 2012-2020 (Linesight, 2020).

Furthermore, in planning to meet the demand for infrastructures, the Government of the Republic of Ireland in her Project Ireland 2040 report emphasised the need for government to plan and invest in infrastructural projects. This is because it is anticipated that population in Ireland will grow with an additional one million people from the current four million, seven hundred and ninety-two thousand, five hundred (4,792,500) (Government of Ireland, 2018a). Population growth will lead to an increase in the demand for transportation, buildings and other infrastructural facilities.

However, there is some concern on some of the impediments that may likely alter the proposed plan and effort in meeting the desire of the government in terms of infrastructural development. These impediments as reported by the Society of Chartered Surveyors Ireland (SCSI) and PricewaterhouseCoopers (PwC) are government policies and regulations such as taxes, tender prices and planning and approvals delays most especially in the residential sector (SCSI & PwC, 2017, 2018). For example, the SCSI House Delivery Cost Report published in 2016 established that 45% of the total cost of constructing a three-bed semi-detached home accounted for 'bricks and mortar', with the other 55% accounting for VAT, levies, finance, Part V and connection charges (SCSI & PwC, 2017).

Additionally, with the Irish economy dependent to some extent on direct foreign investments and exports, there is the need for the construction sector to provide adequate housing need and infrastructure to support such investments (AECOM, 2018; SCSI & PwC, 2018). In addition, with BREXIT there could be an opportunity for the construction sector, but Ireland will need to have the necessary skills to deliver the anticipated growth (AECOM, 2018; SCSI & PwC, 2018). However, a report by PricewaterhouseCoopers and Construction Industry Federation (CIF) with regards to BREXIT showed that the AEC sector in the Republic of Ireland is likely to be negatively impacted (PwC & CIF, 2019). These they noted will be in the area of cost of materials and movement of equipment, supply chain, route to market, custom compliance, and movement of skilled workers. In mitigating these challenges, the government of the Republic of Ireland has introduced a number of measures like training on contingency plans, and the Brexit Loan Scheme (BLS) (PwC & CIF, 2019). Also, Brooks *et al.* (2020) noted that construction firms are developing strategies to respond with resilience and adaptability.

2. 3 Sustainable Development in the Republic of Ireland

It is evident from section 2.2 that the AEC sector in the Republic of Ireland has the potential in contributing to driving the objectives of sustainable development. To further explore sustainable development in Ireland, this section further review efforts and development in the AEC sector.

The government of the Republic of Ireland in order to comply with the directives of the different international organisations, has put in place policies and laws that ensure buildings and construction products comply with the sustainability and environmental policies and targets. Apart from the laws and policies put in place, the Irish government have made efforts to comply with European Union directives. The directive under SI. No. 243/2012 – European Union (Energy Performance of Buildings) Regulations 2012, that states that every dwelling and non-domestic building offered for sale or rent to any prospective purchaser or tenant must have an Energy Performance Certificate (EPC) (known in Ireland as Building Energy Rating (BER)). The certificate is to be provided by a certified assessor (European Union, 2012). However, there is an exemption for protected structures and some other building types, such as places of worship or non-residential agricultural buildings with low installed heating capacity (European Union, 2012). Another effort made by the government is the implementation of the nearly zero energy building (NZEB) policy. The NZEB is expected to apply to all new buildings occupied after the 31st of December 2020 (SEAI, 2017). In addition, the Department of Communications Climate Action and Environment explained that all buildings built after 31 December 2020 must-have high energy-saving standards and powered largely by renewable energy (Department of Communications Climate Action and Environment, 2012). Likewise, with regards to public buildings, it is expected that by the end of 2018 the public sector must own or

rent only buildings with high energy-saving standards and promote the conversion of existing buildings to "nearly zero" standards (Department of Communications Climate Action and Environment, 2012; SEAI, 2017). For example in driving the adoption and implementation of sustainability practice, the Sustainable Energy Authority of Ireland (SEAI) provided some incentives in developing residential buildings (IGBC, 2018). The incentives are through grants on schemes like Better Energy Homes, Better Energy Communities and SEAI's Deep Retrofit programme. Also, householders and private organisations who invest in energy efficiency may be eligible for tax rebates under the schemes such as the Home Renovation Incentive (HRI) and the Accelerated Capital Allowances for Energy Efficient Equipment (ACA) (Irish Green Building Council (IGBC), 2018).

Additionally, other efforts made by the government of Ireland as reported by the Irish Green Building Council (IGBC), is that public funding to reduce CO₂ emission from the built environment was increased by €35m under the 2018 budget. This brought the annual budget for energy efficiency to over €100m (Irish Green Building Council (IGBC), 2018). IGBC further reported that there are incentives provided through the Sustainable Energy Authority of Ireland (SEAI). The incentives are through the provision of grants on schemes like Better Energy Homes, Better Energy Communities and SEAI's Deep Retrofit programme. Also, householders and private organisations who invest in energy efficiency may be eligible for tax rebates under the schemes such as the Home Renovation Incentive (HRI) and the Accelerated Capital Allowances for Energy Efficient Equipment (ACA) (Irish Green Building Council (IGBC), 2018). Some of the advantages to be gain in Europe in terms of energy efficiency, as noted by Energy Efficiency Financial Institutions Group (2017) are:

- Increase supply security through reduced reliance on imported energy (presently 400 billion EUR per year)
- Enhance the competitiveness of Europe's industry
- Reduce global and local environmental problems

The IGBC (2018) reported that over 745,000 Building Energy Rating (BER) Certificates were issued for dwellings in April 2017. While 47,000 BER certificate for non-domestic domestic buildings was issued by June 2017.

It has been argued that the construction sector in Ireland needs a more innovative approach to reduce the level of carbon emission and to avoid paying fines for not meeting the carbon reduction target (McAuley et al., 2012). McAuley et al. (2012) further argued that the implementation of BIM in the Irish building sector would enable the AEC sector to meet the Energy Performance of Buildings Directive (EPBD). They explained that the EPBD would ensure that Ireland meets strict EU regulations set by the European Parliament since 19th May 2010 and avoid paying fines that could prove detrimental to the economy. Despite the declaration by the government on climate emergency as stated in section 2.1, the European portal for energy efficiency in buildings revealed that meeting the NZEB goal is still far away (Build Up, 2019). Some of the reasons given are issues of different definitions of the zero metrics, and different energy consumption and production boundaries, direct comparison between the schemes is quite problematic (Build Up, 2019).

However, the AEC sector to disclose their sustainability practices in Ireland had the first construction site to be registered with the Constructors Considerate Scheme (CCS) in 2017 (Irish Building, 2017). Disclosing their sustainability practice enables companies to communicate their performance, develop a reputation for responsible

behaviour and gain a competitive advantage (Glass, 2012). The CCS is an independent non-profit organisation, which was set-up in 1997 in the UK to raise standards and improve the image of the construction industry (Considerate Constructors Scheme, 2018). Construction firms and suppliers voluntarily register their sites with the scheme and agree to abide by the code of considerate practise, which is designed to encourage best practice beyond statutory requirements (Considerate Constructors Scheme, 2018). The code of considerate practice is divided into five parts that are used for the assessment of firms. These are: care about appearance, respect to the community, secure everyone's safety, and value their workforce (Considerate Constructors Scheme, 2018). By 2017 the scheme has registered over one hundred thousand (100,000) sites in the UK and Ireland (Considerate Constructors Scheme, 2018; Irish Building, 2017). However, Watts et al. (2020) observed that there is a different level of understanding amongst teams with regards to the benefits of CCS. Despite the different level of understanding some benefits such as improved company image and improved perception about the project by the community were experienced (Glass & Simmonds, 2007; Murray et al., 2011; Watts et al., 2020). Therefore, to improve the implementation of CCS, there is the need to establish a communication protocol with the community (Glass & Simmonds, 2007; Murray et al., 2011). Also, there is the need to plan and align the client, contractor and workforce objectives by engaging all members of the project team (Glass & Simmonds, 2007; Murray et al., 2011).

The procurement mechanism is an innovative way of improving the performance of buildings and promoting sustainable construction practice (Environmental Protection Agency, 2014). However, some barriers have been identified in the implementation of sustainable procurement by the Irish, Environmental Protection Agency

(Environmental Protection Agency, 2014). The barriers observed are the perception that GPP costs more, annual budget constraints, lack of support for GPP from senior management, the risk of legal challenges, the complexity of verification, the effect of central procurement frameworks, and lack of resources (Environmental Protection Agency, 2014). They suggested that for effective implementation of GPP, the policy should be clear in terms of the scope of procurement activities covered and how compliance will be monitored, and outcomes reported. In addition, Staff should be given adequate time to consider the impact of the changes and identify any specific steps which need to be taken on their part. Where possible, GPP criteria should be discussed with existing and potential suppliers in advance of their use in tenders, as part of a pre-procurement consultation exercise or technical dialogue (Environmental Protection Agency, 2014). Therefore, how construction firms implement and develop their sustainability policies, engage their staff and supply chains in driving sustainable procurement, will need to be further explored. This study explores how construction-contracting firms utilise their organisational resources (staff, supply chains, and digital technologies) in driving and implementing sustainable procurement.

Sections 2.1 to 2.3 provide a general background and understanding of sustainable development and the AEC sector in the Republic of Ireland. Subsequent sections will focus closely on reviewing literature that will help to address the research question.

2.4 Sustainable Construction Practice and Adoption in the AEC sector

Given these overarching sustainability goals (TBL) as discussed in sections 2.1 to 2.3, there will be pressure on the built environment to drive the implementation of the TBL. The World Economic Forum reported that the construction sector is the largest global consumer of raw materials, and its constructed objects accounting for about 25-40% of the world's total carbon emissions (World Economic Forum, 2016a). Embedding

and implementing sustainable construction practice is one way the construction sector can effectively improve their performance by reducing the negative effects of their products and activities on the environment. Hill and Bowen (1997) defined sustainable construction as a process of managing the serviceability of a building throughout the life cycle of the building. Alternatively, Kibert (2007) defined sustainable construction as a process where the construction industry together with its product 'built environment', among many sectors of the economy and human activity, can contribute to the sustainability of the earth including its human and non-human inhabitants. It is expected that a sustainable construction product will have to promote in a long-term perspective its economic value, a neutral environmental impact, human satisfaction and social equity (Berardi, 2013). Sustainable construction can be seen to address the main ethical dilemma posed by sustainable development, namely the obligations of the world's contemporary population to a future generation (Kibert, 2007). Given the various definitions and explanations of the term sustainable construction, this research adopts the definition by Kibert (2007) that defines sustainable construction as a process where the construction industry together with its product among many sectors of the economy and human activity, can contribute to the sustainability of the earth including its human and non-human inhabitants.

The British Standard 8903:2010 outlines some of the key issues that need to be addressed when planning for sustainable construction (British Standard Institution (BSI), 2010). Table 3 shows the various issues that organisations need to focus on planning and implementing sustainable construction. Therefore, this study aim to develop a sustainable procurement framework that will enhance sustainable procurement practice in the Irish construction sector.

Table 3: Key Issues on Sustainable Construction Source:(British Standard

Institution (BSI), 2010)

Environmental issues	Social issues	Economic issues
<ul style="list-style-type: none"> • Emissions to air (e.g. greenhouse gases, such as carbon dioxide, and other pollutants). • Releases to water (e.g. chemical pollution of waterways). • Releases to land (e.g. chemical fertilizers). • Use of raw materials and natural resources (e.g. sustainable forestry, biodiversity). • Use of energy (e.g. energy efficiency, renewables). • Energy emitted (e.g. heat, radiation, vibration, noise). • Waste and by-products (e.g. recycling and waste prevention). 	<ul style="list-style-type: none"> • Encouraging a diverse base of suppliers (e.g. minority or under-represented suppliers). • Promoting fair employment practices (e.g. fair wages, workforce equality, diversity, avoidance of bonded labour). • Promoting workforce welfare (e.g. health and safety, trade union membership). • Enabling training opportunities and skills development (e.g. apprenticeships). • Community benefits (e.g. supporting community groups, volunteering). • Fairtrade and ethical sourcing practices (e.g. fair pricing policies). 	<ul style="list-style-type: none"> • Job creation (e.g. green technologies, creating markets for recycled products, back to work schemes). • Understanding whole life costs to achieve value for money. • Supporting small and medium enterprises (SMEs) (e.g. facilitating opportunities for small businesses). • Reducing entry barriers (e.g. facilitating open competition). • Ensuring operating business remains a viable operation able to provide employment. • Ensuring suppliers' agreements are at fair and viable margins. • Ensuring business continuity (e.g. supply chain resilience)

In driving sustainable construction practice, Robichaud and Anantatmula (2010) revealed that both the private and public clients in the AEC sector and building users are becoming aware of the benefits of sustainable construction. Some of the benefits highlighted by the authors are the reduction in the environment's impact on greenhouse gas emissions and natural resource consumption, reduction in higher energy prices; reduce costs of building materials and regulatory incentives. Similarly, the Kyoto Protocol 2008 report, discloses that there is a potential in reducing the energy consumption of the products of the construction sector without significantly increasing investment costs. They suggested that such energy savings can be achieved through a range of measures including smart design, improved insulation, low-energy appliances, high-efficiency ventilation and heating/cooling systems (Cheng et al., 2008). Adopting these mechanisms as suggested by Cheng et al. (2008) has been observed to have a significant impact on occupant comfort, health and wellbeing which in turn influences their productivity (Mulville et al., 2016).

In terms of the factors influencing investment decisions in the adoption of sustainability practice in the AEC sector as shown in figure 8, Ofek et al. (2018) found that the requirements of building standards and improving professional image are the main factors that affect Architects' willingness to design Environmental Friendly Buildings (EFBs). While energy prices increase and striving for innovation are the main forces behind developers' decisions to promote sustainable construction. Likewise, potential energy and maintenance savings and real estate values increase are the main factors influencing consumers' decisions to opt for EFBs, as opposed to a conventional one. The authors further noted that consumers' familiarity with the sustainable building concept increases their willingness to pay 30% more for EFBs (Ofek et al., 2018).

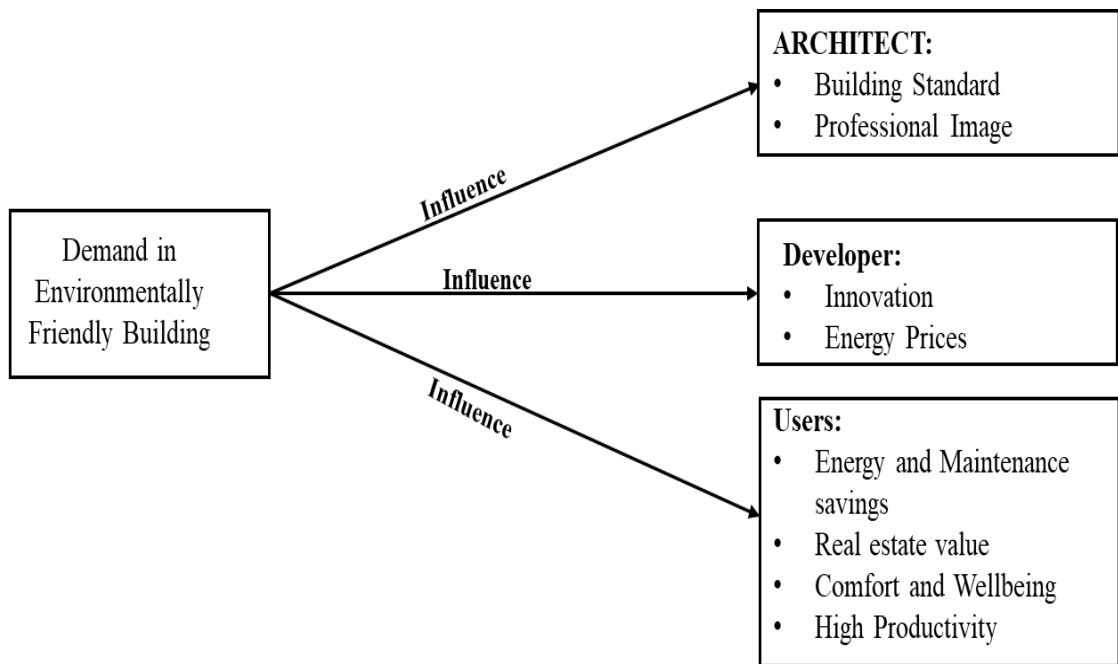


Figure 8: Factors influencing Demand in EFB Adapted from (Mulville et al., 2016; Ofek et al., 2018; Robichaud & Anantatmula, 2010).

Examining the experiences of construction professionals in the adoption of sustainable construction, Hwang and Tan (2012) in a survey of the AEC sector in Singapore observed that the project cost is seen as a major barrier. However, government intervention through providing incentives can deal with cost-related items in sustainable projects. Similarly, Oladapo et al. (2014), in a survey of practitioners in the UK AEC sector, revealed that some benefits in adopting sustainable construction were realised. Benefits such as improved corporate image and sustainable competitive advantage, improved process flow and productivity, improvement in environmental quality and increased compliance with customer's expectations were realised. The Sustainable Construction and Innovation through procurement network (Sci-Network) suggested that innovative thinking could help the construction sector in meeting the pressure and demand of their clients and regulatory bodies. They suggested that

innovative thinking through improve quality and environmental performance, reduction in the cost of construction, and speed up construction process are some of the vital areas (Sci-Network, 2011).

2.4.1 Implementing Sustainable Construction

There have been several academic pieces of research undertaken to report the level of implementation of sustainable construction practice globally. Darko and Chan (2016), in a systematic literature review, observed that there had been an increase in the number of academic research between 1990-2015. Such an increase in the number of researches suggests the importance attached to sustainable construction by the construction industry. Darko and Chan (2016), further revealed that construction sustainability practices in the US, Hong Kong, Singapore, the UK, Italy and Australia are mostly reported in the developed countries. While from the developing countries, practices from China, Egypt and Colombia are also making a good effort. However, sustainability practice and implementation might differ between developed and developing countries (Du Plessis, 2002). This differences as argued by Du Plessis (2002) is due to the reason that development priorities, the capacity of the local industry and governments, as well as the skills levels, are often radically different. Furthermore, there are also certain cultural and worldview differences between the developed and developing world countries that have an impact on the understanding and implementation of sustainable development and construction (Du Plessis, 2002).

Also, it has been noted that there is still a lack of a comprehensive structure and a supply chain perspective in the implementation of sustainability practice in most business organisations (Brockhaus et al., 2013). This lack of a structure is one of the main reasons why sincere attempts to implement sustainability often result in simple solutions that deliver insignificantly improved sustainability performance (Brockhaus

et al., 2013). Therefore, top management of construction firms needs to develop strategies that could enable them to communicate their sustainability plans. This is necessary because It will be illogical if a firm's adoption of sustainability practices at the corporate level is not entirely infused into the entire organisation and its process (Schulz & Flanigan, 2016). One way of developing such strategies is through organisational learning. Opoku and Fortune (2011) suggested that organisational learning through post-project review and post-occupancy evaluation by construction firms should embrace sustainability. This is because project-review and post-occupancy evaluation focus more on technical issues. Likewise, Anbari et al. (2008), argued that post-project reviews are a vehicle for continual learning and improvement in organisations. They further explained that learning from completed projects encourages team members to participate in post-project reviews in a meaningful way and helps develop a learning culture in the organisation (Anbari et al., 2008).

Irrespective of construction firms level of sustainability Myers (2005) suggested that construction firms should have the capacity and knowledge to educate their clients and investors. Such education should be between those who approach sustainability as a public relations (PR) exercise, and those who are genuinely committed to delivering sustainable products (Myers, 2005). As it was explained in section 2.2 that the construction sector is the largest global consumer of raw materials, and contributes negatively to the total carbon emission (World Economic Forum, 2016a). In addressing such challenges, Kibert (2007) suggested that construction organisations need to be knowledgeable about the activities carried out in the physical boundaries that they operate. The activities as shown in figure 9 include the extraction of materials, the manufacturing of products, the assembly of products into buildings, the maintenance and replacement of systems, and the ultimate disposition of waste,

building systems, and ultimately the building structure. Other factors include the energy and water consumed during all phases of the product and building life cycles, the impacts of the manufacturing, construction, operation, and disposal phases on the human and natural environment. Considering these factors, according to Kibert (2007) helps in evaluating the level of success or efforts made in attempting to implement sustainable construction. He further suggested that in terms of implementing sustainable construction, there is a need for the construction sector to pay attention to the understanding of relevant public policies related to sustainability. Also understanding the role of the various actors, the role of institutions of higher learning and construction companies in educating, training, and employing the various actors that will be involved in a project is important (Kibert, 2007). Understanding such roles is important, because driving sustainability practice requires a collective approach through a change of culture that will view sustainability as a norm rather than an exception (Fellows, 2006).



Figure 9: Physical Boundaries in the Built Environment- Adapted from (Kibert, 2007)

In driving sustainability practice in an organisation, Meehan and Bryde (2011) identified the drivers of sustainable construction as either internal or external. They argued that emphasis on internal drivers is what is likely to promote effective, sustainable construction practice. Focusing on the internal drivers as argued earlier by Kibert (2007) will help an organisation in evaluating the level of success or efforts made in attempting to implement sustainable construction. Furthermore, Meehan and Bryde (2011) noted that previous studies have shown that sustainability in an organisation is more of a policy-resistant dynamical system. Policy-resistant is the tendency for an intervention within a system to be defeated by the response of the system to the intervention itself (Sterman, 2002). Therefore, to address such resistant to the adoption of sustainable development in a construction organisation, strategic

planning is needed along with an approach that considers the triggers of sustainable development, which will act as a catalyst in converting pressures into practices (Meehan & Bryde, 2011).

In summary, this section provides an appraisal of some of the benefits to be gained in adopting sustainable construction practice. From the review, it can be argued that sustainable construction practice is gaining prominence in the AEC sector (Darko & Chan, 2016). In addition, sustainable construction adoption provides an opportunity for innovation and better collaboration amongst the various actors in the industry (Kibert, 2007; Meehan & Bryde, 2011; Schulz & Flanigan, 2016). To build upon this appraisal of the benefits and increasing prominence of sustainability development, the next section explores actual implementation across the AEC sector.

2.4.2 Level of Adoption and Practice of Sustainable Construction

This section reviews the level of adoption and practice of sustainable construction. It is important to understand the adoption of sustainability from a different perspective. This is because sustainability practice requires a change of behaviour and organisational practices (Elkington, 1997; Fellows, 2006). Therefore, this section reviews the adoption of sustainable construction practice from the organisational, stakeholders' and the size of the firm perspective. Also, the impact of government policies and laws is reviewed.

2.4.2.1 Organisational practice perspective

The AEC sector, like any other economic sectors, has made commitments to improving the way they operate by adopting sustainable construction practices. Some of the reasons driving the adoption of sustainability are as a result of pressure and demand from construction clients, and mandatory laws and policies from regulatory

agencies (Yusof et al., 2016). Despite all efforts and commitments, the level of implementation of sustainability practice in the AEC sector is still low (Russell et al., 2018). It is worth noting that the mainstreaming of sustainability in the AEC varies according to the dominant organisational culture and history of each firm (Boyd & Schweber, 2012). Boyd and Schweber (2012), further argue that some see sustainability as a culture (what they do every day) while others see sustainability as a business opportunity (profit), and others see it as a risk. Understanding these attributes is key in addressing sustainable construction requirements in an organisation (Akotia et al., 2017; Meehan & Bryde, 2011)

With regards to the level of understanding of practitioners as it relates to sustainable construction practice, it was revealed that there appears to be general agreement amongst practitioners in the AEC sector (Adetunji et al., 2003; Higham et al., 2016; Opoku & Ahmed, 2013). Most of the practitioners agree that sustainability encompasses environmental, social and economic issues, but the environmental dimension dominating their understanding. Understanding just one aspect (environmental) of sustainability can be likely linked to the low level of implementation in the AEC sector. Similarly, Akotia et al. (2016) in a study to explore the knowledge base of practitioners in the delivery of regeneration projects in the UK found a disparity between the theoretical concept and reality in the practice of sustainability factors as shown in figure 10. Their results show that better understanding and attention is given to the environmental factors with the socio-economic factors having little or no attention.

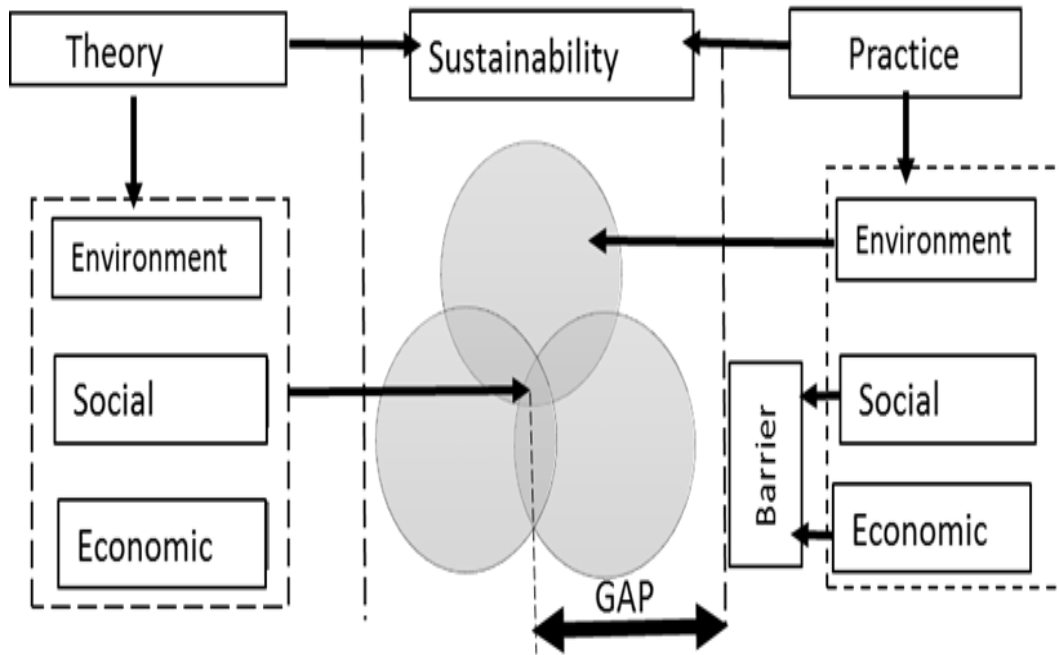


Figure 10: Current level of Sustainable Construction (Akotia et al., 2016)

Figure 10 shows the difference between the theoretical understanding of sustainable construction and what is observed in practice (Akotia et al., 2016). A better understanding of the environmental aspect amongst the various respondents is argued to be as a result of the traditional environmental policies and laws (e.g. waste reduction, energy efficiency and carbon emission reduction) (Adetunji et al., 2003; Ashby et al., 2012). These laws have been in the forefront and have been supported by legislation and numerous industry and government commitments (Adetunji et al., 2003; Ashby et al., 2012). In a critical review of related literature on sustainability and green buildings, Zuo and Zhao (2014) observed that the environmental aspect dominates most of the research on sustainability. On the other hand, Chang et al. (2016) in a case study through analysing the organisational policies and sustainability report statements of three top Chinese construction-contracting firms, observed that the firms are more committed to promoting the social and economic sustainability practices compared to the environmental aspect of sustainability (Chang, Zuo, et al.,

2016). Although the findings by Chang et al. (2016) shows firms willingness to promoting the social and economic aspect of sustainability, it, however, does not reports the firms' performance in terms of meeting the TBL as illustrated by Akotia et al. (2016). Therefore, there is a need to explore further to close the gap by creating an understanding of what firms report in their sustainability report or their policies and what is actually implemented by the firm. This is necessary as it was discussed in section 2.2.1 that the AEC sector needs to demonstrate to their clients' genuine commitment in the adoption of sustainable construction practice rather than mere public relation (Myers, 2005).

Furthermore, Mulligan et al. (2014) examined how public policy, construction actors, and growth of sustainable construction are linked in driving sustainable construction practices in the USA. There study observed that despite the reported benefit of sustainable buildings, barriers to the adoption of sustainability still exists (Mulligan et al., 2014). Some of the barriers observed are the high cost of building, lack of interest by property developers, type of buildings, and poor level of awareness of green policy (Mulligan et al., 2014). However, in an earlier report, Kats (2003) opines that the increase in the cost of green buildings has little to do with the cost of materials and components. Kats (2003) argued that the cost is a result of additional time spent on planning, design and construction.

Similarly, Hoffman and Henn (2008) alleged that challenges faced in sustainable buildings construction are less of technological and economic problems but rather social and psychological. They suggest that addressing the social and psychological barriers, which can influence changes in social structures, rewards, and incentives, is what can promote sustainable buildings construction. Furthermore, in exploring the early-stage evaluation of socio-economic benefits in housing regeneration projects,

Akotia and Fortune (2012) observed that the lack of a mechanism to evaluate the socio-economic benefits of sustainability at the early stage of a project development forms part of the barriers in the promotion of sustainability. This lack of mechanism as observed by the authors is as a result of the low level of understanding in what sustainability means to the practitioners at both personal and organisational level (Akotia & Fortune, 2012). However, the work of Akotia and Fortune (2012) focuses on housing regeneration projects, which could likely make generalisation on other types of projects difficult. Therefore, how the factors identified by Hoffman and Henn (2008) are addressed in a construction firm from the organisational to project delivery need to be further explored.

2.4.2.2 Adoption from the Stakeholders Perspective

The successful implementation of sustainability goal requires the understanding and engagement of stakeholders at the various level and phases of the project (Carter & Fortune, 2003; Klewitz & Hansen, 2014). Project Stakeholders are groups or individuals who have a stake in, or expectation of, the project's performance and include clients, project managers, designers, subcontractors, suppliers, funding bodies, users and the community at large (Newcombe, 2003). These group of stakeholders can further be grouped as either internal or external (Chinyio & Olomolaiye, 2009, pp. 3-4). Internal stakeholders consist of members of the project coalition or those who provide finance. Example of internal stakeholders are the clients, investors, and client project team members. While external stakeholders, are those affected by the project in a significant way such as the external customers, government, and the contractor's team and suppliers. The various stakeholders exert a different level of influence which could be directly or indirectly. Frooman (1999), explained that direct stakeholder influence is a situation where the stakeholder manipulates the flow of resources to the

organisation. While indirect influence is a situation where the stakeholder works with an ally who manipulates the flow of resources to the organisation. The manipulation could either be by withholding or using the resources (Frooman, 1999). Furthermore, in the construction industry Chinyio and Olomolaiye (2009), explained that stakeholders and their associated stakes will manifest the attributes of legitimacy and power. Therefore, they suggested that stakeholders must be managed in each project to avoid any of their influences that could be contrary to a firm’s objectives. They suggested a power-interest matrix template as shown in Figure 11 for mapping stakeholders. The matrix guide in understanding the power differential between a firm and its stakeholders, which enable the firm to develop strategies and tactics for dealing with each other (Chinyio & Olomolaiye, 2009; Frooman, 1999).

Power	High	Maintain these stakeholders in a happy state	Manage these stakeholders closely
	Low	Keep an eye on these stakeholders and act when prompted	Keep these stakeholders happy and informed
		Low	High
		Interest	

Figure 11: Power-Interest Matrix Source: (Chinyio & Olomolaiye, 2009).

Hence, in driving sustainability in the AEC sector, the stakeholders understanding can be developed through engagement and creating awareness (Kashyap & Parida, 2017;

Lim et al., 2015). In addition, engaging the various stakeholders at the various phases of the project enhances a change in the perception of stakeholder and addresses the sustainability agenda (Sfakianaki, 2015). Also, it creates a better understanding of users of the buildings and provides good feedback on the performance of the facility (Lim et al., 2015). Such feedback will assist in planning for future projects while achieving the goal of sustainability in the post-occupancy stage. Correspondingly, Wu et al. (2017) explained that the need for proper communication with users of sustainable buildings, putting into consideration their preferences either product or space-related, is very important to enable their objectives to be met. Nowadays, as explained in section 2.3 that the AEC sector have been observed to have registered their project sites with the Considerate Constructors Scheme (Considerate Constructors Scheme, 2018). This action has been observed to yield a positive outcome to both construction firms and their neighbouring community (Glass & Simmonds, 2007; Murray et al., 2011; Watts et al., 2020). However, how the external stakeholders' are engaged during the procurement of a sustainable project is not well understood.

2.4.2.3. Adoption based on Geographical location perspective

Examining the level of response and adoption of sustainable construction amongst the European Union (EU) member states, Van der Heijden and van Bueren (2013) revealed that sustainability attainment in the construction sector varies amongst the various EU states. They argued that local climate, culture, and institutions influence sustainability adoption. But, they suggested that regulatory homogeneity could only help in smoothening the path towards higher sustainability, but it is likely to raise some barriers as well (Van der Heijden & van Bueren, 2013). In the same way, Montalbán-Domingo (2018) in examining how social criteria are inserted into public

procurement of construction projects, examined 451 tender documents from 10 different countries. Their results showed that there is a significant difference between the English and Spanish speaking countries in the way social criteria in sustainability is embedded in the tendering documents. This differences in practice, as noted in section 2.2.1 as argued by Du Plessis (2002), noted different factors influencing the adoption of sustainability between different countries and regions. Such factors as different development priorities, the capacity of local industry and governments, as well as the skills levels which are often radically different (Du Plessis, 2002). Therefore, in the implementation of sustainability, different countries or region have different practices, and the policies are tailored towards the need and peculiarity of their society. Efforts made by the Republic of Ireland was earlier discussed in section 2.3. Furthermore, the next section discusses the impact of government policies and laws in different regions and countries.

2.4.2.4 Impact of government policies, regulations, and laws

Different government and non-governmental agencies in driving sustainability practices have developed different mechanism and tools for assessing the sustainability performance of buildings (Darko & Chan, 2016; Doan et al., 2017; Lu & Zhang, 2016; WGBC, 2017).

For example, the Office of Public Works (OPW) (OPW 2018), identified five key sustainability priorities. These are:

- i. Reducing energy consumption and greenhouse gas emission
- ii. Avoiding the generation of waste through life cycle thinking, reuse and recycling
- iii. Green procurement

- iv. Improving health and well-being; and
- v. Raising awareness of sustainability issues.

In implementing their five sustainability priorities, the government, through the Department of Public Expenditure and Reform in 2019, issued a press release that will require government agencies and public bodies to have a climate mandate (Government of Ireland, 2019b). A key element of such a mandate was using public procurement mechanisms in the supply and delivery of services to the public sector. The statement instructs public agencies and departments to consider green criteria in their procurement guidelines and activities (Government of Ireland, 2019b).

Furthermore, the government, through the Sustainable Energy Authority of Ireland (SEAI), provided some incentives in developing residential buildings (Irish Green Building Council (IGBC), 2018). The incentives are through grants on schemes like Better Energy Homes, Better Energy Communities and SEAI's Deep Retrofit programme. Also, householders and private organisations who invest in energy efficiency may be eligible for tax rebates under the schemes such as the Home Renovation Incentive (HRI) and the Accelerated Capital Allowances for Energy Efficient Equipment (ACA) (Irish Green Building Council (IGBC), 2018).

In addition, as explained earlier and shown in Table 3 (page 39) on the key issues of sustainable construction, different governmental agencies and bodies promoting the social aspect of sustainability have developed laws and regulations to guide businesses. For example, governments in different countries have passed the anti-corruption and bribery act into law. In the Republic of Ireland, the criminal justice (corruption offences) act 2018 is the key legislation governing bribery and corruption in Ireland (OECD, 2019). As explained by the department of Justice, the act came into law in July 2018. The 2018 act has extra-territorial reach where organisations or

individuals shall be held liable and prosecuted for an offence committed within or outside the state (OECD, 2019). Similar laws have been passed in other countries like the United Kingdom; the bribery act 2010 came into law on the 1st of July 2011 (Ministry of Justice, 2010). The penalties for committing a crime under the act are a maximum of 10 years imprisonment, along with an unlimited fine. Also, in Australia, the government in 1999 ratified the Organisation for Economic Co-operation and Development (OECD) convention on combating bribery of foreign public officials in international business transactions (Global Legal Insights, 2021). The law states that the maximum penalty for an individual convicted is ten years imprisonment, a fine of AU\$ 2.2 million, or both. It further stated that a corporation could be fined the greatest of AU\$22.2 million, three times the value of any benefit obtained directly or indirectly that can be reasonably attributed to the bribe (Global Legal Insights, 2021).

Furthermore, the introduction of different policies, regulations, and laws have been found to drive the adoption of sustainable construction, and as noted in the previous section, this may vary significantly from region to region. For instance, Qi et al. (2010) reported that in the People Republic of China in order to reduce the negative impact of construction activities, the Chinese government introduced laws such as the environmental protection law, the cleaner production promotion law, the pollution prevention law and renewable energy law. Also, in the Malaysian AEC sector, Yusof et al. (2016) observed that organisational support, customer pressure, and regulatory pressure are some of the attributes that motivate firms to implement environmental practices. Furthermore, Bohari et al. (2016) reported that in the Malaysian construction sector, compliance with government policy and guidelines were the major drivers for the adoption of green construction while the low level of

knowledge and awareness of stakeholders were some of the barriers faced in the adoption of sustainable construction.

In addition, from the European perspective, the government of the Republic of Ireland to meet the requirements of the EU Energy Performance of Buildings Directive (EPBD) issued some directives with regards to the energy performance of buildings (Department of Communications Climate Action and Environment, 2012). These include:

- That all buildings built after 31 December 2020 must have high energy-saving standards and be powered to a large extent by renewable energy, and
- By the end of 2018 the public sector must own or rent only buildings with high energy-saving standards and promote the conversion of existing buildings to "nearly zero" standards.

Similarly, in the UK, Naoum and Egbu (2015) reported that all newly built and refurbished buildings must demonstrate compliance with "Target Carbon Emissions Rates". Also, compliance with the Building Energy Model (Part L) of the Building Regulations 2006 is a requirement (Naoum & Egbu, 2016). As it was mentioned in section 2.1, a climate emergency was declared by the government of the Republic of Ireland in 2019. The plan is expected to help in creating a resilient, vibrant, and sustainable country (Government of Ireland, 2019a). On the other hand, Coulson (2014), noted that there is a strong law guiding the procurement of timber and wood-derived products in the UK. It is now mandatory in Europe and some other parts of the world for timber products to be certified by the Forest Stewardship Council (FSC) (FSC, 2020). This certification ensured a chain of custody of each timber products is established.

Despite all the policies and regulations in place as noted above, the level of adoption of sustainability practices in the AEC sector remains challenging (Rietbergen et al., 2015; Russell et al., 2018; Upstill-Goddard et al., 2015). Although it is indicative that there has been a positive impact on the adoption of sustainable construction in China and Malaysia due to compliance with government laws and regulations. However, it is noted that implementing the appropriate regulations globally is challenging (Meacham, 2016). Also, the effectiveness of the current regulations in most of the European states and their impact in driving sustainability is found to be inadequate (Rosenow et al., 2016; Visscher et al., 2016). These inadequacies could be likely because of the gap in understanding building performance and the behavior of the occupants (Karatas et al., 2016; Visscher et al., 2016). Also, the behavior and attitude of practitioners and the enforcement of building codes are the likely challenges (Shapiro, 2016). How construction firms address government laws, policies, and regulations in their procurement process needs to be further understood. This is because implementing an effective sustainable construction practice requires a holistic approach (Fellows, 2006). Implementation of sustainability in the AEC sector varies according the various geographical location. Similarly, the adoption and practice of sustainability varies according to the size of the firm. The next section explores further on the adoption of sustainability based on the size of the firm.

2.4.2.5 Adoption from the Size of firm Perspective

Another important factor that drives the adoption of sustainability in the AEC sector is the size of the firm. Examining the relationship between the size of a firm (considering their annual financial turnover) and its sustainability performance, Adetunji et al. (2003), in a study of some top construction-contracting firms in the UK, reported that differences occur in terms of their level of response to sustainable

construction. Similarly, studies by Boyd and Schweber (2012) and Chang et al. (2016) also indicates that a firm's financial turnover is a likely driver for implementing sustainability practices in their various organisation. Likewise, in a related study, Upstill-Goddard et al. (2016) reported that small and medium-sized construction firms are always very reactive in adopting sustainability. They argued that SME's tend to approach standards if only they see immediate financial benefits stemming from their implementation (Upstill-Goddard et al., 2016). Therefore, strong communication channels and commitment to training programmes is required to increase the capacity for implementation (Upstill-Goddard et al., 2016). Reporting the progress made in the UK, Berry and McCarthy (2011), reported that most top contracting firms are now driving the adoption of sustainable construction by:

1. Setting their standards as part of their value proposition;
2. Educating and challenging their clients, and main suppliers to win long-term competitive advantage;
3. Working closely with their main suppliers to promote sustainability throughout the supply chains and deliver new sustainable solutions;
4. Trying to provide the widest possible sustainability benefits when undertaking construction projects.

Similarly, Zuo et al. (2012), examining top global construction companies in China revealed that sustainability policy development and practice varies amongst the companies. Furthermore, they explained that energy efficiency and conservation, greenhouse, gas emission reduction and integration of renewable energy resources into projects are among the common themes in their sustainability policies. (Zuo et al., 2012). Environmental factors, as highlighted earlier, are more developed across the AEC sector. The development of the environmental factors by a firm, as argued in

section 2.12 has an impact on the economic and social factors (To et al., 2015). In addition, Chang et al. (2017) argued that sustainability attitude is positively correlated with performance. Also, larger firms tend to have a better attitude and sustainability performance compared to smaller firms (Chang et al., 2017). While Zhang and Zhou (2016) argued that there is a positive correlation between carbon reduction regulations and carbon reduction awareness and behaviour. Their study suggests that improving carbon reduction awareness is a possible way to encourage contractors' carbon reduction behaviour. Rickaby and Glass (2017) using value theory argued that individuals' values are critical to the success of sustainability goals in a project or an organisation. They suggested that aligning organisational values with personal values is strongly associated with project success. On the other hand, Terouhid and Ries (2016) argued that workforce management and knowledge management are the key components to people capability, which plays a vital role in the attainment of the sustainability performance of construction firms.

It is important to note that lessons from the manufacturing and automobile sector in the adoption of sustainability could be beneficial to the AEC sector (Brockhaus et al., 2013; Cox, 2001; Kenichi & Russell, 1994). Lessons such as how the buying firms relate to their supply chains or suppliers in driving sustainability could be beneficial. Eiadat et al. (2008) using the Porter hypothesis in the chemical industry in Jordan, observed that environmental innovation strategy is associated with the business performance of the firm. In the innovative driving strategy in the AEC sector, Opoku et al. (2015), argued that organisational leadership and managerial capability is required. Leadership capabilities, as argued by Opoku et al. (2015), influence the implementation of sustainability practices by providing training and awareness on sustainable construction matters. In addition, such leadership provides sustainable

construction guidance notes and policies. Similarly, Eilers et al. (2016) in studying the sustainability practice in the AEC sector in the Mid-West region of the USA revealed that a positive impact is experienced through employee satisfaction. Furthermore, project opportunities and the market advantage is also experienced in firms that embrace corporate sustainability culture in their business practices (Eilers et al., 2016).

Nevertheless, there are no clear pieces of evidence or reports to show how construction firms relate their sustainability agenda with their supply chains and other stakeholders at the various phases of a construction project. This gap needs to be close by exploring how construction-contracting firms engage their workers and supply chains in promoting sustainable construction practice.

In summary, Table 4 presents the factors that drive the adoption of sustainable construction across the AEC sector. These factors are developed out of the literature review carried. The factors are demography, size of the firm, law and regulations, organisational policies, leadership and workers engagement, stakeholder's and user's engagement. From the review, it can be argued that most of the discussions on the adoption and implementation of sustainable construction practice are mostly descriptive lacking in empirical evidence. Empirical evidence is required to enable an in-depth understanding of how construction firms adopt and implement sustainable construction. In addition, there is the need to investigate how the uniqueness of a construction project influences sustainable practice and behaviour of the various actors. This is necessary because innovations like the adoption of sustainability in an organisation are better observed and understood at the project level due to the complex nature of projects that are shaped by a network of different project actors (Ageron et al., 2012; Papadonikolaki, 2018). In addition, Montalbán-Domingo et al. (2018) opine

that the size and cost of the project are likely to drive the adoption of more sustainability criteria. This is because projects with higher complexity tend to have higher cost or schedule overruns (Hamza & Greenwood, 2007; Mirza & Ehsan, 2017; Montalbán-Domingo et al.).

Table 4: Factors driving the implementation of sustainable construction TBL in the AEC sector

S/N	FACTORS	AUTHORS	COUNTRY
1	Demography	Van der Heijden and van Bueren (2013), Montalbán-Domingo (2018)	EU, Anglo-Saxon and Spanish speaking countries
2	Size of firm	Adetunji et al. (2003) Boyd and Schweber, (2012), Chang et al., (2016b), Chang et al. (2017), Upstill-Goddard et al. (2016)	UK, China
3	Laws and Regulations	Qi et al. (2010), Coulson (2014), Naoum & Egbu (2015), Bohari et al. (2016), Yusof et al. (2016)	China, UK, Malaysia
4	Organisational Policies	Zuo et al. (2012)	China
5	Leadership and Workers Engagement	Opoku et al. (2015), Qi et al. (2010), Meehan and Bryde (2011), Eilers et al. (2016), Terouhid and Ries (2016), Kannan (2021)	UK, USA, Denmark
6	Stakeholder's and User's engagement	Opoku et al. (2015), Sfakianaki (2015), Wu et al. (2017), Yusof et al. (2016)	UK, Greece, China, Malaysia

As earlier stated, adopting to the sustainability agenda has been quite slow and challenging in the AEC sector. Recognising and addressing the various sustainability

criteria at the planning phase of a project is critical in meeting the sustainability objectives. Also, as more firms develop sustainability strategies, the opportunity to develop a competitive advantage becomes more critical (Schulz & Flanigan, 2016). It has been demonstrated that both public and private enterprises have used their procurement mechanism and processes in driving their sustainability agenda (Bratt et al., 2013; Perera et al., 2007). The next section of this work reviews sustainable procurement and its importance in driving sustainable construction.

2.5 Construction Supply Chain Management

In the delivery of a construction project, the main contracting firms assemble different teams with different expertise. This enables them to collaborate in order to realise the vision of the construction client. Managing the various teams by the main contracting firm is popularly referred to as supply chain management. This section sets the background and debates around supply chain management in the AEC sector and how it can be effectively utilised to promote sustainable procurement practice.

In the delivery of construction projects, different challenges and problems are faced, which are primarily linked to the complexity of the sector and actors involved (Ageron et al., 2012; Papadonikolaki, 2018). These challenges and problems encountered in a construction project are principally linked to the poor management of the supply chain, which originates at the interface of different parties or functions (Vrijhoef et al., 2001). The term supply chain refers to the stages through which construction materials specifically proceed before having to become a permanent part of the building or another facility (Vrijhoef et al., 2001). The objective of SCM is to create the most value, not solely for any one company, but the whole supply chain network (Akintoye et al., 2000; Tennant & Fernie, 2014). Similarly, Kim et al. (2016) explained that the goal of SCM is to reduce the cost incurred within the supply chain. They noted that

the benefit of undertaking SCM could be appreciated when there is collaboration within and beyond the capacities of individual organisations.

Nevertheless, Kim et al. (2016) observed that due to the complexities of the construction supply chain, it is always very difficult to identify the chain that contributes to or reduces the cost of construction. Such difficulties arise as a result of the multiple entities involved in the supply chains process such as from engineering to fabrication and installation of an element or component in a building structure (Kim et al., 2016). Also, Vrijhoef and Koskela (2000) observed that construction supply chain management is explicitly related to the general SCM methodology as found in the manufacturing or automobile sector. The SCM process in the manufacturing sector has information and material flow to all the processes in delivering a product to the users. Furthermore, SCM views the entire supply chain, rather than just the next part or level, and aim to increase transparency and alignment of the supply chain's coordination and configuration, regardless of functional or corporate boundaries (Vrijhoef & Koskela, 2000).

However, it has been found that the adoption of supply chain management in the AEC sector is slow, patchy, and inconclusive (Fernie and Tennant, 2013). These challenges have been attributed to the fact of drawing or by making comparisons of the construction supply chain management with that of the manufacturing sector (Tennant & Fernie, 2014). In addition, such a comparison with a complex and project-driven industrial environment such as construction is unhelpful. As an alternative, supply chain management in the AEC sector needs to be studied and better understood from a fresh perspective, which should be rooted in an economic organisation (Tennant & Fernie, 2014).

Observing the collaborative nature of members of the supply chain in the South African AEC sector, Emuze and Smallwood (2014) found out that short-term objectives and price-oriented approach are prevalent in the industry. Other factors are poor problem-solving mechanisms exist between project partners, poor use of modularisation, significant numbers of irregular clients and rigid adherence to contents of contract data. Construction clients are the key drivers of performance improvement and innovation and are the most significant factor in achieving integration in the supply chain (Briscoe et al., 2004). It is quite clear that the construction client has an influence on the activities of the supply chains, but London (2008) notes that close attention should be paid in managing the main contractor. This is because of their influence which can easily abrogate their roles through passing the risks to either the client or the sub-contractors. Also, the main contractor exerts more influence during the project procurement process.

Therefore, how do the main contractors influence their supply chains in embedding sustainability? In addition to an effective, sustainable procurement process, the entire supply chain actors must embed sustainability practices in their organisational processes. This is because a business is said to be sustainable when it is able, together with their various supply chains to meet the “triple bottom line” target (Jeurissen, 2000). To further understand the implementation and adoption of sustainable procurement in the supply chain of a construction organisation, the next section reviews sustainable supply chain management.

2.5.1 Sustainable Supply Chain Management

Introducing sustainable development practice in the supply chain is a way of improving performance and influencing the competitiveness of a company and that of its supply chain organisations (Chardine-Baumann & Botta-Genoulaz, 2014; Pagell & Wu, 2009). Another reason argued for introducing sustainable development in the supply chain is as a result of pressure from clients, stricter environmental laws and regulations, and increased competition (Kumar & Rahman, 2016; Ruparathna & Hewage, 2015a). Sustainable supply chain management (SSCM) is defined as:

“the management of material, information and capital flow as well as cooperation among companies along the supply chain while paying close attention to all the three dimensions of sustainable development, i.e. economic, environmental and social, into account which is derived from customer and stakeholder requirement.”

(Seuring & Müller, 2008).

Adetunji et al. (2008) define sustainable supply chain management as the identification of the problematic economic, social and environmental issues throughout the supply chain. By assessing their potential impact and risks; and developing measures in reducing the impact and mitigating the risk.

In a supply chain relationship, buying firms take responsibility for the behaviour and products of their suppliers to their stakeholders and customers (Lin & Tseng, 2016; Sancha, Gimenez, et al., 2016; Wu & Barnes, 2016). It is expected that in sustainable supply chain management, that all members of the supply chain take into consideration the social, economic and environmental aspect of sustainability in their organisational and production process. For instance, the Economist (2018) magazine reported that many goods enjoyed in rich countries might have murky origins because most of the

countries where production is taking place are engaged in one form of modern and child slavery. Adetunji et al. (2008) argue that a well crafted SSCM has the potential of creating value to construction firms, and they suggested that for construction firms to deliver successful sustainable projects, there is the need for them to embrace the SSCM practice fully. Embracing the SSCM, as observed in section 2.6.1 requires construction firms to develop strategies that will enable them to achieve their sustainability goals (Tan et al., 2011). Developing these strategies can lead to improvements in an organisation's capability that, in turn, creates value and results in a sustained competitive advantage (Barney, 1991). However, it is pertinent to note that the organisation's intention in developing a sustainability strategy might be at odds with retaining its competitive advantage in the pursuit of profit (Glover et al., 2014). This is because driving sustainability provides a rare opportunity to create value or profit at the short-term (Adetunji et al., 2008). In addition, sustained competitive advantage can only be sustained if the capabilities creating the advantage are supported by resources that are not easily duplicated by competitors. In another way, a firm will gain a sustained competitive advantage when they face a cost disadvantage in developing and acquiring and using a resource (Barney, 1991). These organisational resources, as earlier mentioned in section 2.7, include physical and financial assets as well as employees skills and organisational processes (Barney, 1991; Hart, 1995). How are these resources effectively managed and controlled by construction firms in driving sustainable procurement capabilities?

In ensuring that buying firms supply chain network adhered to the TBL principle, Sancha et al. (2016) revealed that assessing supplier practices contributes to improving the buying firm's social performance while collaborating with them enhances the suppliers' social performance. Kumar and Rahman (2016) found out that Buyer-

Supplier relationships through supplier selection, supplier development and supplier performance review, has a positive impact in achieving the triple bottom line objective amongst the various supply chains organisations. For active suppliers participation in addressing sustainability-oriented objectives in an organisation, there is the need to develop a very clear purchasing and supply policy (Roy et al., 2018). Implementing the policies by ensuring that all targets are met, and the buyer's compliance with the policy through trust-building, are key factors in developing suppliers' participation (policy development, policy implementation, and intent building with suppliers) (Roy et al., 2018). Developing a close relationship with the various supply chains can be done through supply chain integration. SmartSheet (2017) explained that supply chain integration could be done tightly through a merger with another firm in the supply chain or loosely through the sharing of information and working more exclusively with particular suppliers or customers. In addition, Zander et al. (2016), in undertaking a case study of the wood industry in Germany, contended that for effective delivery of sustainable products there is the need for firms to do the following:

- Developing long term and trustworthy relationship with buyers;
- Suppliers should focus on core business and avoid vertical integration;
- Long term coordination is very important;
- Government support through monetary and non-monetary incentives should be encouraged;
- Reducing information and communication barrier amongst network is very important. Furthermore, in a case study of housing development project Warren-Myers and Heywood (2018) observed that housing developers are the main actors that can drive the wide-spread adoption of sustainability innovation in the mass production

of housing among the entire supply chain. This is due to the influence as discussed in section 2.8 that the developers exert during project procurement which is a determinant to the success of a project (London, 2008). Other factors that can drive the adoption of sustainability among the various supply chain management are governance mechanisms (transactional or relational), collaborative relationships (mandated or collaborative approach), and innovations (improving performance) (Govindan et al., 2016; Lin & Tseng, 2016). It has been argued that sustainability is mostly self-driven in an organisation rather than complying to laws and regulations. Many authors have argued that sustainability in an organisation is mostly self-driven than the imposition of laws or regulations (Rietbergen et al., 2015; Russell et al., 2018; Upstill-Goddard et al., 2015). For instance, Russell et al. (2018) argued that promoting shared values aligned with transparency and monitoring will be more effective in attaining sustainability goals in the supply chain than imposing standards through legislation and regulation. In a related study, Rietbergen et al. (2015), studied the target-setting process of firms participating in the CO₂ performance ladder (CO₂PL). Their study found that within the implementation of energy management and carbon accounting schemes using CO₂PL, the adoption of the target-setting process does not necessarily lead to ambitious corporate GHG emission reduction goals. This was because different firms interpreted the certification requirements differently. Similarly, Upstill-Goddard et al. (2015) found that the performance against the life cycle assessment and resource use clauses of BES 6001 did not influence the overall sustainability performance of a firm. Therefore, in order to drive the adoption of sustainability by the supply chain, what is required is a degree of flexibility in building regulations which encourage/enable innovation by the supply chain of an organisation (Hardie et al., 2013; Hardie & Newell, 2011).

Sustainable procurement is a driver to innovation in the sustainable construction process. For instance, illustrating how innovative practices can positively impact construction processes, Bildsten (2011) explained that prefabricated components have the potential to reduce lead-times. He further stated that gaining a higher quality, decreased complexity of co-ordination, and reduced risks of production failures are some of the benefits of prefabricated components. However, earlier studies by De Melo and Da Alves (2010) observed that some of the benefits to be gained in the supply chain of prefabricated wooden doors were lost. These losses were due to lack of trust between contractors and suppliers, a lack of consideration of pre-conditions necessary for successful site installation, and a lack of standardization and tolerance management resulting in sub-optimal solutions during the installation phase. Such challenges could have been resolved if there was a close collaboration amongst the various actors in the project. As explained in section 2.7 that the closer the collaboration amongst team members the more intergrated will be the relationship (Vurro et al., 2009). Additionally, using the analytical hierarchy process methodology in a survey of construction firms, Hardie and Newell (2011), found that, industry employment rates and profitability are both positively correlated with high rates of innovation. They further reported that innovative solutions to environmental and social problems have potential benefits for the future direction of the construction industry.

On the other hand, using Hybrid Life Cycle Analysis methodology Dadhich et al. (2015) found out that collaboration along the supply chain is essential in measuring the carbon emission in the production of plasterboard. They further argued that such collaboration is necessary in order to collect the relevant data and to identify the emission hotspots and implement strategies to reduce the emission level (Dadhich et

al., 2015). Also, better synergies could be gained in embedding sustainable development practices in the AEC sector if the sector can embed innovations like BIM, lean construction and sustainability practice (Saieg et al., 2018) simultaneously. In addition, for an effective, sustainable supply chain management, Ageron et al. (2012) suggested that the following conditions influence the implementation of SSCM. These conditions are:

- i. External factors or pressures have a positive impact on the development of SSCM;
- ii. Internal factors have less impact on SSCM as compared to external factors.
- iii. Performance objectives are more appropriate for selecting suppliers in the upstream supply chain.
- iv. Sustainability strategies and action plans tend to have more positive outcomes on sustainable supply management than do performance objectives;
- v. Waste reduction efforts have a greater impact on greening supply chains than do environmental issues.
- vi. Suppliers' demographic characteristics significantly influence SSCM;
- vii. Multi-national, small and medium enterprises have a differential impact on sustainable supply management.
- viii. Active, collective and reactive decision-making approaches have a more positive impact on SSCM than make pro-active, collaborative and individual approaches.
- ix. Financial barriers have more impact on SSCM than do non-financial barriers
- x. The vision of supplier firm top management and their support is a critical success factor in SSCM.

- xii. Key benefits such as customer satisfaction, supplier innovation, quality and capacity have a greater positive impact on SSCM than do lead-time, cost, flexibility and inventory optimization

In summary, understanding the behaviour of the supply chain in the AEC sector is key to realising sustainability objectives. Due to the complexity of the supply chain network, embedding sustainability requirements remains challenging. There is a need further to understand the integration and development of the supply chain. The next two sub-sections review supply chain integration and suppliers development

2.5.2. Supply Chain Integration

Most global construction organisations are socially integrated, where the main contracting firms are dependent on their supply chains (Oyegoke et al., 2010). However, Cox and Ireland (2002) argued that a socially integrated type of relationship creates an overlap in terms of their governance structure that is made up of contracting firms, professional services, materials, equipment and labour. Such complexity is a result of the simplistic approach used in the AEC sector in viewing the supply chain structure (Cox & Ireland, 2002; London, 2008; Tennant & Fernie, 2014). The complexity of the supply chain leads to poor articulation and activation of commitments (Vrijhoef et al., 2001). These problems can be addressed with an effective procurement strategy (Love et al., 1998; Oyegoke et al., 2010). The procurement strategy can alter the firm-to-firm relationship significantly and most especially the structural organisation of the chain at the higher levels in particular (London, 2008). The inter-firm collaboration in the supply chain network in driving sustainability, as observed by Adetunji et al. (2008) has the characteristics of structural dominance and power regime. Such structural dominance exists in the client-contractor relationships and the contractor's network of supply chains. Broft (2017), argues that implementing SCM seems to be a long-term

and complex process that requires a certain level of understanding and learning throughout the supply chain. Hence, for effective management of the supply chain, there is the need to understand what effective supply chain management is and how the concept of power in business relationships is understood within the construction industry (Cox & Ireland, 2002). This is necessary because of the fragmented nature of the industry that has led to lack of trust and structural dominance amongst the various actors (Adetunji et al., 2008; Cox & Ireland, 2002).

Contrary to the various calls made by construction clients and regulatory bodies, on the need for the construction sector to be more innovative through collaborative practice with their supply chains, Cox and Ireland (2002) argued that such calls ignore the buyer and supplier power relationship. They explained that understanding the concept of power in business relationships amongst industry players would help the clients, contractors and suppliers in achieving their objectives (Cox & Ireland, 2002). In a related study, Adetunji et al. (2008) revealed that two schools of thoughts exist in the literature relating to conditions of successful implementation of SCM in the construction industry (as shown in Figure 12). The first school of thought (A) is based on operational efficiency and effectiveness by way of collaboration based on equitable relationships. While the second school of thought (B) is based on strategic efficiency and effectiveness by way of collaboration based on power relations. Adetunji et al. (2008) further explained that most construction literature falls into the first school of thought (A). The first school of thought (A) explained that fragmentation, adversarial culture, low profits margin and issues of trust in the construction industry can be managed through integration and cooperation. While the second school of thought (B) argues that there is a flaw in assuming that successful SCM based on trust and equitable relationships is achievable in all relationships. They argued that successful

SCM is achieved through collaboration based on a power regime. Furthermore, such power is exercised when the dominant player is strategically placed and creates a structural hierarchy of relatively dependent suppliers (Adetunji et al., 2008; Cox, 2007).

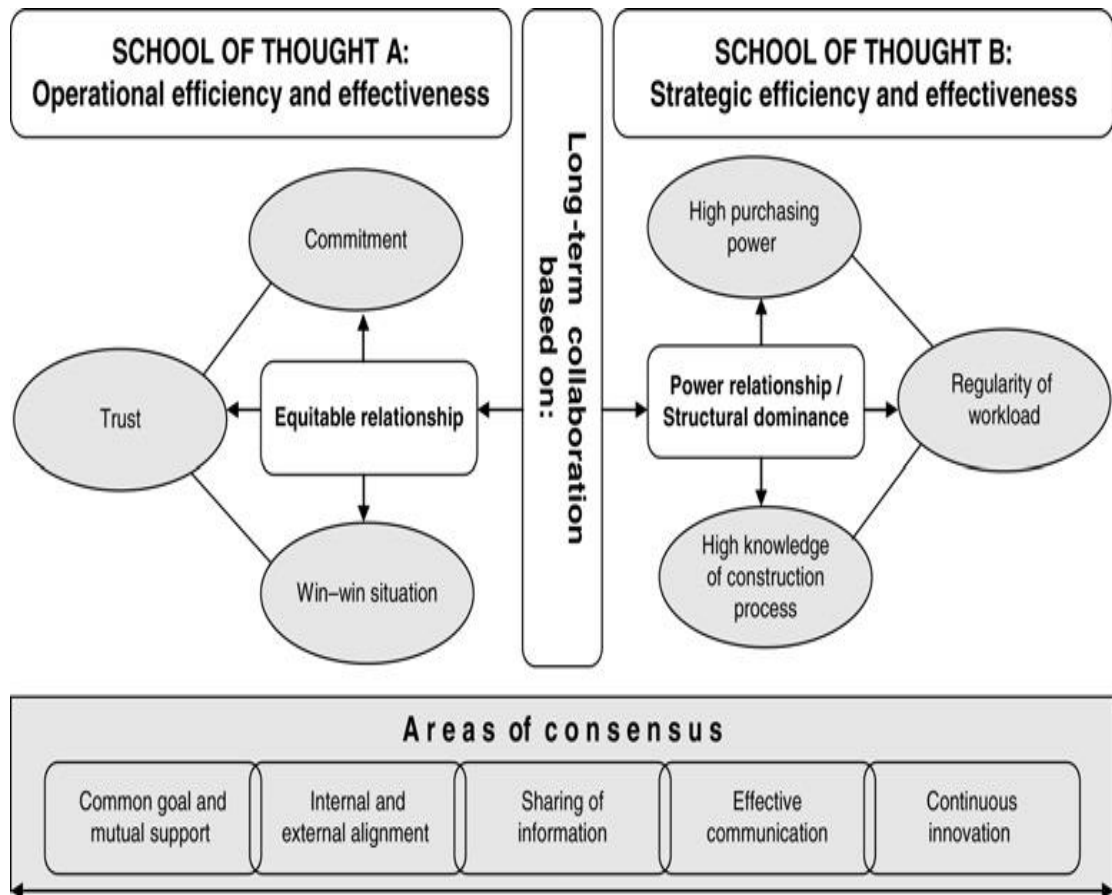


Figure 12: The Two School of Thoughts for Achieving SCM (Adetunji et al., 2008)

In addition, the dependent suppliers pose no threat to the flow of value appropriation and are forced to pass a value to the dominant player. Such dominant players in gaining a competitive advantage normally widen their suppliers' alternatives in order to promote innovation and commitment (Adetunji et al., 2008; Stannack, 1996). Although irrespective of the differences in the two school of thoughts, there exists an area of consensus between the two groups, as shown in figure 12. These areas of consensus are internal and external alignment through coordinated teams and cross-functional integration to ensure flexible, adaptive, and open organisations; appropriate exchange of information and knowledge transfer leading to innovation. Other areas of consensus are effective communication in terms of frequency and quality of information; willingness to share information to improve overall performance; commitment to a common goal and mutual support; and continuous innovative effort.

However, in a case study of the road maintenance sector in the UK, Adetunji et al. (2008) observed that in driving sustainability, the supply chain relationship is based on the extended structural dominance and power regime (school thought B, figure 12). They argued that the extended structural dominance and power regime provides the environment for the diffusion of sustainability issues. Similar studies in other sectors also showed that buying firms always use their buying power (mandated approach) in extending their sustainability efforts to their suppliers (Adenso-Díaz et al., 2008; Brockhaus et al., 2013). What is expected instead is a more collaborative approach which could yield a better sustainability performance (Adenso-Díaz et al., 2008; Brockhaus et al., 2013). Although several benefits have been reported with regards to collaboration in driving sustainability. Therefore, a well crafted and successful integration of sustainability issues throughout the supply chain can create value to the business organisation (Adenso-Díaz et al., 2008; Adetunji et al., 2008; Brockhaus et

al., 2013). Hence, there is a need to explore further how these factors influence the implementation of sustainable procurement in the AEC sector. Close collaboration and influencing supply chain members can be achieved through the implementation of suppliers development. Suppliers development is the process where the buying firm or main contracting firms work closely with their supply chain members to help in improving their organisational processes and performance. Suppliers development is further discussed in the next section.

2.5.3 Suppliers Development

Small construction businesses have the potential to make significant ongoing contributions to the economic and environmental performance of the industry if sufficient support and encouragement is provided to them (Hardie, 2010). This support is through what is referred to as the supplier's development. The Chartered Institute of Procurement and Supply (CIPS), (Chartered Institute of Procurement & Supply, 2018) described supplier's development as a process that involves embracing the supplier's expertise and aligning it to the buying organisation's business need. They further explained that the supplier development might involve developing a supplier's business such as helping the supplier to evaluate and redesign their corporate strategy.

Studying the sustainable procurement practices of Social Housing authority in the United Kingdom, Meehan and Bryde (2015), proposed that for effective delivery of sustainable construction projects, procurement consortia should be able to transfer knowledge and the requisite skills to individuals and their supply chains. Also, the experience of contractors who undertake sustainable projects can be utilised in identifying material-related risks during the selection of alternative construction materials or products (Polat et al., 2017). Transferring of knowledge and developing the requisite skills is key in driving sustainable procurement (De Giacomo et al.,

2018). Mahamadu et al. (2015), argued that a lack of expertise and experience in the use of modern and integrated procurement arrangements could prevent effective management and realisation of Quality, Safety and Environmental (QSE) performance. In addition, they noted that there is a need for personnel involved in the procurement of infrastructure to develop skills in computing/ICT; problem-solving; communication; decision-making. Other areas are health and safety, management; quality management; relationship management; team building; project monitoring and evaluation; time management and procurement planning (Mahamadu et al., 2018).

On the other hand, exploring how buying firms/focal organisations (Main Contractors) can improve the performance of their supply chain, Krause et al. (2000) argued that buying firms can improve the performance of their suppliers through supplier assessment. Other methods are by providing incentives for improved performance and instigating competition among suppliers, as shown in Figure 13. In addition, they suggested that direct involvement of the buying firm's personnel with suppliers through activities such as training of supplier's personnel will enhance suppliers performance.

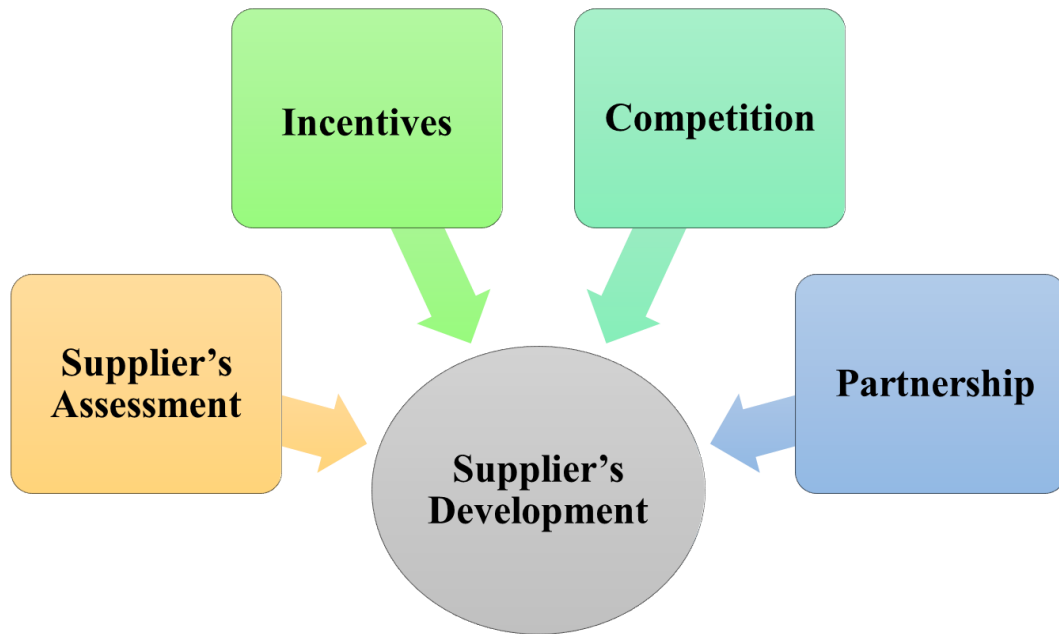


Figure 13: Supplier's Development Improvement (Source: Author)

In a related study, Gosling et al. (2015), studying the impact of supplier development in the supply chain in the construction sector, found a significant difference in the level of performance between different groups of the supply chain. They observed that the higher the level of partnership in the relational category, the more consistency there would be in performance. Other factors that can enhance high performance in the supply chain network are building a long-term relationship between suppliers and manufacturers; transforming non-core businesses into affiliated subsidiaries; and learning to cooperate in Research and Development ventures (Kenichi & Russell, 1994)

In enhancing the effectiveness in a supply chain network in the AEC sector, it is suggested that gradual supplier development could occur by the regularity of work to the supplier or sub-contractor (Noorizadeh et al., 2018). Regular engagement of a supplier or sub-contractor contributes to their social capital accumulation and trust

building (Noorizadeh et al., 2018). Using the recency, frequency and monetary value, and product model (RFMP), Noorizadeh et al. (2018) explained that investment in a suppliers development should vary based on the contribution of the supplier's to the business and its position in the pyramid. The RFMP model is used for the segmentation of supplier chain members into different categories according to their performance and level of activities (Noorizadeh et al., 2018).

In the same vein, Rizzi et al. (2014) explored the interactions between green Small and Medium Enterprise (SME) networks and Green Public Procurement (GPP) opportunities on road construction. Their study revealed that in order to avoid the Abilene paradox a situation where an organisation frequently take actions in contradiction to what they want to do and therefore defeat the very purposes they are trying to achieve (Harvey, 1974). There is a need for buying firms to be enablers of the informal and formal relations that lead to knowledge circulation and meeting the GPP requirement. Such knowledge as further explained by Rizzi et al. (2014), could be shared through informal discussions. Nevertheless, it is important to note that in the development of a supplier, it is significant that buyers (focal firms) assess the requirement and expected outcome that will be gained in developing a supplier (Cox & Ireland, 2002).

Studying the supply chain management of the construction sector, Lönngren et al. (2010) observed few practical examples of managing supply chains in the construction industry and little empirical evidence. They suggested that strategic alliances are a crucial requisite for the successful management and integration of services and products within the construction industry. Such a strategic alliance can be achieved by identifying the key players in the supply chain and their various demands during the procurement process; this is essential in meeting the project objectives (Kamann, 2007).

Kamann (2007), added that organisations should be able to translate the appropriate strategy through operational excellence, product leadership or customer intimacy. This strategy forms the basis for the design of three interdependent elements: policies (P) goals of the organisation, organisation (O) ways of organizing and process (p) corresponding activities (Kamann, 2007). Also, Ross and Goulding (2007) observed that the use of supply chain price information for pre-contract negotiation and post-contract governance could influence the propensity of the supply chain to provide richer information. Information on the costs assumptions made within their estimates to improve the empirical basis for future decision making. Other ways of improving the performance of the supply chain are through identifying the pathogens that could have a negative impact on the supply chain (Abidin & Ingirige, 2018). Pathogens are underlying or latent conditions or events that cause disruptions such as errors, failure and disputes to occur during a construction project. Abidin and Ingirige (2018), explained that such pathogens are not identified early during the planning of the project. But that the identification of such pathogens would help the organisation to assess their vulnerability and build in proactive strategies that will mitigate negatively on the supply chain. The types of pathogens identified in the supply chain in the construction sector are practice pathogens, circumstances pathogen and behaviour pathogen (Abidin & Ingirige, 2018).

2.6 Sustainable Procurement Practice

To further answer the research question of this study, that attempts to understand how construction-contracting firms embed sustainability criteria in their procurement process. This section provides a background to sustainable procurement and reviews the processes in sustainable procurement.

2.6.1 An In-depth Overview

The procurement process is a vital phase in the planning of construction projects, Belfit et al. (2011) explained that procurement is the one-way companies interact with members of their supply chain. Project procurement in construction is the system that assigns specific responsibilities and authorities to the organisations and people and defines the relationships of the various elements in the construction of a project (Love et al., 1998). Similarly, Oyegoke et al. (2010) explained that project procurement creates the contractual framework that governs the nature of relationships between the project team within the duration of their collaboration. Nowadays, procurement practice has developed from the traditional purchasing for cost and quality to a strategic business practice aiming to deliver a sustainable competitive advantage (Hong & Kwon, 2012). This strategic business practice changes the focus of procurement from the short-term cost minimisation to long term value creation and delivery (Walker et al., 2008). Walker et al. (2008), further argues that creating value through procurement is evolutionary and requires longitudinal collaboration. As noted by Kähkönen and Lintukangas (2012), such value can be created through the organisation's capabilities in three areas. Through competing and responding to industry-level challenges, exploiting relationship capabilities, and understanding and responding to customers' needs. Although, it is pertinent to note that in the AEC

sector, sustainable products innovation stem from the upstream product manufacturers and suppliers of the building materials (Dewick & Miozzo, 2002).

Additionally, Dewick and Miozzo (2002).argued that all parties in the AEC sector have the responsibility of promoting the adoption and use of sustainable products. For example, the client has an important role to play by including sustainability criteria in the procurement policies and procedures (Dewick & Miozzo, 2002; Du Plessis, 2002). In addition it is the responsibility of the design and construction team to interpret the client's requirement by including technologies and methodologies that will improve buildability (Dewick & Miozzo, 2002).

On the other hand, the sustainable procurement of goods and services aims to deliver real long-term value to the organisation, individual or end-user (Berry & McCarthy, 2011). Sustainable procurement in construction can be explained as the process or mechanism where organisations or firms collaborate with their various supply chains and relevant stakeholders in delivering the sustainability goals in a project. Sustainable procurement involves understanding and assessing the effect of goods, works or services on the environment, the communities affected by its supply chain and the economy and then taking steps to reduce any negative effects and promote benefits wherever possible (Berry & McCarthy, 2011). The International Organisation for Standardisation (ISO) suggested that ensuring decent working conditions of employees, purchasing products or services that are sustainable and having consideration to socio-economic issues, such as inequality and poverty in the procurement process will help in realising the sustainability goals (International Organization for Standardization, 2017a). The United Nations Environment Programme (UNEP) explained that sustainable procurement practices are widely recognised as a major driver of innovation, and means for improving the sustainability

performance of both public and private organisations (United Nations Environment Programme, 2017). It has been observed that sustainable procurement practice is growing as an area of importance to the top management of both public and private organisations, and its implementation has shown to have significantly increased globally (Grob & Benn, 2014). This is demonstrated by placing sustainable procurement as a primary focus in firms organisational policies (Bratt et al., 2013). Equally, the International Institute for Sustainable Development (IISD), reported that different governments and agencies globally have strategically used their procurement mechanism to further their sustainability objectives (Perera et al., 2007).

One of the benefits of implementing sustainable procurement practice as reported by the UK Department for Environment, Food and Rural Affairs was in the London 2012 Olympic and Paralympic games where they stated that:

“Sustainable procurement helps ensure value for money and lower operational costs whilst protecting the environment and bringing us wider societal benefits. London 2012 showed how this could be done practically and efficiently.”

(Department for Environment Food and Rural Affairs, 2013, p. 1).

This example explains that the disposition of an organisation towards sustainability practice is demonstrated through its procurement process, which has a significant influence on the behaviour and practices of their supply chains (Belfit et al., 2011). It has also been argued that there is a direct impact on the performance of the firm in implementing sustainable procurement practice (Carvalho & Rabechini, 2017; Sanchez et al., 2014; Zhu et al., 2007). Zhu et al. (2007), further noted that companies with a relatively higher level of green supply chain management (GSCM) implementation achieve better performance outcomes.

However, Meehan and Bryde (2011) revealed that organisations sustainability policies are rarely reflected in their sustainable procurement practices. The policies, as observed by Meehan and Bryde (2011), failed to consider the activities of other supply chain actors. Similarly, it was observed that sustainability criteria in the Canadian AEC sector were rarely reflected in their bids (Ruparathna & Hewage, 2015b) . Some of the reasons observed are lack of knowledge on sustainable procurement, local environment, and environmental aspect given better priority (Ruparathna & Hewage, 2015b). In addition, the poor reflection of sustainability goals/policies in the procurement process could be likely as a result of the disconnect between the supply chain vision, strategy, and execution (Reefke & Sundaram, 2018). The complex nature of the supply chains that involve different actors with different business requirements, cultures, and opinions have been argued to be some of the reasons for the disconnection (Reefke & Sundaram, 2018). Nevertheless, the successful delivery of sustainable building design and construction processes are characterised as collaborative and interdisciplinary (Riley et al., 2003).

Exploring further, how contracting firm's sustainability policies align with their supply chain vision, strategy, and execution will provide a better understanding of the implementation of sustainable procurement in the AEC sector. Although most of the published studies on sustainable procurement focus on practices in the public sector. Also, such studies rarely demonstrate how organisational policies align with supply chains goals(Iles & Ryall, 2016; Walker & Brammer, 2009). Therefore, this study is intended to fill that gap by understanding how large construction-contracting firms address the needs and demand of their supply chains. The next section further explores the implementation of sustainable procurement.

2.6.2 Implementing Sustainable Procurement

Meehan and Bryde (2011) observed that organisations sustainability policies were not reflected in their sustainable procurement practices. Arguably, this could be linked to the peculiarities of the construction sector, which is complex and made up of several actors and supply chains (Reefke & Sundaram, 2018). The fragmented nature of the industry and lack of knowledge of practitioners in the past with regards to the benefits of sustainable procurement is one of the major barriers (Ofori, 2000). Fragmentation of the industry was found to be one of the major impediment affecting the performance of the construction sector in delivering projects that meet client objectives (Egan, 1998; Latham, 1994). Fragmentation affects project performance, reduces productivity, inhibits learning and encourages adversarial relationships (Kesidou & Sorrell, 2018). It also creates a barrier to innovation by inhibiting collaboration, coordination and knowledge exchange between the relevant team members (Akintoye et al., 2012). Productivity, learning, innovation and collaboration can significantly be improved through a transitional approach where new knowledge is brought into the project by being made relevant, available and effective, and through social learning amongst the project teams (Hojem et al., 2014). In addition, Hojem et al.(2014), further explained that social learning in the project team enables the collective act of exploration, discovery, and analysis, which improve the project objectives and enhances innovation. Developing social learning strategies enables the incorporation of elements of trust and the identification of the benefits of the contracts by the various actors (Sparrevik et al., 2018). Also, trust and identifying the benefits of the contracts can stimulate the supply chain members to be proactive in achieving the project objectives (Sparrevik et al., 2018). Similarly, with modifications and developments in the method of procurement practices globally, Nathália de et al. (2017) revealed that

sustainability practices and demands in the USA had changed the nature of design, construction and operation of buildings. They revealed that for a firm to gain a competitive advantage, there is the need to address sustainability practices in their strategic planning (strategic positioning), marketing, business management, financial management, organisational structure, and people management.

Implementing sustainability at the procurement phase requires a clear definition of sustainability objectives. Some of the benefits gained in the adoption of sustainable procurement as observed Iles and Ryall (2016) was that practitioners affirm to cost savings. Nevertheless, suggested the need for proper communication on the advantage of adopting sustainable procurement. Furthermore, Iles and Ryall (2016) observed that the lack of clarity of the policies and principles in the implementation of sustainable procurement are some of the major causes for the fragmentation and adversarial nature of the UK construction industry. Even though the study by Iles and Ryall (2016) focused more on public sector procurement of construction projects. It will be important to explore the behaviour of private construction-contracting firms in the way they relate sustainability issues to their supply chains and other stakeholders. This is because implementing sustainable procurement requires the collective engagement of all team members (Fellows, 2006). Also, the collaboration of team members throughout the procurement process can lead to reductions in raw materials utilisation and waste generation (Witjes & Lozano, 2016). Such a waste reduction is likely to deliver a long-term value to the organisation, individual or end-user (Berry & McCarthy, 2011). As earlier mentioned, sustainable procurement practice calls for a change of behaviour from traditional practice to a more innovative way of practice. For example, the Irish Environmental Protection Agency admitted that Green Public Procurement (GPP) is quite a complex process. This is because, apart from meeting

the green procurement requirement, there is the need to comply with the public procurement rules and environmental legislation (Environmental Protection Agency, 2014).

Similarly, examining real estate developers in Chongqing-China, Shen et.al (2017), revealed that most of the firms studied have little understanding of sustainable procurement and sustainable building materials, and only a few of them have experience in adopting green procurement strategy. While McMurray et al. (2014) observed that the major challenge in the Malaysian private and public sector is that, there is lack of awareness amongst members of the various team as regards to sustainable procurement practices. As discussed in section 2.4.2.3, sustainability practice varies according to regions and countries. Therefore, there is a need to understand the level of awareness and implementation of sustainable procurement amongst construction-contracting firms in Ireland.

Chang et al. (2016) observed that government policies and incentives could be drivers in promoting sustainable procurement. Giving an example of the Chinese AEC sector, they noted that incentives like subsidy policies, award policies, and government participation in promoting the adoption of new technologies like renewable energy had driven sustainable procurement practice. Other areas identified that could drive sustainable procurement practice was through supporting activities like strengthening technology innovation, improving standards and evaluation, establishing demonstration projects, and publicity (Chang, Soebarto, et al., 2016). In studying the process of sustainable procurement practice in the Swedish construction sector, Bratt et al. (2013) as shown in Figure 14, observed that from a strategic point of view a clear definition of sustainability objectives is very important along with the need to identify

the impact. They suggested ways of improving the process of sustainable procurement, such as:

(i) Broaden the competences about environmental and social sustainability within the working groups;

(ii) Define and agree upon clear and solid short and long-term process and criteria objectives and;

(iii) Applying backcasting from such objectives to allow for strategic product-service system innovation and including new forms of market desires and human needs-satisfaction. This is by shifting the focus from the products to the function that will be provided. The advantages of backcasting were demonstrated by Jones et al.(2015), where they explained that backcasting provides the opportunity to envision future scenarios based on complex and uncertain data. Furthermore, backcasting aid in identifying alternative solutions pathway by looking backwards from the future end-goal to the present day (Jones et al., 2015).

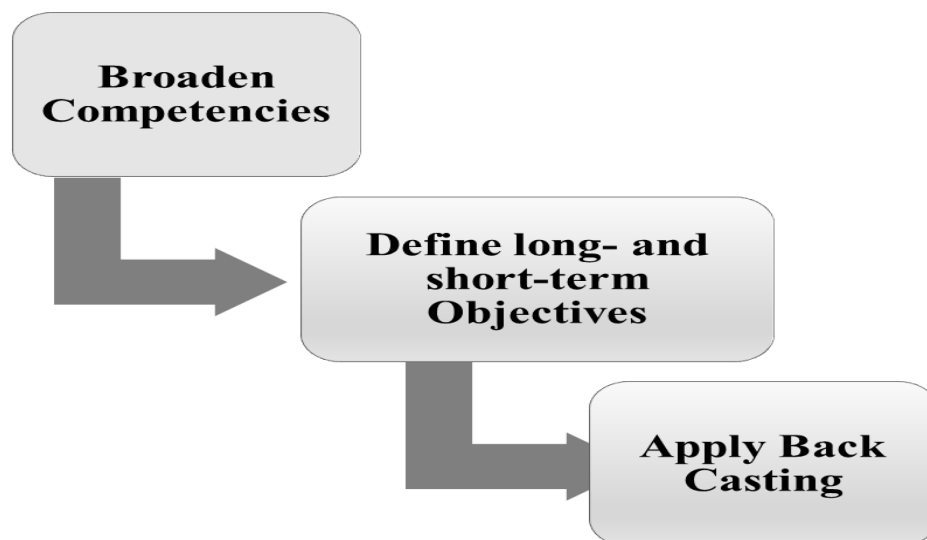


Figure 14: Ways of Improving Sustainable Procurement Practice (Bratt et al., 2013)

Furthermore, the procurement of complex products and systems drives innovation for sustainable construction (Haugbølle et al., 2012). Haugbølle et al.(2012) further explained that understanding the requirements and demands of the various actors in the demand side of the project is very important. They suggested the need to distinguish between building owners and users during the planning of the project. Also, it was noted that procurement of complex products and systems could reshape the linkages between the various constituent of construction through policy processes, business process and learning processes. Figure 15 shows how the various actors that are involved in the construction process interact. The interaction with the market, the supply network, and project-based firms relate through the product's market. Likewise, all the actors are linked through a common regulatory and institutional framework and technical support infrastructure. Understanding these relationships could aid the implementation of sustainable procurement in a construction firm.

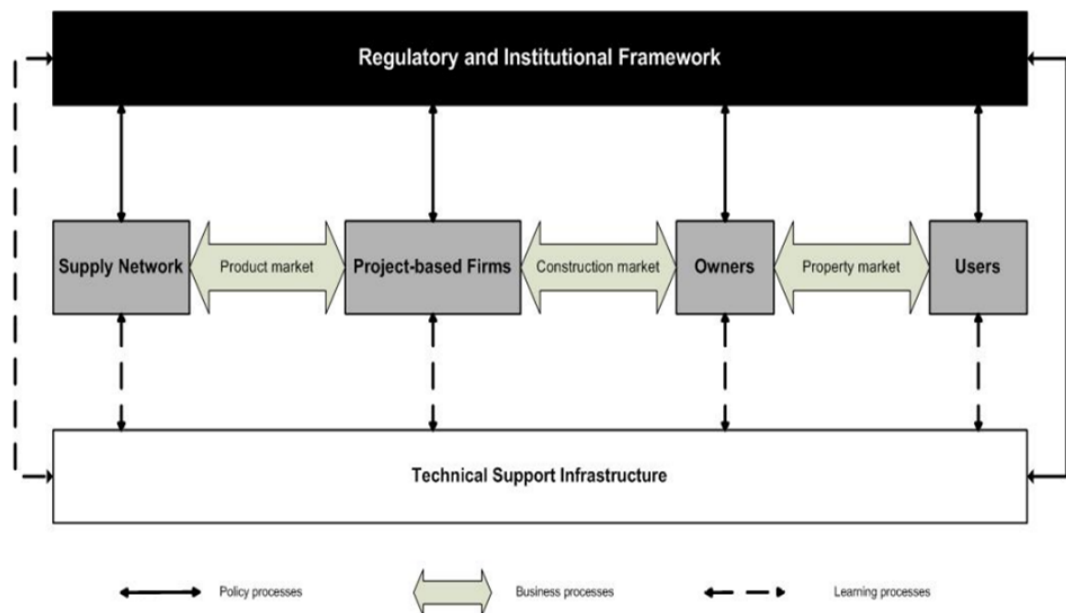


Figure 15: An Alternative Perspective on the Construction System. Source:
(Haugbølle et al., 2012)

In summary, sustainable procurement is a driver to an effective, sustainable construction performance. Sustainable procurement calls for innovative ways of practising by ensuring that the behaviour of all members of the supply chain reflects the sustainable development objectives. Although adopting sustainable procurement could be very challenging for small firms. There is a need for construction firms to understand the sustainability requirement of the client to enable them to communicate effectively to other stakeholders and their supply chain members. Understanding the type of construction client's and their disposition to risk is an effective way of meeting the client's needs (Boyd & Chinyio, 2008; Newcombe, 2003). Also, there is a need for firms and suppliers to change their focus from just the products to more on the function of the products (Bratt et al., 2013; Santos & Lane, 2017). Firms focusing on the function of the product is one of the ways of gaining a competitive advantage (Elkington, 1997).

Finally *“It is unwise to pay too much, but it is worse to pay too little. When you pay too much, you lose a little money - that is all. When you pay too little, you sometimes lose everything, because the thing you bought was incapable of doing the thing it was bought to do”-John Ruskin.*

Different models and frameworks have been developed to aid business enterprises and public organisations in the implementation of sustainable procurement practice. The next section looks at some of the common sustainable procurement frameworks.

2.7 Frameworks for Sustainable Procurement

Different frameworks and models for sustainable procurement have been developed or proposed by different regulatory bodies and governmental organisations. Also, academic research has made a significant contribution in proposing different frameworks for implementing sustainable procurement in the different sectors of the economy. As it was argued in section 2.4.2 that the implementation and adoption level of sustainable construction varies according to regions and organisations. Likewise, most of the frameworks developed are quite specific to a certain region or environment. However, some frameworks are quite generic that provides the foundation for other frameworks to be developed. This section reviews the three most used frameworks produced by different agencies. The three frameworks are leading globally and will provide a good foundation for proposing a sustainable procurement framework for construction-contracting firms in the Republic of Ireland. In addition, other frameworks/models proposed by academic researchers are reviewed in this section. The frameworks considered are the International Organisation for Standardisation (ISO 20400:2017) framework, British Standard Institution framework (BS 8903:2010), and the Republic of Ireland Green Public Procurement framework (GPP). ISO 20400 presents a guideline for global best practices in implementing sustainable procurement practices. Lessons to be learnt from the UK is enormous because the UK is one of the country's leading the implementation of sustainable construction globally (Build Up, 2016). In addition, construction practice in the Republic of Ireland is like that of the UK. In contrast, the GPP focuses on practices in the Republic of Ireland, which is the focus of this study. The three frameworks are discussed below:

1. International Organization for Standardization (ISO 20400:2017)

The International Organization for Standardization Clause 7 of the sustainable procurement guidance provides a framework to guide integrating sustainability into the procurement process, as shown in Figure 16 (International Organization for Standardization, 2017b).

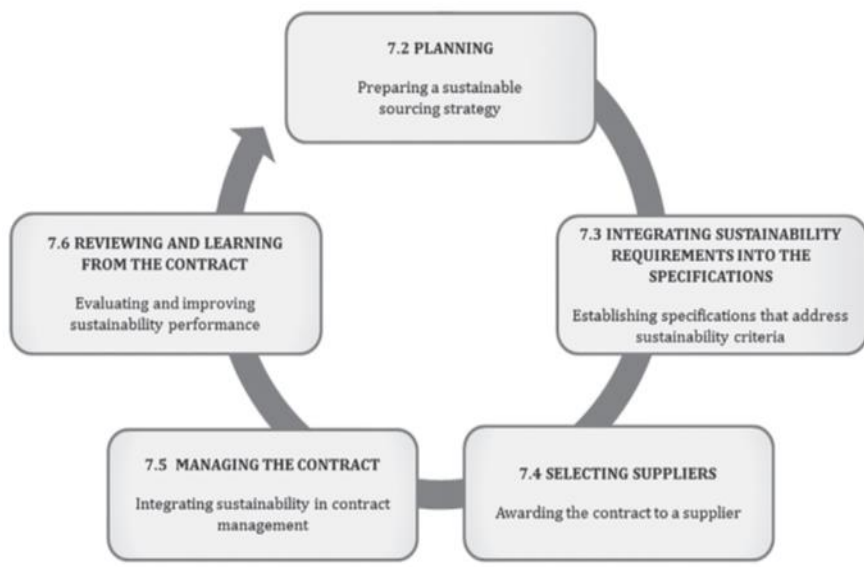


Figure 16: Integrating sustainability into the procurement process
Source:(International Organization for Standardization, 2017b).

At the planning phase organisation are required to address the significant sustainability risks, including opportunities, start engaging and collaborating with relevant stakeholders, and define sustainability criteria that suppliers can adhere to while achieving value for money. Integrating sustainability requirements into the specifications is the next step in the process. This is carried out by defining the sustainable procurement criteria, selecting the types of requirements, applying minimum and optional requirements, finding information to establish requirements, and evaluating that sustainability requirements are met. Selecting suppliers is the third step in integrating sustainability into the procurement process. In selecting suppliers,

the organisation procuring the goods and services assesses the capacity of the suppliers then prequalify the suppliers and manages the tenders before finally awarding the contracts. When the contract award is completed, the procuring entity ensures that the contract is managed effectively. In managing the contract that is the fourth stage, an organisation should strive in managing a good relationship with the supplier. Also, implementing the terms and conditions of the contract, using the contract management plan, managing performance relationship, encouraging supplier-customer joint initiatives, managing supplier failure, and managing disposal and end of life of products. These are some of the key issues that organisations are expected to take into consideration. The final process in the framework is reviewing and learning from the contract. It is expected that for improved performance that organisations conduct a regular review of the contract throughout its duration, as well as after the contract. Some of the areas that need to be reviewed to enhance learning are sustainability risks, the achievement of sustainability objectives and targets, sustainability performance, analysis of key success criteria, and the key lessons for future contracts.

Although, the ISO 20400 procurement framework provided a guide on the implementation and adoption of sustainable procurement in an organisation, but such guide tends to be prescriptive. As it was earlier stated in section 2.4.2.1 that mainstreaming of sustainability in the AEC sector varies according to the dominant organisational culture and history of each firm (Boyd & Schweber, 2012). Therefore, the ISO 20400 framework is likely to be limited in guiding constructions firms in the adoption and implementation of sustainable procurement. An effective sustainable procurement framework would have to consider the different attributes with regards to the organisational culture and history of the firm (Hoejmose & Adrien-Kirby,

2012). Understanding such attributes are key in driving sustainable construction practice (Akotia et al., 2017; Meehan & Bryde, 2011).

Another limitation of the ISO 20400 is the generic nature of the framework, which makes it difficult to be adopted in the AEC sector. The complexity and uniqueness of the AEC sector makes it unsuitable to be compared with other sectors like manufacturing or automobile (Tennant & Fernie, 2014). The British Standard Institution developed a framework for sustainable procurement (BS 8903:2010). The framework guides the implementation of sustainable procurement in the built environment. The framework (BS 8903) is discussed next.

2. British Standard Institution framework (BS 8903:2010):

BS 8903 framework provides the key elements that are likely to drive implementation of sustainable procurement (British Standard Institution (BSI), 2010). Presented in a pictorial view in Figure 17.

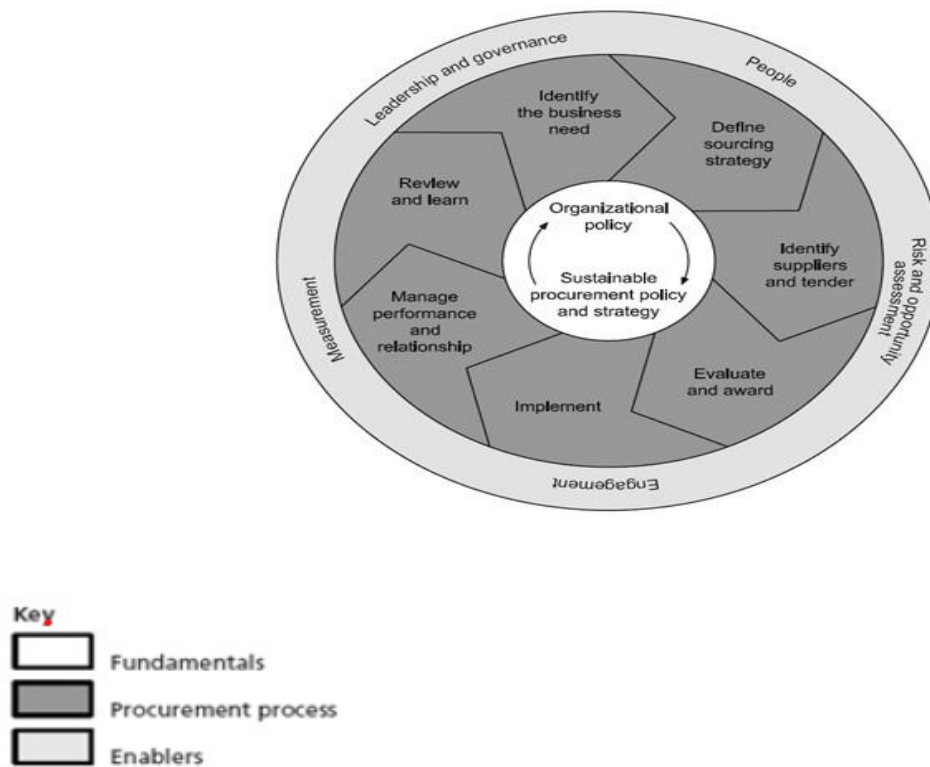


Figure 17 BS 8903 Sustainable Procurement framework (BS 8903:2010)

The inner core is the 'fundamentals' followed by the 'procurement process', and the outer core is the 'enablers'. The fundamentals outline the higher level of organisational and procurement policies and strategy that provide the strategic context to support sustainable procurement practice. The procurement process itemised the necessary sustainability considerations and activities that organisations ought to address across the various point within the procurement process. While the 'enablers' include ways

of working, competencies, practices and techniques that ought to be in place and used by procuring entities on an ongoing or periodic basis to support procurement activity.

The BS 8903 sustainable procurement framework provided an insight on the various levels of activities required by an organisation in the adoption and implementation of sustainable procurement. However, as earlier stated on the poor reflection of sustainability policies in the procurement process (Meehan & Bryde, 2011), which could likely be due to lack of clarity and principles in the implementation of the policies (Iles & Ryall, 2016). Another reason could be attributed to the resistance of supply chains in the adoption of sustainability practice (Upstill-Goddard et al., 2016). Therefore, there is a need to further explore how firms implement and communicate their sustainability policies to their employees and supply chains. Such understanding is required because of the benefits that could be gained from collaboration in the implementation and adoption of sustainable procurement (Witjes & Lozano, 2016).

Furthermore, focusing on the sustainable procurement practice in the Republic of Ireland, the Green Public Procurement (GPP) framework, is reviewed next.

3. Republic of Ireland GPP framework: the green procurement guidelines for the public sector published by the Environment Protection Agency in 2014. The guidance provided a framework for implementing a GPP policy in the public sector (Environmental Protection Agency, 2014). The framework provides a four-step procedure for implementing GPP, as shown in Figure 18. The first step in implementing the policy is to **define organisations priorities and set targets** by assessing the overall procurement spending and prioritising certain products and services. The second step is **adopting procedures** through delegating responsibilities and managing and reviewing GPP in practice. The next step is **monitoring the GPP**

implementation. This is through continuous improvement and effectively targeting the life cycle environmental impact and costs of goods and services. The last step is **driving continuous improvement.** Driving continuous improvement is through reviewing and improving the procurement process. Getting both informal and formal feedback from those involved in GPP implementation is one way of driving continuous improvement.



Figure 18: ROI GPP policy design and implementation (Environmental Protection Agency, 2014)

Although the GPP framework, focuses more on public sector procurement, but it is evident that government policies and regulation influences sustainability practices in the AEC sector (Coulson, 2014; FSC, 2020; Naoum & Egbu, 2015). It will be rewarding to focus and explore the adoption and implementation of sustainable procurement practice of construction-contracting firms in Ireland. Such a study will provide a framework that aligns and reflects the current practice amongst construction contracting firms. Also, the adoption of

sustainability in an organisation was noted to be better understood at the project level (Ageron et al., 2012; Papadonikolaki, 2018).

Going through pieces of academic literature, different frameworks or models have been proposed. For example, Uttam and Le Lann Roos (2015) proposed a competitive dialogue procedure framework for public sector procurement in the AEC sector in Sweden. The model proposed that contracting authorities need to hold discussions with shortlisted contractors regarding the authority's requirements before officially engaging the contracting firm. While Sanchez et al. (2014), proposed an evaluation framework for green procurement for road construction in the Australian construction industry. The framework evaluates green procurement practices throughout the lifecycle of road construction projects in the public sector in Australia. Also, Tang et al. (2019), using system dynamic model, analyses the influences of different procurement systems on sustainable building success. Other frameworks are by Roman (2017), that developed an actionable model of adoption of sustainable procurement at an organisational level. It focuses on the conditions which a given organisation is more likely to engage and prioritise sustainable procurement in the USA public agencies. While Atkin and Gergin (2016) developed a mixed-integer linear programming model to analyse the different sustainable procurement strategies. The mathematical models are developed to distribute demand to the most sustainable firms in the supplier pool of the company. Lastly Witjes and Lozano (2016), proposed a framework that considers the collaboration link between public procurement process and the development of more sustainable business models. A summary of the frameworks is presented in Table 5 below

Table 5: Summary of some Selected Frameworks

Authors	Focus	Organisation	Country
International Organization for Standardization (ISO 20400:2017)	Generic	Generic	International
British Standard Institution framework (BS 8903:2010):	Generic	AEC Sector	UK
Republic of Ireland GPP framework	Generic	Public Sector	Ireland
Sanchez et al. (2014)	Evaluation framework for Road Construction	Public Sector	Australia
Uttam and Le Lann Roos (2015)	Competitive dialogue procedure	Public Sector	Sweden
Atkin and Gergin (2016)	Mixed Linear programming for analysing sustainable procurement strategies	Private Organisation	Turkey
Witjes and Lozano (2016)	Collaboration link between public procurement	Public Sector	Netherlands
Roman (2017)	Actionable model of adoption of sustainable procurement at an organisational level	Public Sector	USA
Tang et al.(2019)	Dynamic model analyses the influences of different procurement systems	Generic	Generic

Examining the various frameworks critically, it is apparent that they are mostly focused on public sector procurement practices. Practices on private construction-contracting firms are rarely considered. The private construction-contracting firms have a unique role to play in driving sustainable procurement because of their structural dominance in influencing their supply chains (Adetunji et al., 2008; London, 2008). Also, most of the frameworks are silent on the nature and the type of construction projects. The nature and type of construction projects need to be understood because as stated earlier sustainable construction practice in an organisation are better observed and understood at the project level due to the complex nature of projects that are shaped by a network of different project actors (Ageron et al., 2012; Papadonikolaki, 2018). Also, the frameworks tend to be developed on the assumption that the adoption or implementation of sustainable procurement is a linear process. However, mainstreaming of sustainability in the AEC sector is not the uniform linear process as it is made to be seen but varies with the dominant organisational culture and history of each firm (Boyd & Schweber, 2012). The complex set-up of the construction organisation will need to be considered in implementing sustainable procurement (Ageron et al., 2012; Papadonikolaki, 2018; Ruparathna & Hewage, 2015a; Russell et al., 2018). Therefore, there is a need to understand and develop a framework that will unveil how large construction-contracting firms utilises their organisational resources in implementing their sustainable procurement practice. Such a framework is currently lacking, and the research intends to address the problem. In addition, studying large construction-contracting firms is beneficial because their performance is much better than average firms. Also, their practices are often regarded as the benchmark of the learning model for other firms (Chang, Zuo, et al., 2016). Lessons learned will enable other firms to

develop strategies in improving their sustainable procurement practice because construction firms will only be motivated to fully adopt sustainability practice if only they see some financial benefits in implementing the practice (Ethical Corporation, 2018; Upstill-Goddard et al., 2016).

To further explore sustainable procurement practice in the AEC sector, the next section is a review of the different procurement routes presently available in the delivery of a sustainable construction project.

2.8 Sustainable Delivery Process

The section reviews the various processes and delivery methods used in sustainable procurement practices.

As stated in section 2.4, sustainable procurement is aimed at delivering real long-term value to the organisation, individual or end-user (Berry and McCarthy, 2011). Creating this long-term value in the AEC sector requires close collaboration with the various supply chains and relevant stakeholders. In addition, the routes or mechanism followed in the delivery of sustainable projects is one of the major determinants to the success of the project (London, 2008). Successful delivery of sustainable building design and construction processes are characterised as collaborative and interdisciplinary (Riley et al., 2003). Riley et al. (2003) argued that construction-contracting firms have a key role in promoting sustainable building delivery through a change in organisational culture and procurement practices to more collaborative practice with other members of their supply chain.

Similarly, Kenley et al. (2014) revealed that some non-price incentives and rewards could be beneficial to both the Client and Contractor in adopting a collaborative procurement approach. They disclosed that early completion and reduction in the greenhouse gas emission (GHGE) are some of the benefits to the client and the contractor (Kenley et al., 2014). Furthermore, Garcia et al. (2014) disclose that influence in decision making, integrated communication, and timing for key decisions are some of the major factors that determine the success for project delivery and optimising project cost. In addition, other factors driving successful delivery of sustainable projects are the level of team integration and effectiveness in communication that is primarily determined by the procurement/delivery method adopted (Berry & McCarthy, 2011; Mollaoglu-Korkmaz et al., 2013; Naoum & Egbu, 2016; Woo et al., 2016).

2.8.1 Delivery Routes

Illustrating the performance of the various delivery methods in a sustainable construction project, Mollaoglu-Korkmaz et al. (2013) observed that the Design-Build (DB) and Construction Management at Risk (CMR) procurement methods have better chances of facilitating integration. In comparison, Design-Bid-Build (DBB) has the potential to provide higher levels of integration when the constructor is informally involved in the earlier phases of the project. Besides, Hamza and Greenwood (2007) argue that under the traditional, design and build procurement arrangement, designing environmentally sensitive buildings might be a very challenging task. This is because the iterations required are at odds with the contractor's incentive to avoid delays and extra cost. However, Koolwijk et al. (2018) revealed that collaboration is an independent component in an integrative and collaborative practice in the delivery of a construction project. They explained that both the traditional and integrated project-delivery method tends to lead to collaboration over time. Such collaboration is due to the long-time relationship established between different firms and actors (Koolwijk et al., 2018). Likewise, Lei et al. (2005) maintained that the private finance initiative (PFI) method of delivery of projects has a natural relationship with sustainability and suggested the need for designing a stakeholder involvement method for the sustainable solution in PFI projects. Utilising the PFI arrangement in delivering sustainable projects creates a partnership that take a long-term view of creating and maintaining buildings to meet the client's current and future needs (Lei et al., 2005). However, Hughes et al.(2006) argued that the PFI is more of a funding arrangement than a procurement system. Therefore, the high risk and interest rates involved in a PFI project might discourage the main contractor in considering the long-term sustainability issue (Lei et al., 2005). Irrespective of the procurement arrangement,

collaboration has been noted to be a key component in each of the procurement methods as argued by Koolwijk et al. (2018). Therefore, exploring how such collaboration occurs amongst the various team members in driving sustainability is one of the focus of this study.

In assessing team performance and innovation implementation, Sun et al. (2015) argued that sustainable project delivery could be improved through monitoring, managing, challenging, and negotiating behaviours of team members. Applying the fault tree theory, Jelodar et al. (2013) revealed that the type of project, contracting arrangement and built environment culture determines the systematic framework of relationship quality for different projects. Other factors like the procurement method adopted, a clear statement of client objective and the level of participation of the relevant stakeholders during the planning of the projects are some of the key attributes to the success of a sustainable project (Gultekin et al., 2013). In addition, the level of expertise of practitioners in sustainable procurement is an important factor in aiding the delivery of a successful sustainable project (Mahamadu et al., 2015; Mahamadu et al., 2018). Such expertise can be developed through organisational learning (De Giacomo et al., 2018; Meehan & Bryde, 2015); team integration (Rizzi et al., 2014; Uttam & Le Lann Roos, 2015) and engaging independent environmental impact assessment verifiers (Wessels et al., 2015). In terms of location and environment, as discussed in section 2.4.2, the delivery of a sustainable project differs according to location and environment. In comparing the sustainable procurement practices between the UK and Italy, Chiarini et al. (2017) found out that sustainable procurement practices vary in the two countries with each country having different priority and needs. They explained that the UK health sector seems to have a propensity for requesting suppliers with an improvement in environmental

performance over time and compliance with voluntary social accountability standards, while the Italian healthcare sector seems more focused on the mandatory laws and regulations concerning environment and safety.

The AEC sector in the drive to create value and gain a sustained competitive advantage have developed various corporate strategies (Berry & McCarthy, 2011). Cheah and Garvin (2004) categorised these strategies into seven different groups namely: business strategy, operational strategy, information technology (IT) strategy, marketing strategy, technology strategy, human resource strategy, and financial strategy. Adapting Cheah and Garvin (2004) strategies, Powmya et al. (2017) identified six strategies to be considered by construction organisations in the implementation of sustainable procurement. As shown in Table 7, the six strategies are human resource strategy, technology strategy, finance strategy, knowledge strategy, capacity development strategy and environmental pro-activeness strategy. The human resource strategy deals with the recruitment of experienced technical staff, education and training, employee empowerment, and the employee reward system. The technology strategy pays attention to Improving communication system through information technology. Followed by the technology strategy is the finance strategy where issues of surety, bonds and insurance policies are addressed. The knowledge strategy is close to the human resource strategy, but it focuses more on monitoring and evaluation of projects, inter-firm collaboration, and continual professional development. The fifth strategy deals with capacity development. It focuses more on the firm's external relations and collaboration. Some of the key issues are the collaboration with the following bodies: international sustainable construction body, international bodies, and international sustainable construction firms, and collaboration with varying size contractors.

Table 6: Implementation Strategies: Adapted from Powmya et al. (2017)

STRATEGIES	FACTORS
<ul style="list-style-type: none"> • Human resource strategy 	<ul style="list-style-type: none"> • Recruitment of experienced technical staff • Education and training • Employee empowerment, and • Employees reward system.
<ul style="list-style-type: none"> • Technology strategy 	<ul style="list-style-type: none"> • Improving communication system through information technology
<ul style="list-style-type: none"> • Finance strategy 	<ul style="list-style-type: none"> • Surety • Bonds and • Insurance policies
<ul style="list-style-type: none"> • Knowledge strategy 	<ul style="list-style-type: none"> • Monitoring and Evaluation of projects • Inter-firm collaboration, and • Continual Professional Development
<ul style="list-style-type: none"> • Capacity Development strategy and 	<ul style="list-style-type: none"> • Collaboration with international sustainable construction body • Collaboration with international bodies • Collaboration with international sustainable construction firms • Collaboration with varying size contractors. • Partnering with Suppliers and • Research and development.
<ul style="list-style-type: none"> • Environmental pro-activeness strategy 	<ul style="list-style-type: none"> • Compliance with sustainability legislation • Voluntary rating and Environmental Management System (EMS) • Industrialised Building Systems (IBS)/ Prefabricated Building units • Sustainable Procurement, and Sustainable construction management.

Other issues are partnering with suppliers and lastly research and development. The sixth and last strategy is the environmental pro-activeness strategy. This strategy focuses on compliance with sustainability legislation, voluntary rating and Environmental Management System (EMS), and Industrialised Building Systems (IBS)/ prefabricated building units, sustainable procurement, and sustainable construction management.

However, it is not very clear how construction firms implement these various strategies in their organisations drive to deliver a high sustainable procurement performance (Li et al., 2014). Therefore, there is a need to explore the level of importance and performance of the various strategies within a construction organisation. Assessing the level of importance and performance could enable construction firms to improve their practice and enhance their organisation's sustainable procurement performance (Martilla and James, 1977).

In Summary planning and delivering sustainable construction requires a high level of teamwork and effective communication (Demaid & Quintas, 2006; Fellows, 2006). Such collaboration can only be achieved if there is a close relationship amongst the various actors in the construction. Even though Korkmaz and Singh (2011), argued that the delivery of sustainable projects among different disciplines and actors is quite challenging and requires a high level of interaction and leadership to achieve a positive result. To further understand how collaboration amongst the various teams is driven, the next section reviews collaboration and integration critically in the AEC sector.

2.9 Collaboration and Integration of Team Members

Collaboration and Integration in an organisation as explained by Koolwijk et al. (2018) is the soft aspect of supply chain management which is people-focused that deals with the social relationships amongst team members such as trust and commitment. While integration refers to practices that are performed at a project level, these practices concern tangible activities or technologies, such as the shared use of a building information model or using the shared office that allows face-to-face communication. Constructing Excellence UK refers to Integration as assembling the different teams involved in the delivery of the project to work in harmony to achieve a common goal (Constructing Excellence, 2010). On the alternative, Beck (2005), explained that collaboration is a data-centric activity where each discipline provides or contributes data information to other disciplines for processing to achieve a common goal. While integration is a knowledge-centric activity where participants share their knowledge in the form of rules, algorithms and proprietary practices to identify a project. Beck (2005) further explains that in a knowledge-centric environment, the knowledge of participants is utilised in identifying a specific project while in a data-centric environment, data is shared on one project at a time. The level of collaboration and integration of team members in an organisation or a project is determined by the method of procurement to be used in the delivery of the project (Beck, 2005; Oyegoke et al., 2010).

Different organisational set-up exists in the AEC sector. Oyegoke et al. (2010) observed three forms of organisational set-up. These are fragmentation, economic integration, and social integration. Fragmented organisational set-up, has a clear organisational boundary, an example can be seen in different independent firms collaborating on a particular project like independent firms of different consultants

and main contracting firms. While in economic integration, there are separable activities under one ownership that is different departments or trades in a single firm. While social integration is made up of the integrated team for a project at a time mostly seen in outsourcing, where the main contracting firm engages other sub-contractors and suppliers. Oyegoke et al. (2010) further revealed that most UK construction firms are socially integrated, which have proved successful through a series of demonstrative projects. However, it is evident that most construction firms globally are socially integrated, which have made them dependent on several suppliers or sub-contractors in the delivery of projects or contract (London, 2008). This assertion was further proven by Oyegoke et al. (2014) that revealed that there is a shift from the traditional contractor's contractual role from active participation in construction activities to a mere management role.

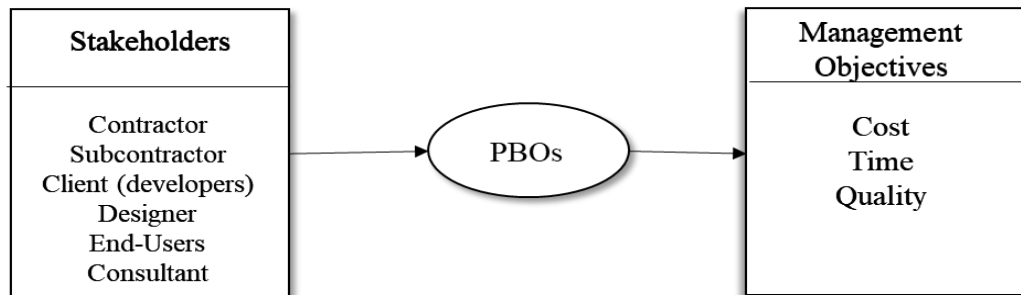
In examining how team members collaborate in planning for a sustainable project, Rääkkönen et al. (2016) noted that assessing and communicating the impact of embedding sustainability into the construction process has been quite challenging. They suggested that the ability to communicate the various impacts of sustainable development to local societies, people, investors and other stakeholders can provide a competitive advantage. Similarly, information sharing amongst the project teams is a critical factor in motivating collaboration between suppliers and buyers (Woo et al., 2016). Through an empirical study, Woo et al. (2016) revealed that the communication capability of suppliers positively influences green cost reduction and their competitiveness directly and indirectly through environmental collaboration. Likewise, Akotia et al. (2017) observed that the level of involvement and roles of practitioners varies differently at each stage of the project. They explained that the project requirements (time, cost, quality, and sustainability), type of project

organisations (nature of work undertaken), type of contract and procurement methods used in a project (traditional or integrated method) are determinants that defined the role of practitioners. Utilising network theory to understand how collaboration can drive sustainable practice amongst networks, Vurro et al. (2009) demonstrated that as centrality increases, firms could exert influence over their network, coordinating integrated approaches along the value chain. Therefore, the adoption of more collaborative working, greater use of non-adversarial procurement and contracting processes, and harnessing performance-related incentives to align interests are key in promoting the performance of the AEC sector (Farmer, 2017). What this indicates is that collaboration, and good governance is powerful tools for driving sustainability initiatives in an organisation (Russell et al., 2018). Although, it is important to note that conflating supply chain management with collaborative practices will only make sense when there is an understanding that better reflects the dynamic project-driven characteristics of construction projects (Tennant & Fernie, 2014).

In enhancing the collaboration and integration of team members in driving sustainability practice in the AEC sector, positioning of a sustainability champion who drives the adoption of sustainability practice has been proven to yield positive sustainability performance (Boyd & Schweber, 2012; Wessels et al., 2015; Zhang et al., 2015). The accessibility of sustainability champion to both senior management and business units is a major determinant in mainstreaming sustainability in an organisation, and it directly relates to the sustainability performance of the firm (Boyd & Schweber, 2012; Wessels et al., 2015; Zhang et al., 2015). Illustrating from the Chinese AEC sector perspective, Zhang et al. (2015) argued that the traditional project management organisation (PMO) mode is not quite effective in the delivery of sustainable buildings. The traditional PMO focuses on how the various stakeholders

collaborate in achieving the triumvirate objectives of cost, time, and quality. Zhang et al. (2015) proposed a paradigm shift from the traditional PMO by introducing an Independent Environmental Representative (IER) to the traditional PMO structure, as shown in figure 19. The IER is involved at all stages of the projects with the primary aim of protecting and advising on environmental issues. Also, Robichaud and Anantatmula (2010) opined that organisations could gain some financial benefit by adjusting the traditional project management practices by adopting a cross-disciplinary team at the initial to the final stage of a project.

Traditional Mode PBOs



New Mode of PBOs

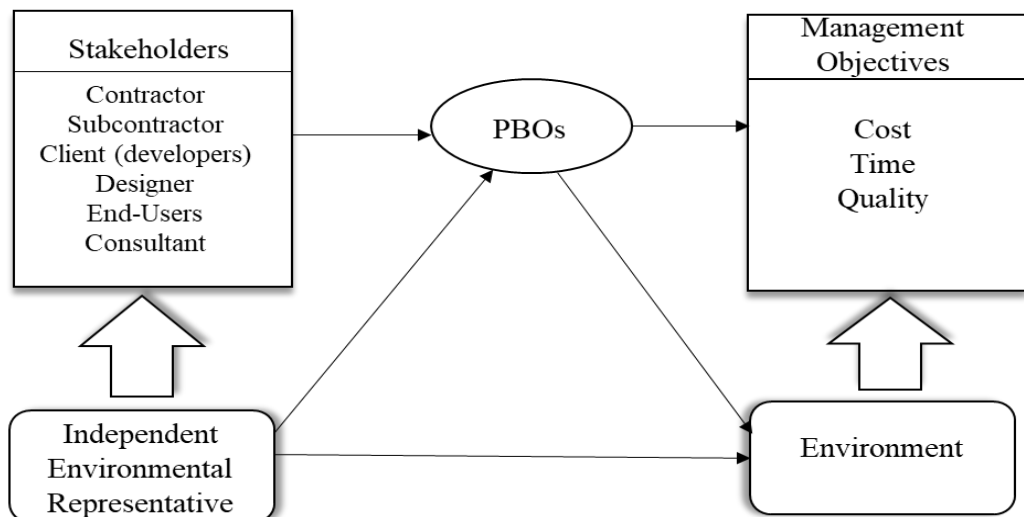


Figure 19: A typology model of green embedded project-based organizations

Source: (Zhang et al., 2015)

Reviewing other factors that enhance collaboration and integration in the adoption of sustainability in construction organisation, Rodriguez-Melo and Mansouri (2011) assessed the impact of government policy, managerial attitude, and stakeholder engagement. Their findings show that stakeholders' engagement was identified as the defining factor in increasing the managers' awareness by helping legislation to be effectively implemented and making sustainability highly appealing to clients. Similarly, using the competitive dialogue procedure (CDP) mechanism in the Swedish AEC sector, Uttam and Le Lann Roos (2015), claimed that in undertaking a complex construction project, the CDP could aid in the implementation of sustainable procurement practice. Such type of collaboration if properly utilised can help in evaluating different alternative technologies which can significantly contribute to sustainability aspects by use of more sustainable materials thereby releasing less pollution in the open environment (Nanyam et al., 2017). Correspondingly, a clear project specifications and Clients requirement is also a very important factor. Examining the construction industry in Hong-Kong, Lam et al. (2010) identified five independent factors for the successful specification of sustainable construction. These factors are:

- (1) green technology and techniques,
- (2) reliability and quality of the specification,
- (3) leadership and responsibility,
- (4) stakeholder involvement, and
- (5) guide and benchmarking systems.

They identified that sustainable technology and techniques and stakeholder involvement are the most important factors to drive a successful specification.

Likewise, the type of project and level of relationship of stakeholders to a project also determines its success (Liang et al., 2017).

The findings in this section of the review indicate that stakeholder's engagement, understanding of project requirements/type of project, government policies, and the level of involvement of the various team members are significant factors in enhancing collaboration and integration. These factors, as shown in Figure 20, drive the implementation of sustainable procurement. Figure 20 illustrate that for effective collaboration and integration, construction organisations need to address these four key elements.

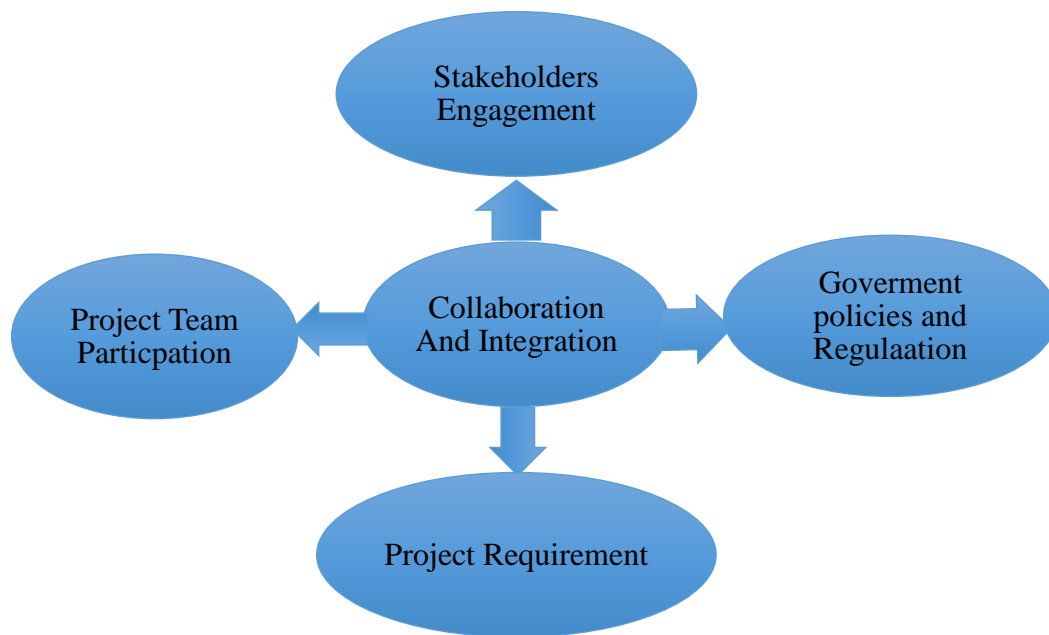


Figure 20: Collaboration Key Elements (Source: Author)

However, how main-contracting firms address these factors in their procurement process is not well understood. Therefore this study examines how contracting firms are utilising their organisational resources in driving their sustainable procurement. Organisational resources in this context refer to a firm's assets, which could either be tangible or intangible, that enhances their performance, enabling them to gain a

competitive advantage (Barney, 1991). The firm's resources that will be considered are the organisation's human resources, supply chain management, and their digital technology tools. These resources are vital to the implementation of sustainable procurement. As earlier discussed that corporate goals and strategies in driving sustainability can be effectively achieved if the workers are engaged in the implementation process (Schulz & Flanigan, 2016). Also, the position of the supply chains in the AEC sector that has made the main contractors dependent on their services in the delivery of their projects has made them be valuable organisational resources (London, 2008; Oyegoke et al., 2010). Lastly, collaboration amongst the various actors in the AEC sector would be largely dependent by the utilisation of digital technologies (Farmer, 2017; Roland Berger, 2016). This makes possession of digital technology tools and resources also to be a valuable resource. As it was earlier indicated that gaining a sustained competitive advantage can only be possible if firms utilise the various resources that enhance their capabilities (Barney, 1991). The complexities of the construction sector and their supply chains calls for the adoption of modern and innovative technologies/tools that will enhance collaboration and effective communication. Also, the World Economic Forum suggested that for the AEC sector to enhance their performance, there is the need for modern and advanced technologies to be adopted in their operations (World Economic Forum, 2018). Adopting and implementing such technologies in the AEC sector have the greatest potential of enhancing the effective implementation of sustainable procurement and delivery the best value for construction clients (Naoum & Egbu, 2016; Saieg et al., 2018). The next section reviews the role and application of digital technology in sustainable procurement.

2.10 Role of Digitisation in Sustainable Procurement

In driving sustainable procurement, apart from the cost implication, there is a need to have an understanding of other factors that will drive sustainability performance of a project (Wu et al., 2018). Focusing on the environmental, economic and social impact of the various construction products and processes is essential. Assessing the environmental impact provides the opportunity for firms to gain a competitive advantage in their bids. This claim was supported by Liu and Cui (2016), who demonstrated that firms that quantify and estimate the level of emission in a project stand a better chance of winning their bids. They further contended that quantifying or estimating the level of emission, enable construction clients and designers to know the level of impact of the various construction materials and products (Liu & Cui, 2016). Undertaking such an exercise is vital because organisations or firms that pay close attention to delivering effective environmental management can improve an organisation's image (To et al., 2015). Improving an organisation's image enables gaining a competitive advantage in the market, and improving relations with society due to better environmental performance (To et al., 2015).

The adoption of digital technologies can be beneficial to the AEC sector through an increase in profit and performance (Agarwal et al., 2018). Also, Farmer (2017) noted that the collaborative working of the industry would be enabled by future generations' acceptance of digital technology. In the same manner, Berger (2016) stated that the adoption of digital technology is changing the way organisations operate at different levels. They described digitization as a process where businesses encounter connected systems at every link in the value chain. It is about working with tools and practices based on information and communication technology. The Mckinsey group reported that compared to other economic sectors, the AEC sector is the least digitized (Agarwal

et al., 2018). However, the adoption of digital technology in the AEC sector could offer significant benefits (Saieg et al., 2018). The supply chain management of an organisation can be improved with the adoption of new technologies through managerial support and commitments (Papadonikolaki, 2016; Papadonikolaki et al., 2015). In driving sustainability, the managerial and technological abilities of a firm are related to the firms' performance (Li et al., 2013). For example, the adoption of digital technologies like the Building Information Modelling (BIM) in inter-organisational management will help in managing the inherent complexities of the industry and provide an effective way of managing the supply chain and construction processes (Papadonikolaki, 2016; Papadonikolaki et al., 2015).

Furthermore, in an earlier study, Irizarry et al. (2013) proposed a model which integrates building information modelling (BIM) and geographic information systems (GIS) into a unique system, which enables organisations to keep track of the supply chain status and provides warning signals to ensure the delivery of materials. Similarly, a supply chain cost model was proposed by Kim et al. (2016) suggesting the supply chain coordinator beyond understanding the whole supply chain cost, also need to understand the costs of the primary processes of the supply chain. Illustrating the application of IT systems for project planning, Abedi et al. (2014) proposed that cloud-computing technology has the valuable potential to mitigate the obstacles experienced in the pre-cast construction industry and also to develop an effective collaboration system. They explained that some of the problems identified in the pre-cast construction industry are poor planning and scheduling, less flexibility in design, production lead-time, heavy precast component, and poor on-site coordination.

2.10.1 Areas of Digital Technology Application in the AEC Sector

For the AEC sector to make progress in their operations and practice, the Mckinsey group, Roland Berger Consulting and World Economic Forum identified five specific areas (see Figure 21) that digitization can be beneficial to the AEC sector. These areas are:

- i. **Higher-definition surveying and geolocation:** This application will help to resolve geological challenges that lead to time and cost overruns. This can be achieved through high-definition photography, 3-D laser scanning, and geographic information systems, enabled by drone and unmanned-aerial-vehicle technology.
- ii. **Building Information Modelling (BIM):** BIM technology is expected to provide a platform that will enable a collaborative process among team members. Some of the benefits that will be derived from the adoption of BIM technology is access to additional information about the asset scheduling, cost, sustainability, operations and maintenance. BIM technology has the potential to power new technologies such as prefabrication, automated equipment and mobile applications for team integration.
- iii. **Digital collaboration and mobility:** digital collaboration and mobility will enable the AEC sector and project teams in minimising and relying on the use of paper to manage construction processes and deliverables. Such processes as blueprints, design drawings, procurement and supply chain-orders, equipment logs, daily progress reports, and punch list can be effectively managed through digitization. Digital collaboration and mobile application will be in the form of a cloud-based, mobile-enabled field-

supervision platform that will integrate project planning, engineering, physical control, budgeting, and document management for large projects.

- iv. **The Internet of Things (IoT) and advanced analytics:** IoT technologies will help in capturing the vast amount of data generated on project sites. This will be achieved through the IoT-sensors and wire technologies that will enable equipment and assets to become “intelligent” by connecting them. On the construction site, IoT technologies would allow construction machinery, equipment, materials, structures, and even formwork to “talk” to a central IT platform to capture critical performance parameters. Sensors, near-field-communication devices, and other technologies can help monitor productivity and reliability. Potential uses include equipment monitoring and repair, inventory management, quality assessment, energy efficiency, and safety.
- v. **Future-proof design and construction:** the development of new building materials and construction approaches can lower costs and speed up construction while improving quality and safety. Development in building materials, construction approaches, pre-assembly, 3-D printing, and Robot-assembled construction will enhance the performance of the AEC sector.

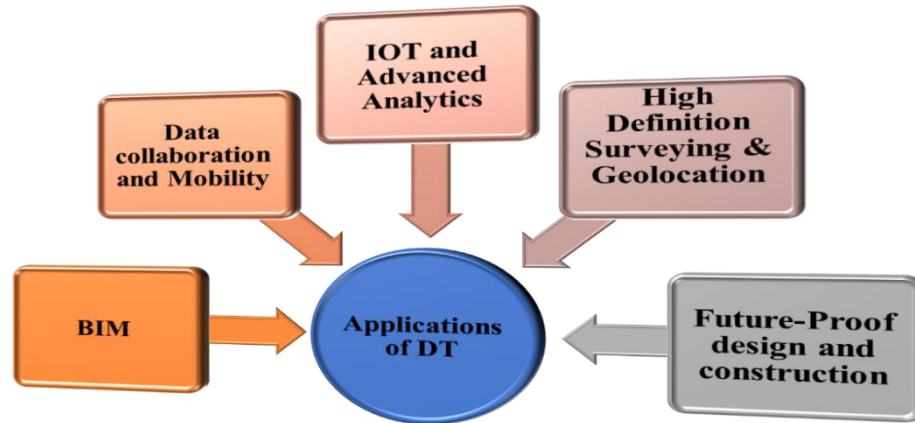


Figure 21: Application of Digital Technologies (DT) for Sustainable Procurement (Source: Author)

2.10.2 Examples of Application of Digital Technologies in Driving Sustainable Practice

Illustrating how digital technologies can drive sustainable construction practice, Akanbi et al. (2018) in a case design analysis, developed a mathematical model BIM-based Whole-Life Performance Estimator (BWPE). The model appraises the salvage performance of structural components of buildings from the design stage. The authors argued that apart from identifying the building materials or components that can be re-used or recycle, reduction of energy and landfill degradation are some of the likely benefits to be gain. Similarly, Al-Nassar et al. (2016) proposed a Life Cycle Impact Index (LCII) which enables comparison of alternative building elements under different scenarios. These scenarios are an eco-centric scenario that provides high emphasis to the environment; a neutral scenario that provides equal weights to the TBL of sustainability; and the economy-centric scenario that provides higher emphasis to the economic performance. Illustrating with a wall-roof system for low-rise commercial building construction in Canada, they found out that concrete-steel

building is the most sustainable alternative in the neutral and economy centric scenario.

In comparison, the steel-wood building is the most sustainable in the eco-centric scenario. Therefore, it is evident that the utilisation of digital technology tools and resources has the potential for improving collaboration and integration in the implementation of sustainable procurement. As discussed in section 2.9, that collaboration requires effective communication and sharing of data amongst the various team members (Beck, 2005). Sharing of data contributes to achieving a common goal and the project objectives (Fellows, 2006).

Furthermore, illustrating the benefit of using Life Cycle Analysis (LCA) Borghi et al. (2018) illustrated that the LCA could provide the best-case scenario to assess the impact of construction demolition waste (CDW). While, Gan et al. (2017), using the LCA technique in a case study of a 60-storey composite building in Hong-Kong, demonstrated that recycling of steel and concrete product tends to reduce the embodied carbon in a building by 60% and 10-20% respectively. These processes and techniques, as observed by Häkkinen et al. (2015), can be effectively utilised with BIM solutions and tools that can aid the design process in reducing GHG in buildings. However, they observed that some of the barriers that could affect the adoption of BIM technologies are lack of data availability for calculations purposes and lack of knowledge about reference and benchmark value. In addressing the challenge of data availability, Craggs et al. (2016) demonstrated using drones for reality capturing with the aid of a BIM model which enhances collaboration in retrofitting and redevelopment projects within an architectural Small and Medium Enterprise (SME) firm. Although the works of Craggs et al. need to be explored further to understand

the behaviour of the various team members during the planning of construction projects.

Other areas demonstrated on how digital technologies applications can enhance effectively, sustainable procurement was illustrated by Liu et al. (2014) in designing and planning of existing building exterior energy-saving design in a BIM environment. They conducted an energy simulation to determine the efficiency of the external shell of existing buildings. Their findings revealed that by using simulation estimates for verification, the results integrate a building environmental efficiency model (EEM) and evaluate its life cycle cost and efficiency (LCCE). They explained that the results found in the experiment could act as a reference for sustainable building design transformation principles. Similarly, in determining a suitable energy rating for a building, Wong and Kuan (2014) using BIM technologies in a residential building project seeking BEAM Plus sustainability rating in Hong Kong found out that BIM technology application enhances the accuracy of BEAM Plus submission. Achieving this accuracy was due to the potential of the BIM-based technology to update all information and the data automatically by providing the latest information on changes carried out during the design process. Although utilising the full potentials of digital technologies is primarily determined by the level of collaboration of the team members. Such collaboration is driven by the procurement route adopted as discussed from section 2.4 to 2.8. Also, one of the benefits that could be derived from the utilisation of digital technologies irrespective of the method of procurement is that it will enable several iterations to be carried out at several phases of the project. Therefore, how firms carry out such activities using digital technologies will be explored in this study.

Apart from determining the potential environmental impact, BIM technologies can aid in the assessment of material supply decisions. Ahmadian et al. (2017), proposed a framework for sustainability assessment of construction material supply chain decisions using BIM-enabled life cycle assessment into the supply chain and project constraints management. Undertaking a case study in Australia, they found out that the framework addresses the hierarchy of decisions in the material supply process, which consists of four levels including material type, the source of supply, supply chain structure, and mode of transport. The framework provides users with a decision-making method to select the most sustainable material alternative available for a building component and, thus, may be of great value to different parties involved in design and construction of a building. Although the authors noted that for effective implementation of the framework, availability of information to the various databases is very important (Ahmadian et al., 2017).

However, it is important to note that possession of digital technology tools alone by firms does not enhance a sustained competitive advantage for the firm. Rather the managerial capability through an effective process of organising and managing the digital tools in the firm is what enhances competitive advantage (Mata et al., 1995; Powell & Dent-Micallef, 1997).

In summary, and as outlined in Table 7, the various applications and utilisation of digital technologies innovations in driving sustainable procurement. From the review, it was found that digital technologies can aid in assessing the value of construction products to be salvaged either for re-use or recycling. Also, assessing alternative building elements; demolition waste assessment, quantifying the level of carbon emission and reduction, calculating the level of energy savings/rating; and materials supply selection decisions are some of the areas that digital technologies could

enhance sustainable procurement. This is because the adoption of sustainability practice has changed the way organisations practise by focusing on the function and performance of the products rather than focusing on sales (Elkington, 1997). Lastly, in driving the triple bottom line objectives and, gaining a sustained competitive advantage will require team collaboration and information sharing. How team collaboration and information sharing is carried out in the procurement of sustainable projects amongst main contracting firms and their supply chains, need to be further explored.

Table 7: Summary of Studies on Application of Digital Technologies in Sustainable Procurement

S/N	Author(s)	Focus
1	Akanbi et al. (2018)	Salvage performance of building materials.
2	Al-Nassar et al. (2016)	Sustainability of various building elements and products.
3	Borghini et al. (2018)	Environmental performance of construction demolition waste.
4	Gan et al. (Chan, 2017)	Quantification and analysis of embodied carbon in high rise building
5	Häkkinen et al. (2015)	Reducing embodied carbon during the design process
6	Liu et al.(2014)	Energy-saving design using BIM models.
7	Liu and Cui (2016)	Bids discount on low-carbon buildings.
8	Nanyam et al. (2017)	Evaluating off-site technologies alternative
9	Rietbergen et al. (2015)	Application of CO2PL for analysing CO2 reduction.
10	Santos and Lane (2017)	Material recovery (an example of steel)
11	Wong and Kuan (2014)	Application of BIM in enhancing the rating of buildings (BEAM Plus)
12	Wong et al. (2016)	Factors for implementing Green Procurement practice
13	Wu et al. (2018)	Decoupling relationship between economic output and carbon emission
14	Ahmadian et al. (2017)	Material selection
15	Craggs et al. (2016)	Reality capturing using BIM models for information sharing.

2.11 Underpinning Theory

Disciplines like construction management/economics borrow theory and methods from other mature disciplines (Fellows & Liu, 2020). In calling for applying theories in sustainable procurement, Grob and Benn (2014) and Walker et al. (2012) observed paucity of research that utilises theories to explain sustainable procurement practices in an organisation. Also, in terms of the epistemological orientation of sustainable procurement literature, Hoejmose and Adrien-Kirby (2012) noted that most of the studies are quite descriptive that fails to contribute to theory. Therefore, for any significant contribution to be made by a researcher in his/her research, it is expected that industry best practices will have to be underpinned on a theoretical base (Farrell et al., 2016).

In understanding construction organisational strategies and processes, different underpinning theories have been used. For example, Taggart *et al.* (2014) applied the Lean theory to understand the role of the supply chain in the reduction of construction rework and defects. While Olanipekun *et al.* (2017) use self-determination theory (SDT) to explain the motivation levels for the adoption of green building. However, in terms of understanding supply chain management in the AEC sector, Fernie (2005) argued about the difficulty in identifying a single theory for understanding supply chain management but demonstrated how other borrowed theories could be used. Furthermore, Carter et al.(2021) suggested the need of developing a supply chain specific theory.

Regarding adopting sustainability practice, different theories like stakeholder's theory, neo-institutional theory and transaction cost theory have been used (Boyd & Schweber, 2012; Sarkis et al., 2011; Touboulic & Walker, 2015). Therefore, in

answering the research question on "how do Irish Construction-Contracting firms embed sustainability in their procurement practices", different underpinning theories were considered. For example, lean theory considers maximising customer value while minimising waste (Broft, 2017; Marhani et al., 2012). In comparison, theories like institutional theories, stakeholder theory, and transaction cost theory focus on social structure or economic efficiency (Boyd & Schweber, 2012; Liang et al., 2017; Williamson, 1975). To address the research question, lean management theory that focuses on promoting efficient use of resources and waste reduction was appropriate.

Koskela (1992) explained that lean management focuses on defining value from the standpoint of the end customer and eliminating all waste in the business processes. He further noted that lean management helps in continuously improving all work processes, purposes and people. In relating lean management to sustainability, Marhani et al. (2012) noted that the construction industry benefits by maximising value and improved sustainability by implementing lean management. Also, applying lean management principles was a vital enabler for effectively implementing construction operations and supply chain management (Aslam et al., 2020). Lean management and sustainability have been noted to hold particular common objectives in promoting resource efficiency and minimising waste (Francis & Thomas, 2020). Although lean philosophy is not specifically designed to address sustainability issues, it promotes efficient use of resources and emphasizes waste reduction that eventually influences sustainability performance (Francis & Thomas, 2020; Saieg et al., 2018).

The complexity of the AEC sector has made exploring sustainable procurement practices of contracting firms be best understood from multiple perspectives (Barrett & Sutrisna, 2009; Sutrisna & Barrett, 2007). Therefore, how the lean principles are utilised in driving sustainable procurement practices of the top-fifty construction-

contracting firms is explored. As stated in chapter one, learning from large construction firms could be beneficial to knowledge because their practice is often regarded as the benchmark of the learning model for other firms (Chang, Zuo, et al., 2016). As shown in figure 22, the various organisational resources that will be explored are human capital resources, organisational capital resources (supply chains), and physical capital resources. The various organisational policies influence the utilisation of such resources. For example, utilising digital technologies using lean principles in a construction organisation is expected to deliver continuing financial benefit, efficient use of time, and the ability to support automation (Büyüközkan et al., 2021; Yevu et al., 2021). Other benefits are effective coordination, and conformity which are identified as highly critical in design. Furthermore, Kurdve & Bellgran (2021) explained that construction practitioners would have to be innovative to contribute to the sustainability performance of the industry. Utilising lean principles has been noted to create a synergy in the construction stages, specifically during the planning and decision making (Francis & Thomas, 2020). Therefore, how do construction-contracting firms utilise these principles in embedding sustainability in their procurement processes?

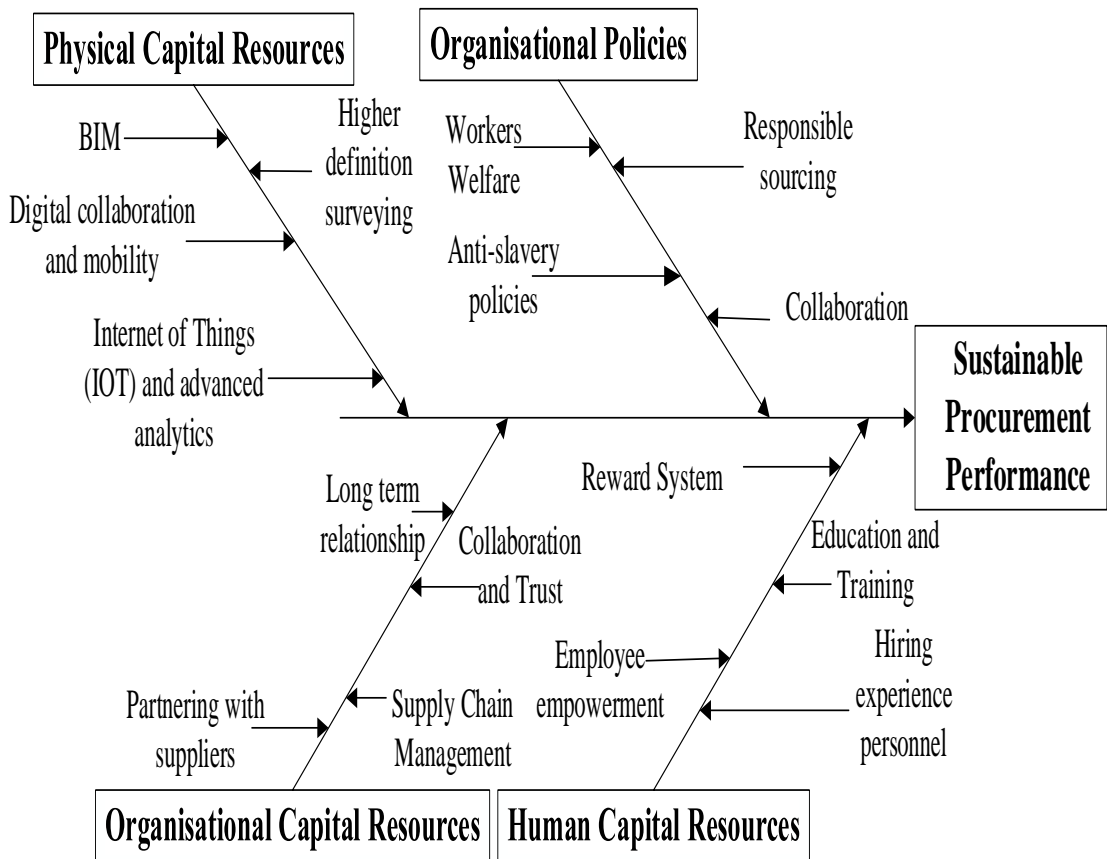


Figure 22: Conceptual Framework

2.11 Summary of Literature Review

From the literature review, it has been noted that the AEC sector globally has been transformed because of the adoption of sustainable construction practice. This transformation was made by making sustainability a primary focus in their organisational policies and restructuring their governance structure (Berry & McCarthy, 2011; Boyd & Schweber, 2012). Other efforts made by the AEC sector, most especially leading contracting firms, is through working collaboratively with their clients and members of their supply chain in meeting their sustainability goals (Berry & McCarthy, 2011). In driving sustainable construction practice studies have shown that the size of the firm (annual financial turn over), client demands, and government laws and regulations are some of the major drivers (Adetunji et al., 2003; Bohari et al., 2016; Boyd & Schweber, 2012; Chang, Zuo, et al., 2016).

Sustainable procurement practice is aimed at ensuring that all goods and services procured or to be procured comply with the organisation's sustainability policy requirements. Implementing an effective and successful sustainable procurement practice requires close collaboration of all the team members (Fellows, 2006; Korkmaz & Singh, 2011; Woo et al., 2016). This collaboration can be achieved through aligning organisational policies with workers values (Eilers et al., 2016; Rickaby & Glass, 2017; Terouhid & Ries, 2016); supply chain collaboration and development (Dadhich et al., 2015; Sancha, Gimenez, et al., 2016; Sancha, Wong, et al., 2016); and effective utilisation of digital technologies (Agarwal et al., 2018; Naoum & Egbu, 2016; Roland Berger, 2016; World Economic Forum, 2016b). However, how construction-contracting firms strategise in utilising these resources are still not very clear in the academic literature.

It is however recognised that leading contracting firms are vital in driving the adoption of sustainability in the AEC sector (Riley et al., 2003), and their performance is much better than the average firms; as a result, their practices are often regarded as the benchmark of the learning model for other firms (Chang, Zuo, et al., 2016). Despite the critical role of leading contracting firms in sustainability implementation, there is still limited evidence of in-depth studies focusing on their sustainable procurement processes and practices.

In addition, the various sustainable procurement frameworks available tend to be generic and do not adequately recognise the peculiarity and uniqueness of the construction organisation set-up. As a result, there is a need for further exploration of contracting firm organisational practices on how sustainability is embedded in their procurement process. Doing this will help firms in identifying areas of improvement that will encourage them to improve their sustainable procurement practice. This is necessary because sustainable construction performance is dependent on the success of the procurement process that leads to a firm gaining a high-sustained competitive advantage.

CHAPTER 3

METHODOLOGY

3.0 Introduction

In undertaking a research project, the outcome depends on the research question(s) addressed, the patterns and techniques of searching, the location and subject material investigated and the analysis carried out (Fellows & Liu, 2008). This chapter discusses the procedures and methodological approach adopted in finding answers to the research questions raised. The central research question, as stated earlier, is to understand how Irish construction-contracting firms embed the concept of sustainability in their procurement practices. Also, other sub-questions to aid in answering the central research questions are:

Sub-Questions

1. How do contracting firms implement sustainable procurement practice in their organisation?
2. How do construction firms influence their supply chains in driving sustainable construction practices?
3. How have digital technologies promote successful sustainable procurement practice?

4. How can/have government policies and regulations promote sustainable procurement?

In carrying out academic research aiming to make a contribution to the body of knowledge in the relevant discipline, the researcher, in the applied sciences, is expected to make his/her methodological and epistemological assumptions as clear as possible (Knight & Turnbull, 2009). Selecting the appropriate methodology and methods is dependent on the research questions raised (Crotty, 1998; Fellows & Liu, 2008). However, the justification of the methods and methodology a researcher adopts in a study is strongly influenced by the assumptions about the reality the researcher brings to the study and consequently their theoretical perspective (Creswell, 2014; Crotty, 1998; Fellows & Liu, 2008). Thus, the research philosophy and methodology adopted for this study is presented.

3.1 The Research Process

Different authors have provided different means in undertaking research work. For example, Crotty (1998) proposed a four elements procedure that starts from epistemology, theoretical perspective, methodology, and methods. While Gray (2013), adapting the work of Saunders identified the elements of the research process as epistemology, theoretical perspective, research approach, research methodology, time frame, and data collection methods. Similarly, Creswell (2014) developed a framework that interconnects the three components in a research approach, namely philosophical worldviews, design, and research methods. Saunders et al. (2015) illustrated the research process as layers to be peeled (research onions). They identified the elements of the research process as philosophy, approach to theory development, methodological choice, strategy (ies), time horizon, and techniques and

procedures. Table 8 presents a summary of the various research process proposed by the authors.

Table 8: Summary of the Research Process

Crotty (1998)	Gray (2013)	Saunders et al. (2015)	Creswell (2014)
Epistemology/Ontology	Epistemology	Philosophy	Philosophical Worldview
Theoretical Perspective	Theoretical Perspective		
	Research approach	Approach to theory development	
		Methodological choice	Research approach
Methodology	Research methodology	Strategy (ies)	Research Design
	Time Frame	Time horizon	
Methods	Data collection methods	Techniques and procedures	Research Methods

From the summary presented (Table 8) going through the various process, the procedure suggested by Saunders et al. (2015) as shaded tends to be more elaborate. Therefore, it will be adopted throughout this study.

The following sections present the underpinning philosophy and methodologies associated with this research project.

3.2 Research Philosophy

The term research philosophy refers to the system of beliefs and assumptions about the development of knowledge (Saunders et al., 2015). In the development of knowledge, there are two primary tasks faced by a researcher. The first task deals with the issues of methodologies and methods to be employed in undertaking the research, while the second task is about justifying the use and selection of the chosen methodologies and methods (Crotty, 1998). The second task is dependent on the research question(s) that the research will seek to answer. Also justifying the chosen methodologies and methods is significantly influenced by the assumptions about the reality a researcher brings to his/her work (Creswell, 2014; Crotty, 1998; Saunders et al., 2015). To ask about this assumption, as Crotty (1998) discussed is to ask about the theoretical perspective. Creswell (2014) refers to a theoretical perspective as a worldview, while Saunders et al. (2015) refer to a theoretical perspective as philosophy, and Guba and Lincoln (1994) refer to it as a paradigm. For uniformity and clarity, the term philosophy is used in this study.

In driving academic research, different philosophical assumptions are employed. These assumptions are ontology, epistemology, and axiology. A researcher chooses a stance on each of these assumptions; such choice influences the designing and conducting of the research (Creswell, 2007). Furthermore, there is a need to distinguish between the different assumption made by each philosophical position (Saunders et al., 2015). The next section discusses these various research assumptions.

Ontology

The philosophical framework within which a project is situated provides evidence of the world view within which the research is situated and tells us something of the

ontological position of the researcher, their understanding of the nature of reality, about the research being undertaken (Quinlan, 2011). Ontology is the study of the nature of reality. It is concerned with the question of “what is” the nature of existence and structure of reality (Crotty, 1998). Crotty (1998), further explained that ontological assumptions are divided between two extremes, namely realism (objectivism) and idealism (subjectivism). Objectivism incorporates the assumptions of natural sciences that argue that social reality that we study is external to us and others (referred to as social actors) (Saunders et al., 2015). A researcher taking an objectivists perspective views reality as made up of solid objects that can be measured and tested, which exist even when the object is not directly perceived or experienced (O’Gorman & MacIntosh, 2014). The objectivists believe that the interpretations and experiences of social actors do not influence the existence of the social world, and also believe that there is only one true social reality experienced by all social actors (Saunders et al., 2015). The objectivist perspective denies the researcher the opportunity to bring his experience into the study. For a researcher to bring in his experiences and worldview into the research, the idealism stance (subjectivism) is proposed.

The subjectivism ontological stance incorporates the assumptions of the arts and humanities. They consider reality as made up of the perceptions and interactions of living subjects (O’Gorman & MacIntosh, 2014; Saunders et al., 2015). Besides, the subjectivist ontology sees facts as culturally and historically located and therefore, subject to the variable behaviours, attitudes, experiences, and interpretations. The subjectivists are of the view that there is no underlying reality to the social world beyond what people (social actors) attribute to it because of each person experiences

and perceive reality differently which gives ground to multiple realities (Saunders et al., 2015).

In understanding, how leading construction-contracting firms in Ireland embed sustainability issues in their procurement process, the researcher first appreciated the fact that research in the built environment is built up from different disciplines like mathematics, natural sciences, social sciences, arts and humanities (Fellows & Liu, 2008). These different disciplines make undertaking research in the built environment quite complex because the product of the construction process can be considered an object that can be physically examined. However, the different perceptions of the stakeholders to the construction process can be understood as a socially constructed phenomenon (Sutrisna & Barrett, 2007). In deciding the ontological position of this work, the researcher brought his personal experience and values of having the privilege of working in the construction sector in Nigeria and Ireland. The researcher's experience and understanding influenced his choice of philosophical assumptions.

Ontologically, the nature and set-up of the construction industry are quite complex. The complexity of the sector has made exploring sustainable procurement practices of contracting firms to be best understood from multiple perspectives. For example, the objectivist ontological stance in viewing the disconnect between construction-contracting firms' vision with that of their supply chain vision, will focus mostly on viewing the sector as external to the researcher. This stance limits the researcher in appreciating the roles and influence of the various actors because an objectivist believes that the interpretations and experiences of social actors do not influence the existence of the social world (Saunders et al., 2015). On the other hand, the subjectivists (idealist) will view the set-up of the construction sector and the behaviour of the various actors as socially constructed. Socially constructed in the sense that each

person experiences and perceive reality gives ground to multiple realities (Saunders et al., 2015). Therefore, the subjectivists (idealists) ontology is more appropriate in understanding leading firms' sustainable procurement practices. The complexity of the construction sector and the peculiarity of construction projects from the subjectivist point of view gives a better understanding of the study.

When a researcher has identified his/her ontological stance, the next task faced in communicating the knowledge gained to others. In communicating the knowledge, assumptions about what constitutes acceptable, valid, and legitimate knowledge are considered. These questions are questions of epistemology.

Epistemology

Epistemology is the theory of knowledge; it is the branch of philosophy concerned with what knowledge is and how it is created. Epistemology is concerned about the relationship of the knower or would-be knower and what can be known (Guba & Lincoln, 1994). Quinlan (2011) noted that epistemology addresses questions about the methodology and methods used in the research project, which relates to our understanding of knowledge and how it is created and the value we ascribe to knowledge. While Crotty (1998), asserts that epistemology is concerned with providing a philosophical grounding for what kind of knowledge is possible and how we can ensure that they are both adequate and legitimate. Answering epistemological questions is dependent on the ontological stance taking by the researcher (Guba & Lincoln, 1994). A researcher is confronted with different varieties of epistemologies that gives a much greater choice of methods in undertaking academic research (Saunders et al., 2015). The most common types of epistemologies, as suggested by Creswell (2014) are post-positivism, constructivism, transformative, and pragmatism.

- i. **Post-positivism:** it is also referred to as positivism, and it is aligned more to quantitative research. The assumption holds the view that there is only one objective reality. Post-positivist holds a deterministic philosophy in which causes determine effect or outcomes (Creswell, 2014). Hence, the problems studied by post-positivist reflect the need to identify and assess the causes that influence outcomes, such as found in experiments. Furthermore, it is also reductionistic, in that the intent is to reduce the ideas into small, discrete sets to test, such as the variables that comprise hypothesis and research questions. Crotty (1998) argues that the post-positivist view of what it means to know, understandings and values are considered to be objectified in the people or object being studied. When it is carried out in the right way, then objective truth can be discovered. The results from the post-positivist will likely be regarded as objective and generalisable. However, the results will be limited in providing a rich and complex view of organisational realities, accounting for the differences in individual contexts and experiences (Saunders et al., 2015).

The positivist epistemology has been challenged within construction management research. This is a result of scientific foundation could no longer apply to a discipline where the main focus of the study is the people and organisational processes (Seymour et al., 1997). This limitation makes this epistemological view unsuitable in the exploration of the sustainable procurement practices of construction-contracting firms.

- ii. **Constructivism:** this epistemological stance is more aligned or seen as an approach to qualitative research. It is also called social constructivism which is combined with interpretivism (Creswell, 2014). Crotty (1998)

argued that the constructivists reject the view of the post-positivist by claiming that there is no objective truth waiting to be discovered. However, rather a truth, or meanings, comes into existence in and out of our engagement with the realities in our world as meaning is not discovered, but constructed. Similarly, Creswell (2014) explained that social constructivists believe that individuals seek understanding of the world in which they live and work. Also, individuals develop subjective meanings of their experiences-meanings directed towards specific objects or things. Closely related to constructivism is subjectivism. A subjectivist believes that meaning does not come out of an interplay between subject and object but is imposed on the object by the subject (Crotty, 1998). Also, Saunders et al. (2015) assert that social reality is made from the perceptions and consequent actions of social actors (people). They further explained that the order and structures of social phenomena we study and the phenomenon themselves are created by researchers and by other social actors using language, conceptual categories, perceptions, and consequent actions. Although, the ontological stance for the study aligns towards the subjectivist's perspective, which it is seen to align with the constructivist's epistemology. Therefore, in addressing the central research question the constructivist's epistemology will address the research questions in this study in only a limited manner. An alternative approach is needed.

- iii. **Transformative:** This assumption focuses on the needs of groups and individual in a society that may be marginalised or disenfranchised. The assumption criticises the post-positivist and constructivists assumptions by arguing that the positivists' assumption imposes structural laws and

theories. Such laws and theories do not fit marginalized individuals in society or address the issues of power and social justice, discrimination, and oppression. In contrast, the constructivists' assumption does not go far enough in advocating for an action agenda to help the marginalized people (Creswell, 2014). Jackson et al. (2018) assert that the transformative paradigm emphasises the use of qualitative and mixed methods to outline the ecological complexity of a situation and to access the voices of those who have historically been marginalised. Within this framework, unique knowledge may be obtained through building relationships of trust with participants and that this knowledge might not be accessible through other methods. In order to avoid marginalising the participants during the inquiry, the participants are engaged in designing the questions, collecting the data, analysing the information, and also benefiting from the rewards of the research (Creswell, 2014). However, this approach is primarily focused on marginalised in society, which does not align with the focus of this study.

- iv. **Pragmatism:** this form of epistemology arises out of actions, situations, and consequences rather than antecedent conditions (as in post-positivist) (Creswell, 2014). Pragmatism, as a paradigm has disrupted the assumptions of earlier approaches based on the philosophy of knowledge while providing promising directions for understanding the nature of social research (Morgan, 2014). Morgan (2014) further argued that pragmatism points to the importance of joining beliefs and actions in the process of inquiry that underlies any search for knowledge, including the specific activity that we refer to as research. In attempting to address a research

problem, the pragmatist views an inquiry as open-ended, seeking to provide tools which will enable us as participants to cope with the world (Bacon, 2012). Additionally, a pragmatist epistemology views knowledge as constructed with a purpose to manage one's existence better and to take part in the world (Kaushik & Walsh, 2019).

Furthermore, pragmatism focuses on the problem of the research to provide a practical solution, and it is not committed to any one system of philosophy and reality (Creswell, 2014; Denscombe, 2002; Saunders et al., 2015). Focusing on the practical solution of the problem has been observed by anti-pragmatist as one of the weaknesses of pragmatism because what is meant by usefulness or workable can be vague unless explicitly addressed by a researcher (Johnson & Onwuegbuzie, 2004). Such weaknesses, as suggested by Johnson and Onwuegbuzie (2004), can be addressed by the researcher being reflexive and strategic in avoiding such weaknesses. A researcher adopting this worldview will be using multiple methods of data collection or what some authors referred to a plurality of methods to collect data that best answer the research question and will employ both qualitative and quantitative sources of data collection (Creswell, 2007).

In answering the research question for this study, it requires exploring and adopting different techniques and methods. Doing this provides the researcher with the opportunity of having an in-depth understanding of contracting firms' practices. Therefore, the pragmatist's epistemology will be most appropriate in undertaking this study. The pragmatist assumption compared to other philosophical assumptions, provides the advantage to the researcher to join his beliefs and actions in the process

of inquiry and provides promising directions for understanding the nature of social research or reality. Another advantage in adopting the pragmatist position in this study is because sustainable procurement requires the close collaboration of the various actors in the delivery of a project (Lin & Tseng, 2016; Sancha, Gimenez, et al., 2016; Wu & Barnes, 2016). Exploring how this collaboration takes place in the delivery of sustainable projects will be much appreciated when the researcher attempts to understand the problems from a practical point of view and try to proffer solutions that will inform future practice.

Axiology

Axiology is the philosophical study of value, often seen as the collective term for ethics and aesthetics (O'Gorman & MacIntosh, 2014). The axiological position addresses how researchers deal with both their values and those of the research participant (Saunders et al., 2015). Saunders et al. (2015) further state that a researcher's choice of philosophy and data collection technique reflects his/her values. Values inform the bias, which an individual brings to the research. O'Gorman and MacIntosh (2014) highlighted that individuals have their biases but what is important is how the biases are dealt with or acknowledged when undertaking the study. Concerning the role of values from a pragmatist stance, the research will be value-driven. As earlier stated, the researcher's experience in the construction industry in Nigeria and Ireland influences his choice of the philosophical stance. Also, it makes the role of value in this study to be driven by the problem been investigated.

3.3 Approach to theory development

In finding ways to answer research questions, a researcher is confronted with choosing the best approach in answering the questions raised (Blaikie, 2010). The three main approaches available to the researcher to adopt are deduction, induction, and abduction, but a fourth approach known as retroductive is used by some authors like Blaikie (2010). **The Deductive** approach to theory development is more aligned with the scientific method of discovery. The deductive approach attempts to find an explanation for an association between two concepts by proposing a theory, the relevance of which can be tested (Blaikie, 2010; Saunders et al., 2015). Saunders et al. (2015), explained that the deduction approach possesses some essential characteristics that enable researchers to use a structured methodology to describe the causal relationship. Also, it allows concepts to be operationalised (reductionism) in a way that will enable facts to be measured, often quantitatively, and the third characteristics of the deductive approach are that it enables the generalisation of findings. The second approach to theory development is the **Inductive approach**. The inductive approach is aimed at establishing limited generalisations about the distribution of, and patterns of association amongst, observed or measured characteristics of individuals and social phenomena (Blaikie, 2010). The inductive approach to reasoning is likely to be particularly concerned with the context in which events take place (Saunders et al., 2015). Also, a study of a small sample of objects might be more appropriate when adopting the inductive approach to reasoning, unlike using a large sample in the deductive approach (Saunders et al., 2015). Nevertheless, it is essential to note that descriptions produced by the inductive approach are limited in time and space and are not universal laws as claimed by its original proponents (Blaikie, 2010). Gill and Johnson (2002) clarified that deductive research method

requires the development of a conceptual and theoretical structure before testing through empirical observation while the inductive method is the reverse of deduction, as it tends to move from empirical world to the construction of explanations and theories on what was observed.

The third approach to theory development is the **Abductive approach**. The Abductive approach combines the Deductive and Inductive approach. The inductive approach can be used to answer ‘what’ questions and the Deductive approach can be used to answer ‘why’ questions, but the Abductive approach can answer both types of questions (Blaikie, 2010). Blaikie (2010) explained that the abductive approach answers the ‘why’ question by producing understanding rather than an explanation, and by providing reasons rather than causes. The abductive approach is quite like the inductive approach; the difference is a subtle one because the two approaches use evidence to form guesses that are likely, but not guaranteed to be true. However, abductive reasoning looks for the cause and effect, which is grounded on the world view of the research context. At the same time, induction seeks to determine general rule (Blaikie, 2010; Bryman, 2016). A researcher is leaning towards the abductive approach when he/she collects data to explore a phenomenon, identify themes and explain patterns or suggest a plausible hypothesis, or generating a new or modifying an existing theory, which will be subsequently tested through additional data collection (Mitchell, 2018; Saunders et al., 2015; Walton, 2001). In other words, abduction could be explained as a knowledge-extending means of drawing an inference, as distinct from the normal logical conclusion based upon either pure deduction or induction (Eriksson & Lindström, 1997; Mitchell, 2018). Walton (2001), further explained that this form of logical reasoning has often been equated with inference to the best explanation. However, such explanations or conclusions are

provisional commitments that are subject to retraction in the future. Therefore, the abductive approach incorporates what the Inductive and Deductive approach ignores. The incorporation is by discovering why people do what they do by uncovering the largely tacit, mutual knowledge, the symbolic meanings, intentions and rules, which provide the orientations for their actions (Blaikie, 2010). Also, in theory, a development it is only abduction that initiates action since it can open a new way of thinking in relation to practice. It does so by making possible an abstract manner of thinking, which may lead to new insights and to a discovery of meaningful connections (Eriksson & Lindström, 1997).

In summary, the abductive inference can be defined as having three stages (Walton, 2001), as shown in Figure 23 these stages include first, a set of premises that report observed findings or facts the known evidence in a given case. Second, it searches around among various explanations that can be given for these facts. Third, it selects out the inference for the best explanation and concludes that the selected explanation is acceptable as a hypothesis. The researcher's judgement in accepting the inference for best explanation will be based on the plausibility and explanatory power of the explanation (Harman, 1965; Josephson & Josephson, 1996; Lipton, 2004). Harman (1965), enlightened that such plausibility and explanatory power of the explanation will be based on knowledge from authority and knowledge from the mental experiences of other people.

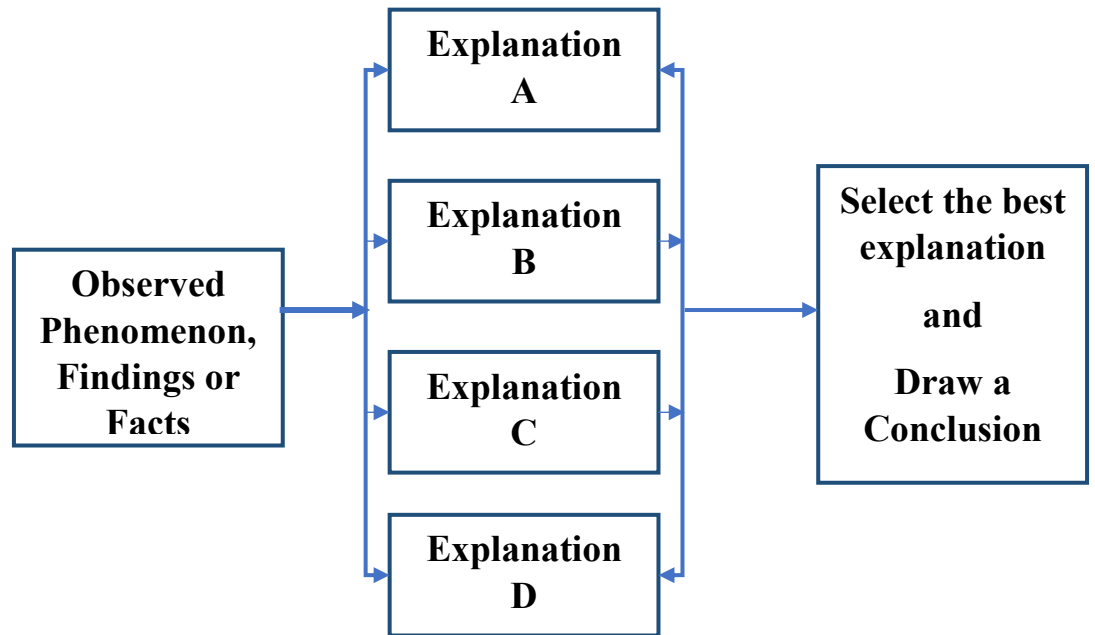


Figure 23: The Abductive Reasoning Process (Source: Author)

Therefore, understanding how construction-contracting firms in the Republic of Ireland embed sustainability in their procurement practice, requires a back and forth approach. Adopting the back and forth approach is necessary because of the paucity of studies in unveiling sustainable procurement practices of construction firms. Therefore, abductive approach becomes more appropriate in understanding a firm procurement practice. Using the abductive approach enables constant switching between empirical observations and theory which generates a greater level of understanding of both empirical phenomena and theory (Dubois & Gadde, 2002; Upstill-Goddard et al., 2016) This advantage of switching between methods provide the opportunity of collecting data from multiple sources such as documents, surveys, and interviews to enable a better understanding of the research problem. A summary

to illustrate the deduction, induction, and abduction is shown in Table 9 (Saunders et al., 2015).

Table 9: Deduction, Induction and Abduction: From Reason to Research

Source: (Saunders et al., 2015)

	Deduction	Induction	Abduction
Logic	In deductive inference, when the premises are true, the conclusion must also, be true	In inductive inference, known premises are used to generate untested conclusions	In an abductive inference, known premises are used to generate testable conclusions
Generalisability	Generalising from the general to the specific	Generalising from the specific to the general	Generalising from the interactions between the specific and the general
Use of data	Data collection is used to evaluate propositions or hypotheses related to an existing theory	Data collection is used to explore a phenomenon, identify themes and patterns and create a conceptual framework	Data collection is used to explore a phenomenon, identify themes and patterns, locate these in a conceptual framework and test this through subsequent data collection and so forth
Theory	Theory falsification or verification	Theory generation and Building	Theory generation or modification. incorporating existing theory where appropriate, to build new theory or modify existing theory

3.4 Methodological choice

The methodological choice also referred to as research approaches by Creswell (2014) provide the direction in deciding the methods and procedures to be adopted in a study. Creswell (2014), explains that the strategy of inquiry to be applied in research lies within any of the three types of methodological choice. The different kinds of methodological choice (research approaches) available to a researcher in a study is either the quantitative approach, the qualitative approach, or the mixed methods. The choice of the methodological choice is reliant on the research problem and questions, personal experience of the researcher, and the audience the researcher is writing to (Creswell, 2014). The **quantitative** choice is mainly associated with the numerical form of data collection through the use of questionnaires or data analysis procedure like graphs or statistics that generate or uses numerical data (Saunders et al., 2009). The quantitative methodological choice is mostly associated with the post-positivist world view (Creswell, 2014). Some of the few research strategies that adopt the quantitative approach are experiment or quasi-experiment, and survey methods. The second form of the methodological choice is the **qualitative approach**. The qualitative approach is used in the collection or analysis of non-numerical data. Data collection technique such as interviews or data analysis procedure such as categorising data adopts the qualitative approach.

Apart from using words, qualitative can also refer to pictures or video clips (Saunders et al., 2009). Examples of some of the research strategies that are guided by the qualitative approach include ethnography, narrative research, grounded theory, phenomenological research, and case studies (Creswell, 2014; Denscombe, 2002). The qualitative approach uses data that tends to be open-ended without predetermined responses while the quantitative approach uses data that the responses are usually

closed-ended such as found in questionnaires (Creswell, 2014; Denscombe, 2002). However, the use or application of the term qualitative or quantitative has been erroneously applied in research, for example some of the research approaches categorized as qualitative in the real sense are quantitative (Ketokivi & Choi, 2014). Ketokivi and Choi (2014), offer a definition based on the meaning of words qualitative and quantitative. The defined qualitative approach as an approach that examines concepts in terms of their meaning and interpretation in specific context of inquiry. While quantitative approach examines concepts in terms of amount, intensity, or frequency.

Some level of biases and weaknesses is observed to lie with both the quantitative and qualitative approaches. To neutralise the weaknesses of each form of data, the researcher collects both quantitative and qualitative data in the same study (Creswell, 2014). The combination of these two approaches is what is known as the **mixed-method approach**. The mixed-method approach provides the advantage of triangulating the data to corroborate research findings within a study (Saunders et al., 2009). This is to enable the researcher to both draws from the strengths and to minimize the weaknesses of a more traditional single approach (Mitchell, 2018). Data collection using this approach could be either through **convergent parallel mixed methods, explanatory sequential mixed methods, or the exploratory sequential mixed methods** (Creswell, 2014; Saunders et al., 2009). The **convergent parallel mixed methods** enable the researcher to converge or merge the quantitative and qualitative data to provide a comprehensive analysis of the research problem.

In this approach collection and analysis are roughly carried out at the same time. Contradictions or contrasting findings are further probed or explained (Creswell, 2014). On the other hand, the **explanatory sequential mixed methods** obtain, and

analyses quantitative data first and then build on the results to describe them in more detail with qualitative research. This type of design is most preferred in research that has a high quantitative orientation. Finally, **exploratory sequential mixed methods** are the opposite of the explanatory sequential mixed methods. The researcher begins with the qualitative research phase and explores the view of participants. The data is subsequently analysed, and the results are used to develop the questions for the quantitative phase of the research. Creswell (2014), noted some weaknesses in the explanatory and exploratory sequential mixed methods. He argued that identifying the quantitative results that will be further explored and the unequal sample sizes for each phase of the study are some of the challenges facing the explanatory sequential mixed methods. While focusing on the relevant qualitative findings to use and the sample selection for both phases of the research are some of the challenges using the exploratory sequential mixed methods.

Situating the research on the pragmatist's epistemology, and the abductive approach to knowledge development, the **mixed-method** approach is more appropriate for this study. The mixed-method has the advantage of enabling the researcher to address more complicated research questions and to collect a richer and stronger array of evidence that cannot be accomplished by any single method alone (Yin, 2009). The mixed method approach provides a robust methodology in solving and understanding construction industry problems (Love et al., 2002). Also, to provide an inference of best explanation, the convergent parallel mixed method is appropriate in collecting the data. This is because the abduction approach requires an integrated approach, and handling the interrelatedness of the various elements in the research work is one of the major challenges of case studies (Dubois & Gadde, 2002). Lastly, in designing mixed-method research, there is a need for researchers to address the problems identified in

mixed-method research approach. The problem of representation, legitimation, integration, and politics (Onwuegbuzie & Collins, 2007).

3.5 Strategy (ies)

Research strategies also referred to as methods (Yin, 2009), is the plan of action designed to achieve the research goal (Denscombe, 2014). The focus of the research informs the decision of the research strategy to be used in the study. Other factors are the research question or statement or the research hypothesis, and the type of data required for the investigation, and the location of that data (Quinlan, 2011). What distinguishes the various strategies, as proposed by Yin (2009), are the type of research question posed, the extent of control an investigator has over the actual behavioural events and the degree of focus on contemporary issues as opposed to historical events. Various research strategies are available in addressing a research problem. This study discusses four of the various research strategies. These are Experiments, Survey, Ethnography and Case Study.

- i. Experiments:** Experiments are mostly associated with the natural sciences. They are an empirical investigation under controlled conditions designed to examine the properties of, and the relationship between specific factors (Denscombe, 2014). Experiments help to answer the ‘how’ and ‘why’ questions, and also focuses on contemporary events and require control of behavioural events (Yin, 2009). The purpose of experimenting is to isolate individual factors and observe their effect in detail, by discovering new relationships or properties associated with the materials being investigated, or to test existing theories (Denscombe, 2014). The experimental design is difficult to be conducted in social science research because of the challenges in controlling all the different variables in social

science situations and phenomena (Quinlan, 2011). However, Denscombe (2014) argues that experimenting in social research provides the opportunity to capture the essence of the notion and incorporates the following three things that guide experimenting. These are the identification of causal factors, controls, and empirical observation and measurement. One of the major disadvantages of the experiment is that the exercise of control by the researcher may render the research situation artificial in that it cannot give us information about the natural occurring situations in which we are interested (Hammersley, 1992). This disadvantage of the experiment method that requires control of the conditions will not be suitable for exploring the research question of this study.

- ii. **Survey:** the survey strategy answers the ‘who’, ‘what’, ‘where’, ‘how many’, and ‘how much, questions (Yin, 2009). It is mostly related to the deductive approach. Explaining the advantages of using the survey approach, Denscombe (2014) states that surveys are useful in getting information about a large number of people. Secondly, it works best with clear and narrow targets in terms of the information it is trying to gather. Third, surveys are best suited to gathering on a relatively straightforward, relatively uncomplicated facts, thoughts, feelings or behaviours. Fourth, they are particularly useful when looking for a pattern of activity within groups or categories of people (rather than individuals). However, one of the significant weaknesses of the survey strategy is that the data collected is unlikely to be as wide-ranging as those collected by other methodological choices. This is because there is a limit to the number of

questions that a researcher can ask in a questionnaire if the goodwill of the respondent is not to be presumed (Saunders et al., 2009).

Furthermore, Fellows and Liu (2008) stated that techniques for collecting data in a survey such questionnaires and interviews, are highly labour intensive on the part of the respondents and particularly on the part of the researcher. They further explained that a low response rate is quite common, notably with the postal questionnaires, which can expect a 25-35% useable response rate. The survey strategy can be carried out through with the aid of a postal questionnaire, internet survey, face to face interviews, telephone interviews, documents and observation (Denscombe, 2014). The survey approach answers how many or how much questions. This strategy generalises the results of the study, which will make it of limited suitability in understanding how firms embed sustainability in their procurement process.

- iii. Ethnography:** When a researcher is interested in conducting an in-depth examination of cultural practices and traditions or in interpreting social interaction within a culture, that researcher is engaged in ethnography research. Quinlan (2011), explained that a researcher that adopts ethnography goes inside the culture being investigated to develop a profound understanding of it. The researcher participation in understanding the culture enables him/her to be able to document the culture, and also at the same time outside of the culture to be able to record the culture as well. The primary aim of adopting ethnography strategy is to be able to determine meanings and the processes through which the members of the group make the world meaningful to themselves and others

(Fellows & Liu, 2008). Saunders et al. (2009) suggested that in carrying out ethnography research, the research process needs to be flexible and responsive to change because the researcher will always be developing new patterns of thought about what is being observed. Also, Saunders et al. (2009) further stated that ethnography is time-consuming and takes place over an extended period as the researcher needs to immerse herself or himself in the social world being researched as wholly as possible. Ethnography would be a suitable approach to understanding construction firm's sustainable procurement practices. However, due to the time constraint in undertaking ethnography and some likely industry restrictions to sensitive data, it is deemed unsuitable in this instance.

- iv. Case Study:** The case study research strategy answers how, and why questions. It is used in many situations to contribute to our knowledge of the individual, group, organisational, social, political and related phenomena (Yin, 2009). The case study strategy involves the investigation of a relatively small number of natural occurring (rather than researcher created) cases (Hammersley, 1992). It arises out of the need to understand complex social phenomena (Yin, 2009), Yin (2009), defined a case study as *“as an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are not clear”*. Also, a case study focuses on understanding the dynamics present within a unique setting and usually refers to a relatively exhaustive analysis of a single instance of a phenomenon being investigated (Amaratunga et al., 2002). Therefore, the aim of case studies cannot be to infer global findings from a sample to a

population, but rather to understand and articulate patterns and linkages of theoretical importance (Amaratunga et al., 2002). In terms of exploring the existing theory, Saunders et al. (2009), argued that a well-constructed case study provides the researcher with the opportunity to challenge existing theory and also provide a source of new research questions.

Some of the drawbacks against the case study method as noted by Yin (2009) are that, first, the researcher views might be biased which influence the findings and conclusions of the research. The second concern is that it provides little basis for scientific generalisation, and the third concern is that the process in conducting a case study takes too long time resulting in large, unreadable documents. Although, the issue of the large documents has been overcome with developments in information technology. The case study approach provides the researcher with tentative ideas about the social phenomenon, based on knowledge about the studied event or about the organisation or group, and how it all came about. That is to say, a case study is appropriate in answering the broad research questions, by providing us with an in-depth understanding of how the process develops in the case in question (Swanborn, 2010).

A case study can be designed either as a single case (holistic) or single-case (embedded) design, or multiple cases (holistic) and multiple case (embedded) design (Yin, 2009). A researcher conducting a single case study focuses on an in-depth understanding of a case while when conducting a multiple case study, the researcher focus is on comparing two or more phenomenon or cases. More discussion on case study design will be presented in subsequent sections of this study.

To answer the research question of how? The case study strategy compared to other strategies provides the advantage of exploring in-depth sustainable procurement practice of Irish contracting firms. Also, it aligns well with the pragmatist way of examining complex problem using different approaches. The benefit in the use of case study in construction research is its reliability in capturing rich information for the investigation by providing the researcher(s) with the opportunity of retaining the holistic and meaningful characteristics of real-life events (Barrett & Sutrisna, 2009). Therefore, exploring how construction-contracting firms in Ireland embed sustainability in their procurement processes can appropriately be explored through the case study strategy. Further discussion and justification on the appropriateness of the case study approach are discussed in section 4.8.

3.6 Time horizon

In planning a research work, the time scale available to the researcher should be adequately put in focus (Gray, 2013). The time horizon provided in a study could either be cross-sectional or longitudinal (Saunders et al., 2009). They further explained that the cross-sectional studies usually are time-constrained, but it gives a snapshot of an event at a time. Also, the cross-sectional studies seek to describe the incidence of a phenomenon or to explain how factors are related to a different organisation. While the longitudinal time horizon takes the form of a diary or series of snapshots that represent events over a given period. The advantage of the longitudinal studies is that it provides the opportunity for a researcher to study change and development in a society or organisation which enable the researcher to have a better and in-depth understanding of the problem (Gray, 2013; Saunders et al., 2009). In undertaking this

doctoral study that is time-bound for four (4) years, adopting the longitudinal would not be appropriate considering the financial and time constraint. These constraints have made the researcher utilise the **cross-sectional time horizon** than the longitudinal.

3.7 Techniques and procedures

The final stage of the research process is the techniques and procedures adopted for the collection of the data. Different methods and techniques are available for data collection. The conventional methods are questionnaires, interviews, observation, and documents. In determining a suitable method for data collection Denscombe (2014) and Gray (2013) provided some key points to be considered, these are:

- i. The relationship of the research strategy with methods to be adopted;
- ii. The strength and weaknesses of each of the methods having it at the back of the researcher's mind that there is no perfect or useless method;
- iii. When choosing a method, its usefulness needs to be considered "horses for courses".
- iv. Research methods should not be mutually exclusive, that is using more than one method in compensating for weaknesses of the others is quite an acceptable approach;
- v. The use of triangulation when more than a method is used to enhance the comparison of results of the various methods used.

In undertaking this research, multiple techniques and procedures were adopted. Utilising multiple techniques is one of the benefits of using the case study approach (Yin, 2009). The techniques and tools used are the questionnaire survey, interviews,

and documents. Further discussion on the tools and techniques used in the study is presented in section 4.8.1.8. A summary of the research process is presented in figure 24.

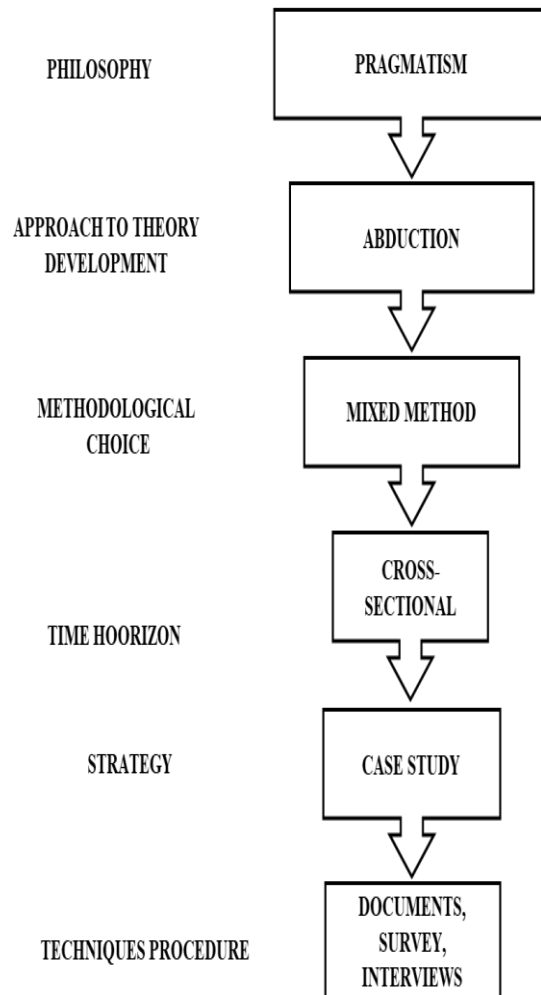


Figure 24: Research Approach Adopted for the Study (Source: Author)

3.8 Why the Case Study Approach?

As noted in section 4.5, there have been many debates, misconceptions and arguments between the difference and importance of single over multiple case studies (Dubois & Gadde, 2002; Yin, 2009). There has been a general perception that undertaking

multiple case study and replication provides a better explanation than a single case study. However, different case study researchers strongly objected such opinion. For example, Dubois and Gadde (2002), argued that what is significant in undertaking a case study is not the issue of either single or multiple case study but rather the situation specificity or the focus of the research. They explained that if the research problem is focused on the comparison of a few specific variables, the natural choice is to increase the number of observations compared. In this situation, the study should be designed to allow for statistical inference instead. While when the problem is directed towards the analysis of some interdependent variables in complex structures, the natural choice would be to go deeper into one case instead of increasing the number of cases (Dubois & Gadde, 2002).

Focusing on large construction-contracting firms to aid in addressing the research questions is to enable an in-depth understanding. This is because learning from leading construction-contracting firms are vital in driving the adoption of sustainability in the AEC sector (Riley et al., 2003). Their performance and practices are often regarded as the benchmark of the learning model for other firms (Chang, Zuo, et al., 2016). Therefore, to have a better understanding of undertaking a cross-sectional study, the single embedded case study is considered the most appropriate. The single embedded case study provides the ability to look at sub-units that are situated within a larger case (Baxter & Jack, 2008). These sub-units, as argued by Yin (2009), provide the opportunities for extensive analysis, enhancing the insights into the single case. Another advantage of the single case study is that is the amount of depth provided is increased, and the chance of there being an error in the information is reduced (Dyer Jr & Wilkins, 1991; Hammersley, 1992). In Addition, it allows a more precise

understanding of the circumstances in which the phenomenon occurred and therefore tended to be more reliable (Stake, 1995).

As represented on the conceptual framework in Figure 17, the case study will provide an understanding of how organisational resources are utilised in driving sustainable procurement. The next and subsequent sections provide an insight into the case study design.

3.8.1 The Case Study Research Design

The essence or aim of undertaking a case study could either be to generate a theory, testing a theory or the elaboration of a theory (Ketokivi & Choi, 2014; Yin, 2009). Case study research for theory generation, most especially in multiple case studies look for both similarities and differences across cases and proceed toward theory generalisations. While in case studies for theory testing, the general theory provides the basic logic for the propositions to be tested. In contrast to the two approaches explained, theory elaboration hinges on the researcher's ability to investigate the general theory and the context simultaneously, in a balanced manner. In addition, theory elaboration is aimed at the reconciliation of the general with the context (Ketokivi & Choi, 2014). Similarly, Tsang (2013) and Welch et al. (2011) explained that in building up theory, a case study could be utilised in the identification of empirical regularities, theory building and testing, interpretive sense-making, and contextualised explanation.

Irrespective of the aim of the case study that a researcher is undertaking, Yin (2009), suggested five key components that a researcher needs to consider when undertaking a case study. These components are:

1. a study's questions,

2. a proposition, if any,
3. unit of analysis,
4. logic linking the data to the propositions, and
5. the criteria for interpreting the findings.

Reflecting on these five components provides the blueprint that will guide the researcher to avoid the situation in which the evidence does not address the research questions (Yin, 2009). Each of the five components is discussed below and shown how it influences the current research.

3.8.1.1 The Study's Question

The procurement system, as explained, is an organisational system that assigns specific responsibilities and authorities to the various actors and parties involved in the delivery of the project (Love et al., 1998). How these responsibilities and authorities are addressed in embedding sustainability in the procurement processes of contracting firms, need to be well understood. This is necessary because the successful delivery of sustainable building design and construction processes are characterised as collaborative and interdisciplinary (Riley et al., 2003). To understand this, process the research raised the question, as stated in section 1.4, “how do Irish construction-contracting firms embed sustainability in their procurement practices?” This question is self-explanatory that will investigate how the various organisational resources (see Figure 17) are utilised in driving sustainable procurement.

3.8.1.2 The Study Proposition

The study proposition or what Stake (1995) referred to as ‘issues’ directs the attention of the study to the main themes to be examined in the study.

The proposition states that the effective utilisation of organisational resources of the firm enhances sustainable procurement performance and enable the firm to enjoy a sustained competitive advantage. The resources to be considered in this study are the physical capital resources (digital technology tools), human capital resources (workers of the firm), and organisational capital resources (supply chains of the firm).

3.8.1.3 Unit of Analysis

The unit of analysis and the case is a phenomenon of some sort occurring in a bounded context (Baxter & Jack, 2008). The case and unit of analysis have been considered to be the same (Baxter & Jack, 2008; Yin, 2009). Bryman (2016), suggested that it is important for a researcher to be clear about his/her unit of analysis because some of the studies carried out that are thought to be case studies are rather cross-sectional design studies. He explained that what distinguishes a case study is that the researcher is usually concerned to elucidate the unique features of the case (the idiographic approach). While research designs like the cross-sectional design are concerned with generating statements that are apply regardless of time and place (known as the nomothetic). However, an investigation may have elements of both (Bryman, 2016, p. 69). To delineate between a case and unit of analysis, Fernie (2005) explained that the definition of the case differs, although not necessarily, from the unit of analysis. He explains that the case broadly outlines the objectives of the study, while the unit of analysis defines the level at which the object will be studied. The research question and the proposition are connected to the unit of analysis because they guide and identify the relevant information to be collected about the case and unit of analysis (Yin, 2009).

Therefore, for this study, the case is defined as “the top 50 construction-contracting firms sustainable procurement practice in the Republic of Ireland”. The unit of

analysis will be a single selected construction-contracting firm. The sustainable procurement practice of the contracting firm will be examined from the organisational level down to the project level. Undertaking this process will develop an in-depth understanding to enable the researcher to draw the best explanation (abduction) as it relates to sustainable procurement practice in contracting firms.

3.8.1.4 Justification of the Single Case Study

In order to select the appropriate sampling technique in a single case study research, Yin (2009), suggested that a single-case design is eminently justifiable under some certain conditions which are: a critical test of existing theory, or rare or unique circumstances, or a representative or typical case, or where the case serves as a revelatory or longitudinal purpose. The first four conditions fit so well with the focus of this study that seeks to understand how construction-contracting firms embed sustainability in their procurement processes. The conceptual framework in Figure 18 in chapter 3 shows the boundary of the study by showing how organisational resources can be utilised in driving sustainable procurement. Undertaking a case study of a large construction-contracting firm creates a unique/rare opportunity because gaining access to any business organisation is very difficult because of the commercial sensitivity (Easterby-Smith et al., 2015; Laryea & Hughes, 2011). Also, the firm to be studied represent a typical case of large-contracting firms that will unveil lessons and insights that could be gained. Due to the time frame in undertaking the research, the study was not designed to be carried longitudinally.

Therefore, in deciding the procedure for data collection, it is noted that the mixed method methodological choice is adopted in this study. In utilising the mixed-method approach in a case study research, Yin (2009) suggested a two nested arrangement in using the mixed method in a case study research, as shown in Figure 25. The first is a

case study within a survey, where the main study relies on a survey or other quantitative techniques for data collection strategies for studying the main case. While the opposite method is a survey within a case study, where the main study relies on holistic data but utilises surveys or other quantitative techniques to collect data about the case.

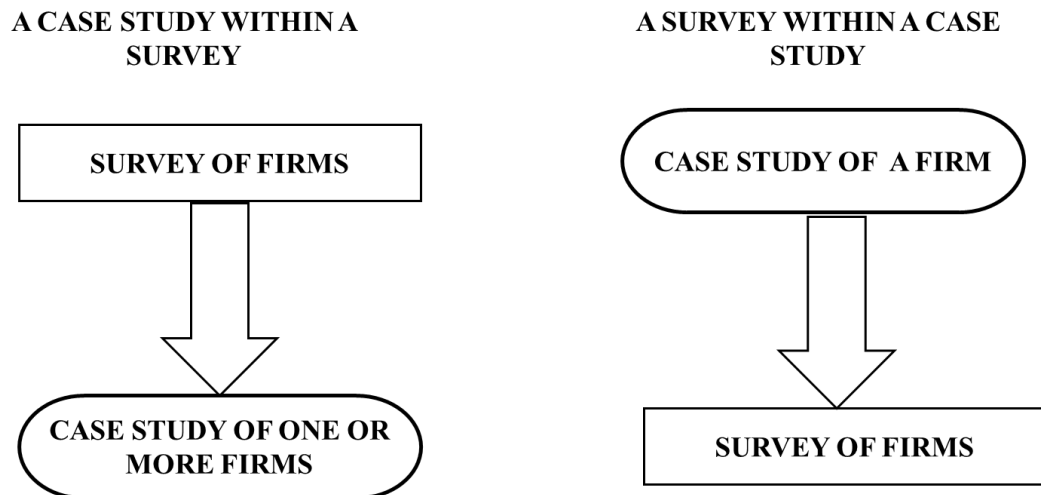


Figure 25: Mixed Methods: Two Nested Arrangement Source: (Adapted from Yin.2009, Pg. 63)

In addressing the research questions for this study, the second alternative, which is a survey within a case study, is found to be appropriate to answer the research questions. The next step after determining the approach in undertaking the mixed-method study was to select the case for the study and the sample size of the study. The selection of the case and the sample size is discussed in the next section.

3.8.1.5 Case Selection

After the domain of the study has been defined, the researcher is confronted with the following questions in the selection of the most suitable case (Swanborn, 2010). The questions are:

1. How to go about finding the cases?
2. How many cases to select?
3. If selection is necessary, which criteria should be used?

How each of the question guide the case selection is discussed below:

1. In addressing the first question different approaches could be used in finding the cases, such as drawing a sample from a list, reputation samples, network/personal contacts or snowballing, and open applications (Easterby-Smith et al., 2015; Swanborn, 2010). The researcher having understood the difficulty in having access to firms in Ireland and undertaking the research when the industry was in one of its busiest periods because of the economic recovery. Therefore, using the researcher's network and personal contacts was the most appropriate. The researcher had to informally discuss the research project with senior staff of the company (case) who agreed to be a go-between. A formal letter was written and supported by the researcher's supervisors requesting for access to the company open documents and specific staff and projects sites that were completed.
2. In selecting the number of cases in a case study research, selecting cases randomly is unreliable (Flick, 2007; Gerring, 2007), because there is no guarantee that a few cases chosen randomly will provide leverage into the research question that animates an investigation. Therefore, the purposive (non-random) selection procedure is adopted in selecting the case. Since the research design was for a single embedded case study, a single large contracting firm with large supply chains, high turnover and long history in the business is found to be adequate. This criterion was found to meet the conditions for conducting a single case study, as suggested by Yin (2009).

3. The third question of the criteria for selecting a case, different authors have suggested different criteria. However, the pragmatic and substantive criteria, as suggested by Swanborn (2010), is adopted. The pragmatic criteria select all cases that satisfy a certain simple objective criterion, such as the location of cases, budget constraints, and targeted respondents. While the substantive criteria consider cases that are informative and representative. Therefore, in setting the criteria, the following factors were considered.
 - i. A case had to be construction-contracting firm listed in the CIF top 50 in 2018. This because the 2018 list was the current information available to the researcher.
 - ii. A case had to demonstrate their commitment to adopting sustainable construction practice, because they will be knowledgeable in addressing the research questions.
 - iii. A case will be respondents that are involved in procurement activities and project delivery.
 - iv. A case will have different units in the organisation and several supply chains in their database.
 - v. Lastly and the most important a case will have to be willing to participate in the study. This is very important because achieving the aim of the study depends on the availability data.

3.8.1.6 An Overview of the Case Study

Following the justification of using the case study research strategy, this section and the subsequent sections gave an overview of the case, sampling population/design approach, and the data collection techniques and procedures.

The construction firm studied is one of the largest construction-contracting firm in the Republic of Ireland with a presence within the European states. They have been in business for over 100 years and had an annual turnover of over €800 million in 2018. The company undertakes construction activities in different sectors such as commercial, data centre, education, healthcare, life sciences, advanced manufacturing and research and development, residential, sports and leisure, and transport and infrastructure. Their staff strength is over five hundred and has offices in a different region of Ireland. Their supply chain base is over 250 different trades and services. The case study focuses on three different levels. The first was at the organisational level where documents were collected, and interviews conducted, the second was at the project level where two successful completed projects in 2019 with a value of over €200 million each and project duration of 3years. Project A is a mixed-use building in a brownfield site around the docklands in the city centre of Dublin. Project B is a recreational facility in a greenfield site located in a forest area of about 120km by road from Dublin. Lastly, a questionnaire survey conducted to the top 50 construction-contracting firms listed by the CIF in 2018.

3.8.1.7 Sampling Population/Design Approach

There is the need to decide on the number of participants in a study by one means or another, whether through a priori determination or a more adaptive approach such as saturation (Sim et al., 2018). Determining the sampling size in mixed-method research is quite complicated because the sampling scheme must be designed for both qualitative and quantitative research component of the study (Creswell, 2014; Onwuegbuzie & Collins, 2007; Teddlie & Yu, 2007). Also, there has been a belief that random sampling schemes are more to the quantitative approach, whereas non-random

sampling belonging to the qualitative. However, Onwuegbuzie and Collins (2007) stated that:

“.....this represents a false dichotomy. Rather, both random and non-random sampling can be used in quantitative and qualitative studies.”

Furthermore, Onwuegbuzie and Collins (2007) explained that the discussion in terms of sample size, that small samples are being associated with qualitative research and large samples are associated with quantitative research is too simplistic and misleading which does not conform or is consistent with practice. But rather determining the sample size should be informed mainly by the research goal, objective, purpose, and question(s). Another important point in sampling is the decision on the sampling scheme, which is categorised as random sampling (probability sampling) and non-random sampling (non-probability). The choice of the sampling scheme (i.e. random or non-random) as suggested by Onwuegbuzie and Collins (2007) and Denscombe (2014) should be based on the type of generalisation of interest which could be a statistical generalisation or analytic generalisation. If the objective of the study is to generalise quantitative and qualitative findings to the population from which the sample was drawn (making inference), then the researcher should try to select a random sample component. Alternatively, if the goal or objective of the study is not to generalize to a population but rather to obtain insights into a phenomenon or events, then the researcher will utilise the non-random sampling. This is by selecting purposefully the individuals, groups, and settings for the study, which will maximize understanding of the underlying phenomenon (Denscombe, 2014; Onwuegbuzie & Collins, 2007).

However, in mixed-method research, sampling scheme must be chosen for both qualitative and quantitative components. Deciding on the sampling scheme is based on time orientation (see section 3.4) (concurrent or sequential) and the purpose of mixing quantitative and qualitative approach which might be for triangulation, complementarity, initiation, development or expansion (Creswell, 2014; Onwuegbuzie & Collins, 2007; Teddlie & Yu, 2007). Finally, once a decision has been made about the mixed-method purpose and time orientation, the next step for the researcher is to select a mixed-method sampling design. Selecting of the mixed-method sampling design is dependent on the time orientation (concurrent vs sequential) and the relationship of the qualitative and quantitative samples. Onwuegbuzie and Collins (2007), explained that these relationships could be either identical, parallel, nested, or multilevel. They explain that an identical relationship indicates that equal sample members are drawn in the quantitative and qualitative phase. While a parallel relationship specifies that the sample for qualitative and quantitative components of the research are different but are drawn from the same population of interest. The third relationship, which is nested, implies that the sample members selected for one phase of the study represent a subset of those participant chosen for the other phase of the investigation. Lastly, the multilevel relationship involves the use of two or more set of samples that are extracted from different levels of the study (i.e. different population).

Therefore, in determining the sample size for this study as represented in Figure 26, the researcher reflected on the research question and the purpose of the study. The research question is aimed at providing insight and in-depth understanding rather than generalising on how organisational resources are utilised in driving sustainable procurement practice.

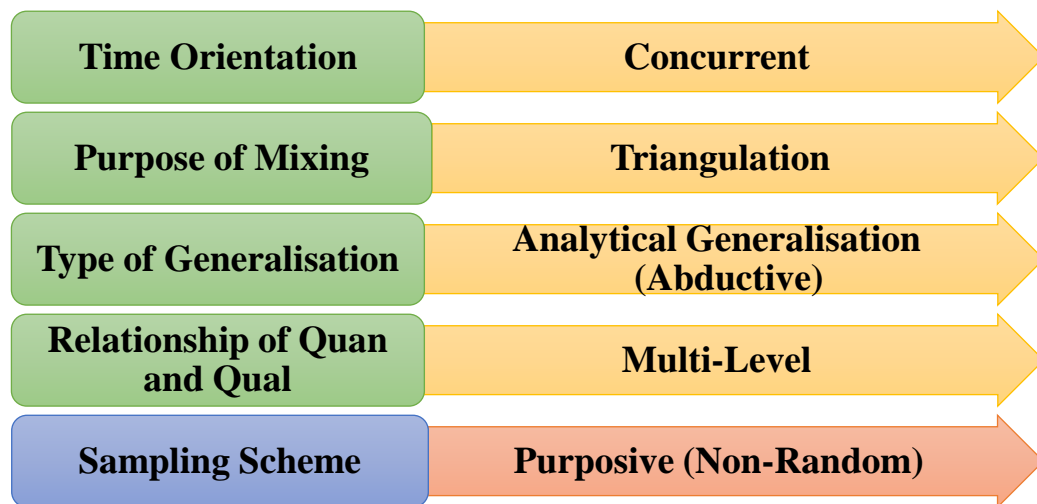


Figure 26: Sampling Design Adopted for the Study. (Source: Author).

Also, having earlier justified the choice of the abduction approach to theory development and the case study strategy, the sampling scheme in terms of time orientation was chosen to be concurrent or what Creswell (2014) refer to as the convergent parallel method. The purpose of adopting the mixed-method approach, as explained in section 3.4 is due to the advantage to be gained. Such an advantage will enable the researcher to address more complicated research questions and collect a richer and stronger array of evidence that cannot be accomplished by any single method alone (Yin, 2009). Using arrays of evidence enable triangulation in gaining depth and insight to sustainable procurement practice of firms. In terms of the type inference to be gained in the study as discussed under the approach to theory development, the inference to the best explanation which aligns more closely to analytical generalisation is adopted. The relationship between quantitative and qualitative samples in undertaking this study will require obtaining data from different samples like documents, questionnaire survey and interviews at both organisational and project level. Therefore, the multi-level relationship will be most appropriate, as suggested by Onwuegbuzie and Collins (2007). Overall, the sampling scheme for both

the qualitative and quantitative scheme will be the purposive sampling because the overall focus of the study is to gain insight rather than to generalise the findings. Although it is important to note that in terms of qualitative data collection that the issue of sample size does not assume a disproportionate prominence and overshadow other essential elements within the process of qualitative data collection and analysis. This is because it is not the number of cases that matters, “it is what you do with them that counts” (Flick, 2007; Sim et al., 2018).

Having determined the sampling design of the study, the next section discusses the various methods adopted in the data collection phase of the study.

3.8.1.8 Data Collection Procedure

Different tools and techniques are adopted in the data collection for the study. These tools and techniques are explained below.

a. Documents

Documentary evidence in a social enquiry uses documents as its source of data. Denscombe (2014, p. 244), classified documents as written text (e.g. books, articles, reports), or digital communication (e.g. web pages, SMS text, blogs, social network sites), and visual sources (e.g. pictures, video, artefacts). This documentary evidence provides valuable insights into societies and dynamics of social life, by allowing comparisons to be made between the observer’s interpretations of events and those recorded in documents relating to those events (May, 2001, p. 175). The digital communication source was utilised in the study by exploring the webpages of the top 50 construction-contracting firms. Exploring the web-pages of the firms was to ensure that the firms qualified in meeting the case criteria. Also, to understand what they are saying

about sustainability. The second digital source utilised was examining the company's (unit of analysis) intranet, where different organisational policies that deal with issues of sustainability were collected. Also, documents from the completed projects were obtained to give a better understanding of the study. Each of the documents obtained were studied and analysed and notes taken on the relevant issues to be addressed during the study. Thematic analysis was adopted in analysing the documents. The themes considered focused on the various level of collaboration, training, supply chain collaboration, utilisation of digital technologies, responsible buying, and anti-bribery issues. Utilising these data collection means, helps to tell a great deal about how events are constructed, the reason employed, as well as providing materials upon which to base further research investigations (May, 2001, p. 175).

b. Questionnaire Survey

The questionnaire survey was designed to collect information that can be used subsequently as data for analysis. Before sending out the questionnaire, the informed consent and participation form was sent to the potential respondents. The researcher provided a consent form which provided enough written information to the respondents to decide to participate in the research study based on the explanation of the proposed research and the nature of their participation (see appendix A). Regarding data handling during the study further discussion is provided in section 3.13.

In designing the questionnaire as suggested by several authors, it was ensured that the questions were fairly straightforward, standardised, readable and understandable, and open to allow full and honest answers (Denscombe, 2014; Fellows & Liu, 2008; Oppenheim, 1992). The questionnaire for the study was divided into four sections to

achieve the various objectives set for the study (see questionnaire in appendix A). Section one of the questionnaire survey deals with general information such the role of the respondents, years the company have been in business, annual turnover, number of employees and the nature of work undertaking. Examining the general information of the respondents ensured that all participants qualifies to complete and participate in the survey. Section two examined the level of performance of sustainable procurement practice of the firms. Examining the performance enable critical analysis to be carried out on the level of implementation of the various strategies identified in the literature. Section three is on the level of collaboration with supply chains and how the main contracting firms influences/motivate their supply chains in the adoption of sustainability. The last section of the questionnaire (section four) is on the application of digital technologies in sustainable procurement. The section examines the current level of utilisation of digital technologies and the level of importance in the utilisation of digital technologies in driving sustainable procurement. The questions were closed questions in categorical and ordinal scales using a five-point Likert scale. A five-point Likert scale was found appropriate because it ensures an objective data scale with little neutral items and less extreme items at either end of the continuum (Oppenheim, 1992). Also, the suitability of the five-point Likert scale maximizes data reliability and validity (Krosnick & Presser, 2010). Although, as suggested by Fellows and Liu (2008) on the need for flexibility in designing a closed questions survey, the questionnaire provided an opportunity for respondents to provide any further comment on sustainable procurement practice. The questionnaire was designed using the google form and was administered as a web-based survey through emails, and social network, specifically LinkedIn. The Social Network System is a valuable tool that can reach broad audiences and simplify the data collection process (Alshaikh et al., 2014; Leng,

2013). However, caution will need to be taking when collecting data through the social network system because self-reported data may introduce self-selection bias, sampling bias, or other generalizability/reliability issues (Alshaikh et al., 2014; Leng, 2013). Section 3.12 (e) reports how the study addresses the various biases associated with collecting data through the social network system.

Furthermore, the benefits of the internet survey are that it saves time, saves money, speed up data processing, allow wide geographical coverage, and provide an environmentally friendly approach to conducting research (Denscombe, 2014). Sections 3.9, 3.10, and 3.11 further provide further information on the response rate, the data collection techniques and analysis.

c. Interviews

Interviews were used for data collection because of their potential to generate rich data to explore a range of perspective and develop a holistic viewpoint (Kvale, 2008). The interviews started from October 2019 to February 2020. The semi-structured interview was adopted in the interview phase. The advantage of the semi-structured interview is that it allows respondents to answer more questions on their terms which provides better clarification and elaboration on the answers given (May, 2001). The targeted participants of the interview were identified and contacted informally to seek their consent. On agreeing to participate the consent and participant information sheet were sent to them via email, also an interview guide was designed and sent to them a month before the date of the interview. The interview guide was designed thematically to focus on the central research question of the study. The themes focus on collaboration within the various units in the firm and with their supply chains. Also, the level of utilisation of digital technologies in promoting

sustainable procurement was explored during the interview. The interviews were carried in three different phases and groups. The first phase was at the organisational level, where four participants at the head office of the firm were interviewed. The second phase of the interview was with the senior member of staff that participated in the delivery of the two completed projects. For the two projects, contract managers and commercial managers were interviewed. The last phase of the interview was the supply chains involved in the two projects. In Project A, the pre-cast concrete, and façade sub-contractors were interviewed, while in project B, the frame and façade sub-contractors were interviewed. Other contacts were made to other sub-contractors, but they could not grant an interview. However, the total number of twelve interviews conducted was quite adequate in providing a good level of understanding of what the research was seeking (Flick, 2007; Sim et al., 2018).

To ensure appropriate data handling and comply to the University research ethics policy, interviews were recorded with a voice recorder device, transcribed, and sent back to the participants to ensure that what was transcribed was the actual information that was discussed during the interview. Each interview lasted for an average time of 45minutes to 1-hour 20minutes.

The interviews were analysed using the five stages suggested by Braun and Clark (2006). The five stages are: transcribing and familiarising oneself with the data, generating codes, collating the codes into themes, defining and naming the themes, and reporting and analysing findings. Figure 27 below shows the five stages in analysing the interviews.

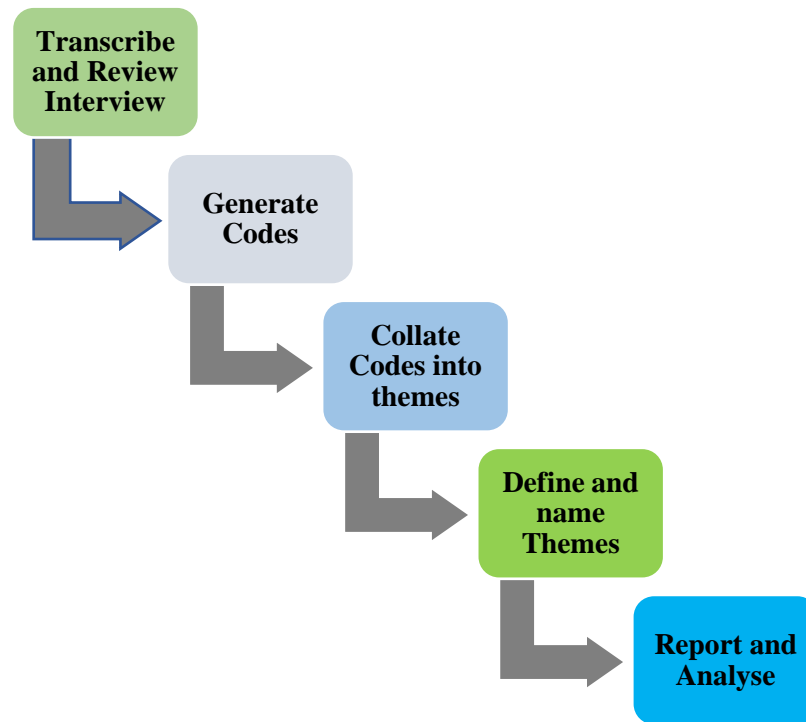


Figure 27: Stages in Analysing Interviews

The interviews were analysed using Nvivo 24 software (see appendix D). The NVivo software aided in the analysis and organising of data from the interviews. Two parent nodes were created to aid in analysing the interviews at the organisational and project level (see Appendix D1). The first level child nodes were created based on the themes of the interviews that guide in answering the research questions. Also, two child nodes were created at the project level to analyse the interviews of the project team members (contractor's and supply chain team). During the analysis of the interviews, different nodes were created based on various themes. For example, at the organisational level (see Appendix D2), several nodes were created that address different themes. Nodes created provided information on themes like reward system, training and manpower development, collaboration within the organisation, client's demand, trust and long-term relationship. Likewise, nodes were created in analysing the interviews at the project level. Illustrating the nodes created in analysing the interviews with the supply chains (see Appendix D3), different themes were coded such as the utilisation of

digital technology, collaboration during projects responsible sourcing, and trust. After the coding was completed, each node was critically analysed by comparing the findings of the different groups with that of the questionnaire survey and documents analysed and the findings reported thematically to address each of the research question and objectives.

3.9 Pilot Study

A pilot study was first carried out to test the relevance and comprehensiveness of the questionnaire before it was sent out to the respondents in the industry. It was necessary to carry out a pilot study to ensure that the questions are intelligible, easy to answer, unambiguous, and less time consuming (Fellows & Liu, 2008; Oppenheim, 1992). With regards to the adequacy on the number of experts to be used for the pilot study, Enshassi et al. (2018), revealed that different authors have different opinions, however, from the review noted that between three to eight experts are adequate. The pilot carried out in this study was done in two phases. Phase one was sending the online survey to twelve potential respondents working in different contractor's organisation. Eight responses were received from the respondents holding different positions in the company. The positions are Regional Director (2nr), Commercial Manager (3nr), Sustainability Manager (1nr), Procurement Manager (1nr), Strategy and development manager (1nr). The response received was analysed and adjusted where necessary. To further ensure the comprehensiveness and suitability of the questionnaire, the survey was further sent to seven members of different academic communities researching the areas of procurement in construction and sustainability. All the seven completed the questions, five of the respondents were full-time academic staff, and two of the respondents were doctoral (PhD) students in their final year. In

all, a total of fifteen experts were engaged in the pilot study, which makes it suitable and adequate for distribution to a larger group. The pilot survey started from July 2019 to November 2019.

3.10 Response Rate from Questionnaire Survey

After having completed the pilot study and all adjustments made to the questionnaire, the main questionnaire was sent to a targeted sample of practitioners who are directly involved in the procurement process of the top 50 firms in the Republic of Ireland. A response rate of about 120 was purposely targeted, but at the end of the survey, 65 responses were received. Out of the 65 responses received, it was found that two of the responses were not adequately completed, and one respondent participated twice. So, three of the responses were discarded, leaving the remaining 62 (n=62) for analysis which indicates a 52% response rate. A fifty-two per cent response rate was judged to be satisfactory for research in the built environment. This is because a response rate of 20-30% is adequate for research in the built environment (Akintoye, 2000; Enshassi et al., 2018; Fellows & Liu, 2008; Hoxley, 2008). Although, the percentage for the response rate was mostly for postal questionnaires survey. With the growth and usage of ICT, comparing the response rate between the web-based and postal mail survey, Shih and Xitao (2008) in a meta-analysis study found out that the web-based survey method generally has a low response rate of about 10% lower on the average. Therefore, to improve the response rate, the snowball sampling method was used to increase the survey sample size. The respondents were requested to forward the survey to their colleagues that are involved in the procurement process in the organisation. Also, some academic staff helped in distributing the survey to some of their acquaintances working in the top 50 terms. Follow-up through phone calls, sending

reminders via emails, and informal discussions were used to increase the response rate. The survey was sent out from the of 2nd December 2019, and it ended on the 28th February 2020.

3.11 The technique for Data Analysis

In analysing the data, different statistical analysis was carried out. Statistical analysis was carried out with the aid of computer software's, known as SPSS24 and the Microsoft office excel package. The descriptive statistics, inferential statistics using chi-square, the relative importance index (RII), factor analysis using principal component analysis (PCA), and Importance Performance Analysis (IPA) were used for the analysis. Each of the statistical analysis is discussed below.

a. Descriptive Statistics

Data do not interpret themselves and maybe meaningless unless descriptive statistics are used to arrange numbers into a coherent and meaning summary of information (Peers, 2006). In arranging data, the researcher should be looking at the best way to present the data only in terms of what gives the clearest, least ambiguous picture of what was found in the research study (Coolican, 2018). It should be noted that descriptive statistics do not, however, allow us to make conclusions beyond the data we have analysed or reach conclusions regarding any hypotheses we might have made. They are simply a way to describe our data. Data could be described in a table or charts form. Denscombe (2014, pp. 292-293) explained that tables provide flexibility in their use and can be used with all numerical data. In addition, he explained that one use of tables is to present a comparison of sets of nominal or categorical data. Such as contingency tables which allow visual comparison of the data and act as the basis for a statistical test of association, such as the chi-square test. While charts are an effective

way of presenting frequencies. The uniqueness and strength of using charts for presentations are that they are visually striking and simple to read (Denscombe, 2014, pp. 292-293).

Descriptive statistics in this research was used in the form of tables and charts using pie charts to present the data. The table and charts present frequencies in numbers and percentages with regards to the general background of the respondents. Also, presented are the level of adoption/performance of sustainability practice, level of influencing supply chains, and level of adoption of digital technology. The tables and charts provided a good insight into the nature and category of the respondents and other information regarding the firms.

b. Chi-Square Statistics (X^2)

Chi-square (X^2) statistics are inferential statistics that are used to test association or relationships between categorical variables. The test provides researchers with a convenient way of determining if two variables are associated. It allows them to gauge whether any apparent link in the data between these variables can be deemed statistically significant (Denscombe, 2014, pp. 292-293). The chi-square (X^2) statistics using the test of independence was used to test the association between groups of responses with regards to the level of compliance in implementing organisation's sustainability policies. In determining the confidence level in the distribution, the p-value is calculated at a 95% degree of freedom. Therefore, if $p < 0.05$, then there is an association (dependence) among the groups of variables. While if $p > 0.05$ it is believed that the variables are independent with no link or association amongst the groups.

c. Relative Importance Index (RII)

The relative importance index was used in this study to score and rank the impact of drivers to sustainable practice, influencing supply chains, and the level of adoption of digital technologies. The RII technique is used extensively in construction research for measuring attitude or perception (Egemen & Mohamed, 2006; Fang et al., 2004). In this study, the perceived level of importance, performance, impact, and frequency are ranked. An ordinal scale was used for the measurement of variables, and the respondents were asked to assign a level from 1 to 5. For each criterion, 1 being 'Not Important or Very low or Never' and the highest 5 being 'Very high, or Very Important, Always'. Data from the questionnaire were extracted to derive weightings of the factors included. The RII ranges from 0 to 1. The RII is given as:

$$\frac{\sum w}{AN} = \frac{5n_5 + 4n_4 + 3n_3 + 2n_2 + 1n_1}{5N}$$

Where w = the weighting given to each factor by the respondent, ranging from 1 to 5

A = the highest weight (i.e. 5 in the study)

N = the total number of respondents

d. Principal Component Analysis (PCA)

Factor analysis is a data reduction technique. There are two main approaches to factor analysis which are exploratory and confirmatory analysis. Exploratory factor analysis is used to explore the interrelationship among a set of variables. In contrast, confirmatory factor analysis is a more complex and sophisticated set of techniques that are used to test (confirm) specific hypothesis or theories concerning the structure

underlying a set of variables (Pallant, 2007; Tabachnick & Fidell, 2013). The term FA encompasses a variety of different, although related techniques. One of the main distinctions is between what is termed Principal Component Analysis (PCA) and Factor Analysis (FA). They are similar and used interchangeably by researchers, both attempts to produce a smaller number of linear combinations of the original variable in a way that captures or account for most of the variability in the pattern of correlations. The difference is that in PCA the original variables are transformed into a smaller set of linear combinations, with all of the variances in the variables being used, while in FA factors are estimated using a mathematical model, whereby only the shared variance is analysed (Field, 2017; Pallant, 2007; Tabachnick & Fidell, 2013). Although, the decision to use either PCA or FA is dependent on what the focus of the research. If you are interested in a theoretical solution uncontaminated by unique and error variability, the FA is used. In contrast, if you are interested in an empirical summary of the data set, PCA is the better choice (Tabachnick & Fidell, 2013).

In this study, PCA was used as a data reduction technique to reduce the factors to a manageable size for better analysis. The various sustainable procurement strategies recommended by Powmya et al. (2017) and other factors identified in the literature were used in the PCA. The factors were reduced to the various groups of capabilities that firms will need to develop to drive their sustainable procurement practice while enhancing their competitive advantage. However, there are several arguments on the issue of sample size in performing factor analysis (de Winter et al., 2009; Field, 2017; Pallant, 2007; Tabachnick & Fidell, 2013). A wide range of recommendations was made, but two major categories are usually used. The first one is with regards to the number of cases (N), while the second is with regards to the subject-to-variable ratio (de Winter et al., 2009; Lingard & Rowlinson, 2006). With regards to the number of

cases, suggestions from less than 50 to greater than 100 has been extended (Enshassi et al., 2018; Field, 2017; Lingard & Rowlinson, 2006; Pallant, 2007). While Tabachnick and Fidell (2013) with regards to the subject-to-variable ratio recommended having at least five cases for each item to be the adequate size.

In conducting factor analysis in construction management research, Lingard and Rowlinson (2006) noted that it would be rare for data to be of sufficient strength to justify the use of factor analysis in small samples. Therefore, they suggested that factor analysis in small samples must be carefully considered and explicitly defended in terms of the strength of the data. On the other hand, MacCallum et al. (1999) argued that the level of communality plays a critical role. When communalities are consistently high (probably greater than .6), then that aspect of sampling that has a detrimental effect on model fit and precision of parameters estimates receives a low weight thus greatly reducing the impact of sample size and other aspects of design. Thus, for this study in understanding the sustainable procurement practice of large Irish construction-contracting firms, a sample size of 62 was found adequate. This was based on the recommendation made by de Winter et al. (2009), which states that a sample size of 50 is quite adequate and can yield adequate results when the data are well-conditioned.

e. Importance Performance Analysis (IPA)

The importance-performance analysis, originally developed by Martilla and James (1977), is a managerial tool that helps management in an organisation in identifying the most crucial corporate attributes regarding their need for managerial action. It also helps decision-makers to set management priorities and determine how scarce resources might best be allocated (R.-d. Chang et al., 2017; Rial et al., 2008). IPA is based on the mean performance and means importance obtained from a surveyed

respondent for each of several attributes or characteristics on a certain factor or product or service. Performance refers to the level of satisfaction on an attribute, while importance refers to the assessment of the attributes by the respondents (Martilla & James, 1977; Taplin, 2012). IPA has been applied in marketing (Martilla & James, 1977), tourism (Oh, 2001; Taplin, 2012), and sports management (Ormanovic et al., 2017; Rial et al., 2008), but very little application in construction management (R.-d. Chang et al., 2017). One of the unique features of the IPA is in the graphical representation that allows for a very intuitive visual assessment of the management of the establishment and the corresponding advice for a better distribution of organisational resources (Rial et al., 2008). The original graphical representation proposed by Martilla and James (1977), as shown in figure 28, is made of four quadrants in a two-dimensional coordinate system. The average values of importance and performance of different attributes are calculated concerning one another, mainly in the area divided into four quadrants. The horizontal axis represents performance, while the vertical axis represents the importance.

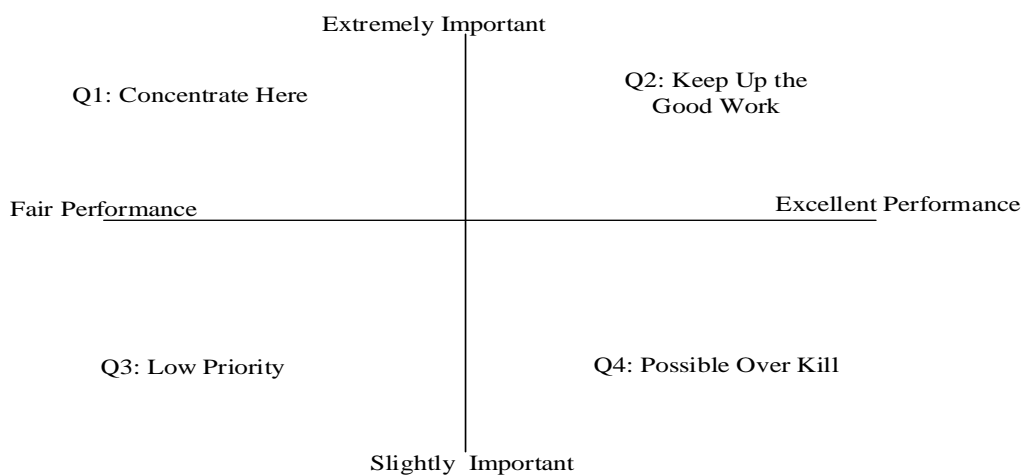


Figure 28: Original Importance-Performance Analysis Source: (Martilla & James, 1977)

Depending on which quadrant a certain attribute is located, managers can decide which attributes are the top priority and low priorities for improvement. As shown in figure 29, the quadrants are defined as follows:

- Concentrate here: attributes in Q1 are perceived to be of high importance while the performance levels are relatively low, indicating that such elements require immediate corrective action or efforts should be concentrated here to make performance improvements.
- Keep up the good work: attributes in Q2 are perceived to be of high importance, and the company or enterprise have high-performance levels on these attributes. This represents the strong side and competitive advantage of companies, which task is to continue to maintain the quality of those elements contained in it (Ormanovic et al., 2017).
- Low priority: attributes in Q3 are of low importance, and even the enterprise also has low-performance levels on these attributes. Ormanovic et al. (2017), explained that such attributes represent no threat to the organisation. However, the manager could rather think about the option of transferring resources from these elements to those requiring urgent action.
- Possible Overkill or Possible Waste of Resources: attributes in Q4 are of low importance levels, but the enterprise has high-performance levels on these attributes. This indicates that the organisation is spending valuable resources on minor elements. Therefore, in this situation, managers can think of ways of allocating the organisational resources appropriately.

In as much as the traditional IPA has contributed significantly to management research, it has been subjected to lots of criticism and controversy (Ormanovic et al., 2017; Rial et al., 2008; Taplin, 2012). Rial et al. (2008), noted that such

controversies arose due to two problems. The first problem is with regards to the position of the axis, determining the quadrants and its interpretation. The second problem is on the measurement of both the importance and performance of the elements which constitute the attributes to be assessed.

In addressing the first problem, it was found that in the original IPA crossing the axis at the middle point of both response scales was straight forward and quite simple. However, Rial et al. (2008), noted that given that any attribute has at least a moderate importance which will make all the attributes to be placed in the upper right quadrant (keep up the good work). Consequently, the IPA graph would suffer from low discriminative power and little utility in terms of management. In providing a solution for this problem, the first issue addressed was crossing the axis at the empirical means obtained from the data (Ormanovic et al., 2017; Rial et al., 2008). The authors explained that such solution allows the IPA graph to provide better discriminative power. Besides, other improvements on the IPA was incorporating the concept of discrepancy or what is known as the gap (R.-d. Chang et al., 2017; Ormanovic et al., 2017; Rial et al., 2008). The discrepancy is calculated as the difference between the performance and importance, to the graphical representation of the IPA. In representing the discrepancy/gap on the IPA graph, a diagonal line is added to the graph, as shown in figure 30. The attributes placed above the diagonal represent areas to improve and the need for improvement increases as the distance to the diagonal increases. The triangular area below the diagonal is in turn divided into three areas (see figure 29) corresponding to the three different elements namely keep up the good work (2), low priority (3), and possible waste of resources (4) (Ormanovic et al., 2017; Rial et al., 2008).

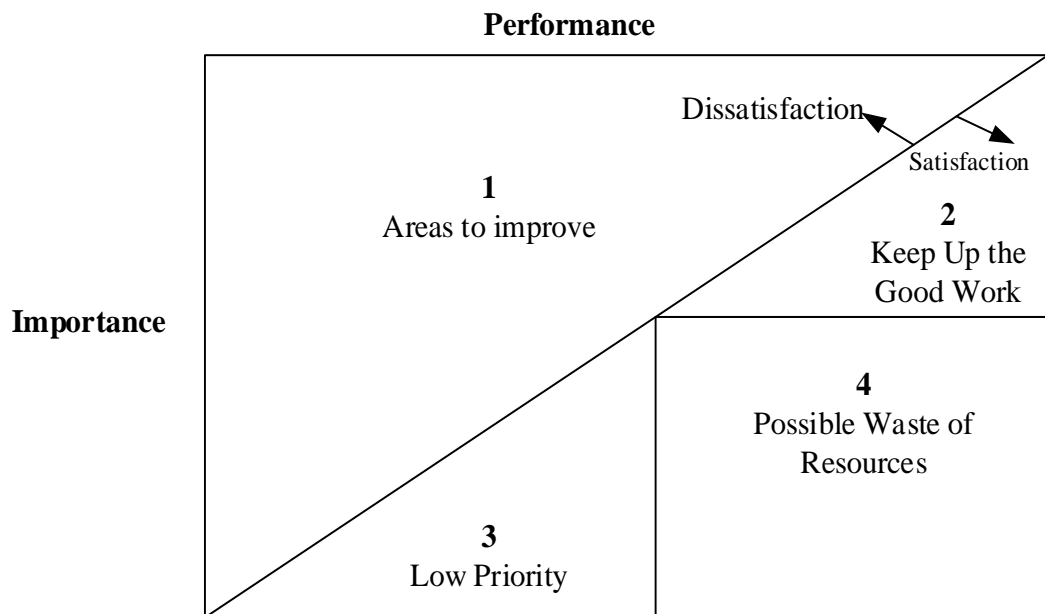


Figure 29: Revised IPA Source: (Rial et al., 2008)

With regards to the second problem faced using the traditional IPA, which focuses on data gathering procedure about the type of attributes to be presented to the subjects, and the response format to be chosen for the elements or items. In providing a solution to these challenges Rial et al. (2008), stated that it is recommended that the researcher conducting IPA should rely on a semi-quantitative response scale (i.e. a 5-point Likert scale). Also, to include a reduced, well-known, and previously tested number of elements, and not the whole set. Once these methodological problems have been solved, the IPA has great potential as a management tool for many organisations (Ormanovic et al., 2017; Rial et al., 2008).

In applying IPA for this study, the level of importance and performance of the various sustainable procurement strategies recommended by Powmya et al. (2017) and other factors identified in the literature will be assessed. Assessing the level of performance

will provide a good picture of the sustainable procurement practice of the top 50 construction-contracting firms in Ireland.

3.12 Quality and Assessment Criteria of Research Design

No matter the type of research undertaken a researcher will need to demonstrate the credibility of his/her findings, this is necessary because of the different philosophical and methodological approaches in studying human activity (Sutrisna, 2009). Validity and reliability are the common tests used in testing the credibility of the research. Validity indicates the degree to which the instrument measures what it is supposed or intended to measure (Oppenheim, 1992), while reliability demonstrates that the operations of a study such as the data collection procedure can be repeated with the same results (Yin, 2009). Oppenheim (1992), further explained that the notion of reliability thus includes both the characteristics of the instrument and the conditions under which it is administered, both must be consistent. Furthermore, in conducting a case study research just like any other research, four tests are commonly used; these are construct validity, internal validity, external validity, and reliability (Yin, 2009). Each of the four tests is discussed below and how it was applied in the study.

a. Construct Validity

Construct validity is concerned with how well the test links up with a set of theoretical assumptions about an abstract construct (Oppenheim, 1992). Yin (2009) noted that construct validity is particularly problematic for case studies because of the difficulty of defining the constructs being investigated. The questionnaires designed were pre-tested through a pilot study in two phases before carrying the main survey. Also, an interview and case study guide were designed that explained the purpose of the study. The guide was sent out to the interviewees a month before the interview to ensure that

all questions were designed appropriately. Furthermore, another step carried out was the validation of the framework with selected industry experts and practitioners.

b. Internal Validity

Internal validity is mainly concern with explanatory case studies when an investigator is trying to explain causality between variables (Gray, 2013; Yin, 2009). Yin (2009) noted that internal validity had been given much attention in experimental and quasi-experimental research because of the numerous threats to validity due to misleading effects. The second threat to internal validity in a case study research comes from the problem of making inferences when it is simply not possible to observe the event (Gray, 2013; Yin, 2009). Hence, the researcher's inference that an event has occurred will be based on case study interview data or documentary evidence. In addressing the first problem in this study, the questionnaire was purposively designed and distributed to experts in the industry. The data analysis techniques were carefully selected for the analysis of the data. While in addressing the second problem as it was suggested by Yin (2009), the pattern matching technique was employed. The technique was employed by utilising several sources of data, such as documents, interviews at the organisational level and project levels.

c. External Validity

This type of validity is primarily concern with the issues of generalisability. The validity raises the question of whether the findings of the study in a small group can be generalised beyond the study itself (Gray, 2013; Yin, 2009). The external validity problem, as noted by Yin (2009), has been one of the major barriers in doing case studies. This is because of the perception of some researchers that single cases offer a poor basis for generalising. However, Yin (2009), made clear that each type of study relies on different generalisation; for example, he explained that survey research relies

on statistical generalisation, whereas case studies rely on analytical generalisation. He further explained that in analytical generalisation, the investigator strives to generalise a particular set of results to some broader theory (Yin, 2009). To address the external validity, the research design was guided by the theoretical lens underpinning the study, with the aim of theory building.

d. Reliability

As earlier explained that reliability is concerned about the replication of the study by another researcher. Gray (2013), further explained that the conditions for reliability are met if the findings and conclusions of one researcher can be replicated by another researcher doing the same case study. While Oppenheim (1992), argued that reliability is a pre-condition to validity. The goal of reliability is to minimize the errors and biases in a study (Oppenheim, 1992; Yin, 2009). In ensuring the reliability of this study, the Cronbach's alpha test was carried out to measure the internal consistency of the questionnaire. Secondly, in conducting the case study, an interview guide was designed, and a database was created where all recordings and transcriptions are stored. In addition, the transcripts of the interviews were sent to the interviewees before the commencement of the analysis.

e. Addressing Biases

As noted in section 3.8.1.8 on the likely biases that could occur because of the techniques adopted in the data collection, this sub-section presents the strategies adopted in addressing the biases. In addressing non-response biases resulting from the right participants not completing the survey; the following strategies were adopted. First, the purposive sampling technique was adopted in the distribution of the questionnaire and interviewees. The questionnaire was designed by requesting all

respondents to indicate their role and company information. Also, a pilot study was carried out to test the suitability and adequacy of the questions. An adequate time frame was given to complete the questionnaire, and reminders through emails and phone calls were made to increase participation. Lastly, to avoid non-response bias, the confidentiality of the respondents was ensured, and incentives through making available publications arising from the research were ensured. Another type of bias was selection bias, which is concerned with selecting or choosing the wrong set of individuals or groups to participate in the study. In addressing this bias, the purposive sampling technique was adopted, and, the questionnaire provided a section where the general information of the respondents is asked. The last type of bias addressed was the researchers bias, or what is known as the observer bias. Observers bias is when the researcher has information or awareness of the subject to be studied. During the data collection process, the observer's bias was addressed at the interview stage. It was addressed by designing an interview guide sent to the various interviewees to study before the interview. Table 10 below shows a snapshot on how the various biases were addressed.

Table 10: Addressing Biases

S/N	BIAS	STRATEGY
1.	Non-Response Bias	<ul style="list-style-type: none">• Purposive Sampling• Respondent's information on questionnaire• Pilot Study• Adequate time frame• Reminders• Confidentiality• Incentives
2.	Selection Bias	<ul style="list-style-type: none">• Purposive Sampling• Respondent's information on questionnaire.
3.	Observer's Bias	<ul style="list-style-type: none">• Interview Guide

3.13 Ethical Consideration

To promote the aim of the research through the expansion of knowledge and ensuring respect and fairness to the respondents, and to adhere to the general data protection regulation (GDPR), an ethical application was submitted. The application was

submitted to the TU Dublin research ethical committee, and approval was granted (see the application in appendix A). After the approval was granted, the participant information sheet and consent form were sent to the respondents. The forms provide details of the research and the ethical consideration in undertaking the study. Also, the information sheet guarantees the anonymity of the respondent's identity and confidentiality to the data obtained. The participants were assured in the case of interviews that transcripts of interviews shall be made available to them before the commencement of analysis.

Regarding data handling and storage, the researcher strictly adhered to the policy on data protection of Technological University Dublin. Respondents were assured that all data obtained shall be anonymised and encrypted with a secure password. Also, the data shall be kept in a database hosted by TU Dublin and stored for a specific period of three years as stipulated in the rules and regulations concerning research in TU Dublin. After the stated period of three years, the data shall be permanently discarded from all electronic devices.

CHAPTER 4

SURVEY RESULTS AND ANALYSIS

4.0 Introduction

This chapter and the next two chapters report the findings of the study. In reporting the findings of a mixed method study Holt and Goulding (2014) suggested the need for clarity to enable better understanding. Such understanding is presented in a chronological order on how the research was undertaken (Holt & Goulding, 2017). Therefore, this study presents the quantitative and qualitative results independently and triangulates the findings on the discussion Chapter (8).

This Chapter presents the results and analysis from the data obtained through the questionnaire survey. The results are presented thematically based on the objectives of the study. Section 5.1 provides general information about the respondents, while section 5.2 report findings on the level of adoption and performance of sustainable procurement. Sections 5.3 and 5.4 report findings on influencing supply chains, and the level of adoption of digital technology.

4.1 General Background of Respondents

This section provides the general background of the various respondents in terms of their roles, years in business, annual turnover, number of employees, and nature of work undertaken predominantly. See Appendix C1, C2 and C3 for more information on the general background of respondents.

Table 11: Role in the Organisation

Role	Frequency	Percentage
Managing Director	7	11%
Regional Director	7	11%
Director	7	11%
Commercial Manager	11	18%
Contracts Manager	10	16%
Sustainability Manager	1	2%
Strategy and Business Development Manager	1	2%
Procurement Manager	4	6%
Chief Estimator	4	6%
Others	10	16%
Total	62	100%

Table 11 shows the various roles of the respondents that completed the survey. As it was discussed in chapter 3 that the purposive sampling technique was used in the data collection. This was to gain better insight from the experience of experts that are directly involved in the procurement processes. Also, the sampling technique (purposive) enables an in-depth understanding of large construction-contracting firms sustainable procurement practices. Learning from large construction firms as noted in the literature have been proven to be learning for the wider industry (Chang, Zuo, et al., 2016). Furthermore, the results, show that twenty-one (21) of the respondents are at the director level, while thirty-one (31) at the managerial level and other roles had ten (10) respondents. These other roles are Project managers, Design and BIM manager, Quantity Surveyors, and Site manager/engineer.

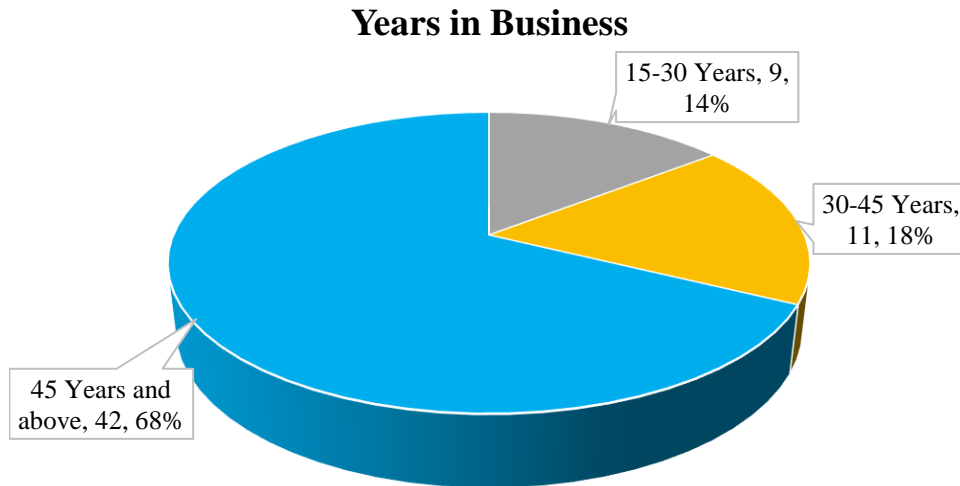


Figure 30: Organisation years in business

Figure 30 shows the years that various firms sampled have been in business. From the figure 68% (42) have been in the construction business for over 45 years and above, while 18% (11) have been operating between 30-45 years, and 15% (9) have been operating between 15-30 years. This indicates that all the firms sampled have gotten a good level of experience in the construction industry.

Figures 31 and 32 are on the annual turnover and number of employees of the various firms. From the figures, all the firms are either medium or large-scale company as categorised by the European Commission (European Commission, 2020) and as explained in Section 1.6. Out of the sixty-two responses obtained, 16% (10) have a turnover between €10-€50 million, while 84% (52) has a turnover of over €50 million. Firms with high financial turnover are motivated in the adoption of sustainability practices compared to smaller firms (Adetunji et al., 2003; Boyd & Schweber, 2012; Chang, Zuo, et al., 2016; Upstill-Goddard et al., 2016). Similarly, in terms of the number of employees, 84% (52) has an employee strength of over 250, and 16% (10) have employees between 50-249.

Based on Turn Over

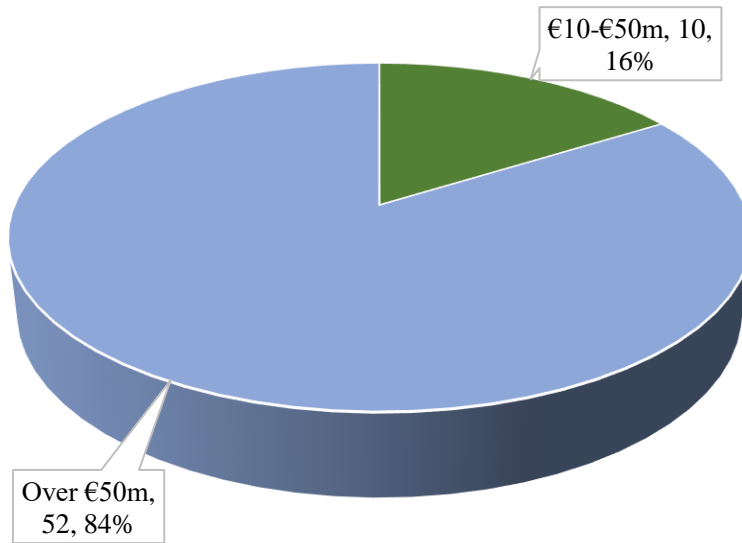


Figure 31: Based on Annual Turn-over

Based on Number of Employees

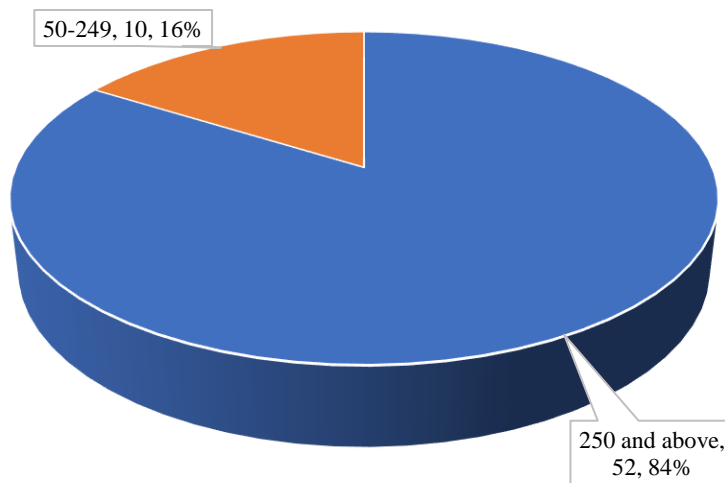


Figure 32: Based on Number of Employees

On the other hand, with regards to the various sectors, the respondents work across are presented in Table 12.

Table 12: Nature of Work Undertaking

Nature of work	Frequency	Per cent
Building and Civil works	48	77%
Building works only	5	8%
Mechanical and Electrical works	7	11%
Mechanical works only	2	3%
Total	62	100%

From Table 12 majority of the respondents undertake Building and Civil works with a total of 77% (48) while Building works, and Mechanical and Electrical works are 8% (5) and 11% (7) respectively. The least was mechanical works only with a total of 3% (2), and none of the respondents undertakes electrical works only.

Overall, from the data obtained, it is shown that most of the respondents work in large construction-contracting firms and are involved with both building and civil works. Therefore, from the general information obtained, it is indicative that the data will aid in achieving the purpose of the study by providing a good understanding of construction-contracting firms sustainable procurement practice. Hence, the subsequent sections in this chapter address objectives two (level of performance and adoption of sustainable procurement), three (influencing supply chains by main contractors), and four (level and potentials of adopting digital technologies) of the study.

4.2 Level of Adoption/Performance of Sustainable Procurement

This section is aimed at addressing objective two of the research, that evaluates the level of adoption and performance of sustainable procurement in the Irish construction industry. In addressing this objective, this section is divided into three sub-sections. The first section evaluates the compliance of firms to their organisation's sustainability policies. The second section is on the impact of some of the drivers in adopting sustainability practices by firms. While the last part is on evaluating the level of adoption and performance of firms in the various strategies in sustainable procurement delivery.

4.2.1 Compliance with Organisations Sustainability Policies

In evaluating the performance and level of adoption of sustainable practice by firms, the development of their organisational policies was first evaluated. Tables 13 and 14 shows how organisational policies were developed. Table 13 categorising the firms based on their annual financial turnover shows that 33 of the respondents indicates that their policies are developed from top bottom. That is from management down to the staff. These findings agree with earlier studies with regard to the role of leadership in motivating the adoption and implementation of sustainability in an organisation (Eilers et al., 2016; Kannan, 2021; Meehan & Bryde, 2011; Opoku & Fortune, 2015; Qi et al., 2010; Rickaby & Glass, 2017). While only four were from the bottom- top. Also, 25 of the respondents stated that the policies had developed both ways.

Table 13: Organisation's Policy Development based on turnover

		Org Policy Development			Total
		Top-Bottom	Bottom-top	Both ways	
Annual Turnover	€10-€50m	3	1	6	10
	Over €50m	30	3	19	52
Total		33	4	25	62

Based on the nature of work predominantly undertaking, Table 14 shows that firms that undertake Building and Civil works develop their policies from top-bottom and both ways more compared to others (28 top to bottom, 17 both ways, 3 bottom to top). While the firms undertaking mechanical and electrical works, five of the respondents stated that the policies had developed both ways. In contrast, only one respondent indicated that the policies were developed from both top-bottom and bottom-up.

Table 14: Organisation's Policy Development based on the Nature of Work Undertaking

		Org Policy Development			Total
		Top-Bottom	Bottom-Up	Both ways	
Nature of Work Undertaking	Building and Civil works	28	3	17	48
	Building works only	3	0	2	5
	Mechanical and Electrical works	1	1	5	7
	Mechanical works only	1	0	1	2
Total		33	4	25	62

Furthermore, to explore the implementation of sustainable procurement by the various firms, the level of compliance in embedding sustainability in their procurement process was examined. Table 15 shows a summary of the level of compliance with the organisation's procurement process. The results show that 15% (9) indicated excellent, 61% (38) good, 23% (14) average, and only 2% (poor). This result confirms that there has been a general awareness in the adoption of sustainability practice by firms (Berry & McCarthy, 2011; Skanska, 2018).

Table 15: Level of Compliance in Embedding Sustainable Procurement

Excellent	9	15%
Good	38	61%
Average	14	23%
Poor	1	2%
Total	62	100%

Having provided a general summary (Table 15) on the level of compliance in embedding sustainability in the procurement process, further analysis was carried out. The analysis examined the level of compliance with the organisation's sustainability policy based on the size of the firm and the nature of work undertaking. Tables 16 and 17, shows the frequency distribution of the level of compliance at the procurement phase. From Table 16 based on annual financial turnover, it is indicative that the different firms have a different level of compliance. Firms with a turnover of €10-€50million (medium size) have four of the respondents fully complying while six partially complied. In comparison, firms with over €50million (large size) have 26 of the respondents' firm fully complying while 29 partially complying and three not complying. These findings further indicate that a firm financial turnover is a likely

factor in motivating the adoption of sustainability (Adetunji et al., 2003; Boyd & Schweber, 2012; Chang, Zuo, et al., 2016; Upstill-Goddard et al., 2016).

Similarly, with regards to the level of compliance based on the nature of work undertaking Table 17 shows that Building and Civil Works have 22 of their respondents fully complying. While 23 partially complying, and three not complying.

Table 16: Level Compliance Based on Annual Turn-over

		Compliance with Org Policy			Total
		Yes	No	Partially	
Annual Turnover	€10-€50m	4	0	6	10
	Over €50m	26	3	23	52
Total		30	3	29	62

Table 17: Level Compliance Based on Nature of Work Undertaking

		Compliance with Org Policy			Total
		Yes	No	Partially	
Nature of Work Undertaking	Building and Civil works	22	3	23	48
	Building works only	3	0	2	5
	Mechanical and Electrical works	5	0	2	7
	Mechanical works only	0	0	2	2
Total		30	3	29	62

The results in Tables 16 and 17 are descriptive in nature, which is likely to make conclusion difficult. Therefore, to enable a better understanding and inference with regards to the level of compliance, Chi-square (X^2) test of independence was carried out. Chi-square (X^2) test, as explained in chapter 4 (section 4.11) determines the level

of association amongst the two groups. The Chi-square (X^2) test results, as shown in Table 18, indicate that there was no significant association between a firm's financial turnover and compliance with organisational policy. The Pearson Chi-Square is 4.018 and $P > 0.05$, ($X^2 (4, N=62) = 4.018, P=0.404$). The implication of these results indicates that irrespective of the financial turnover of the firms, the level of compliance amongst firms in embedding sustainability differ. The results (see table 19) show that there was no significant association between the two categories, $X^2 (4, N=62) = 4.018, P=0.404$. What this means is that different firms embed sustainability differently.

Table 18: Chi-Square Test on the Level Compliance Based on Annual Turn-over

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	4.018 ^a	4	0.404
Likelihood Ratio	4.094	4	0.393
Linear-by-Linear Association	0.947	1	0.331
N of Valid Cases	62		

a. 5 cells (55.6%) have expected count less than 5. The minimum expected count is .44.

Similarly, the Chi-square (X^2) test of independence based on the nature work undertaking is presented in table 18. The results show that there was no significant association between the nature of work undertaking and organisational policy. Pearson Chi-square =4.585 and $P > 0.05$ ($X^2 (6, N=62) = 4.585, P=0.598$). Also, as it was stated earlier from the results of table 17, that different firm's compliance in addressing sustainability in their procurement processes differs. These results confirm the earlier works of Boyd and Schweber (2012) and Zuo et al. (2012), that explained that different construction firms implement sustainability differently. In addition, what these results explain is that a firm financial turnover is not enough evidence to

conclude their level of adoption or implementation of sustainability. However, deeper understanding will be required to understand how the various organisational resources are utilised in the implementation and adoption of sustainability practice (Kibert, 2007; Myers, 2005).

Table 19: Chi-Square Test on the Level Compliance Based on Nature of Work Undertaking

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	4.585 ^a	6	0.598
Likelihood Ratio	5.887	6	0.436
Linear-by-Linear Association	0.064	1	0.800
N of Valid Cases	62		

To examine further the level of implementation and adoption of sustainable procurement, the next section, 4.2.2 evaluates the impact of the seven drivers identified by Elkington (1997). Also, the level of clarity of the clients' sustainability requirements, and the importance of sustainability in the selection of the supply chains were evaluated.

4.2.2 Impact of Drivers to Sustainable Practice

In determining the level of impact of the drivers that Elkington (1997) referred to as the seven-sustainability revolution, a reliability analysis was first carried out on the factors comprising 7 items. The Cronbach's alpha test of reliability was used to measure the internal consistency of the questions; the test also shows how closely related a set of items are as a group. The Cronbach's alpha showed the questionnaire to reach acceptable reliability, $\alpha = 0.789$. All the items appeared worthy of retention without any deletion (see Appendix C4 for details).

After determining the reliability, the relative importance index of each of the factors was determined and ranked, as presented in Table 20. From the results obtained, all

the seven factors were ranked high above 0.7, with the highest-ranked of 0.82. Time was ranked (0.82), Corporate governance (0.80), Markets (0.797), and Values (0.78). While Life-Cycle technology (0.72), Transparency (0.76), and Partnership (0.77) were ranked seventh, sixth, and fifth, respectively. The findings are consistent with earlier researches that reported the strategies and commitments made by firms in the adoption and implementation of sustainability practice (Berry & McCarthy, 2011; Meehan & Bryde, 2011; Zuo et al., 2012). Furthermore, the first three factors centred more on gaining a competitive advantage. In comparison, the remaining four factors are the new practices that are expected for firms to adopt in driving sustainability practice.

Table 20: Level of Impact of Drivers to Sustainable Practice

Factors	Very High	High	Moderate	Low	Very Low	Total respondents (N)	Weighted total	RII	Rank
Time (long term business strategies)	18	33	10	1	0	62	254	0.819	1
Corporate governance (transformation in an organisation's structure)	16	33	11	2	0	62	249	0.803	2
Markets (Gaining competitive advantage, client requirements)	14	35	11	2	0	62	247	0.797	3
Values (by paying attention to human and social values)	11	35	15	1	0	62	242	0.781	4
Partnership (engaging closely with all stakeholders and community)	9	33	20	0	0	62	237	0.765	5
Transparency (disclosing to the public your organisation sustainability performance)	10	32	16	4	0	62	234	0.755	6
Life-cycle technology (focusing on the impact of the product throughout its lifespan)	9	23	25	5	0	62	222	0.716	7

To understand further the impact of the drivers on sustainability, the level of clarity of sustainability requirements from clients was examined. Also examined was the level of importance of sustainability requirement in the selection of supply chains. Figure 33 shows that 79% (49), of the respondents, indicated that the level of clarity of sustainability requirements varies from client to client or projects. While 15% (9), indicated that the level of clarity is not precise, and 6% (4) indicated that it was precise. The level of clarity of sustainability requirements is key in achieving the project sustainability requirements (Iles & Ryall, 2016). How such clarity influences sustainable procurement practice is further explored in subsequent sections of the study.

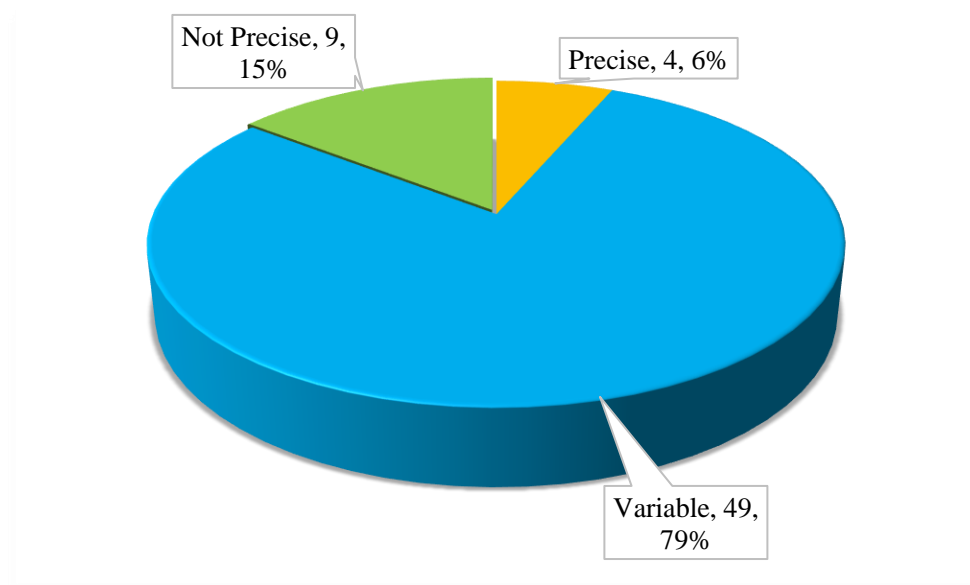


Figure 33: Level of Clarity of Sustainability requirements

In terms of the selection of supply chains, sustainability requirements tend to be significant because Figure 34 shows that 19% (12) and 52% (32) of the respondents indicated that it is very important and important, respectively. While 24% (15) and 5% (3) indicated less important and not important. These results reflect the findings of Kumar and Rahman (2016), that showed the relationship between supplier selection and achieving the triple bottom line objective of a project.

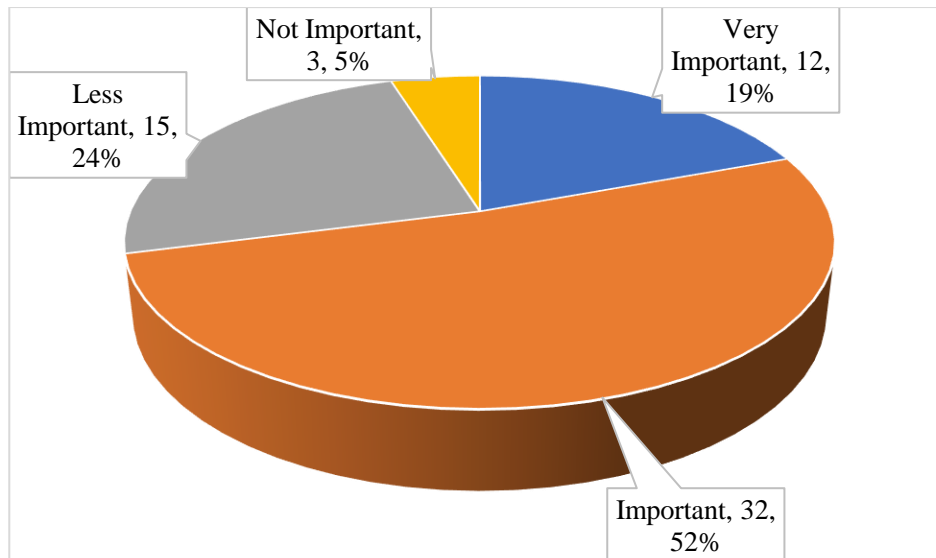


Figure 34: Sustainability Requirements in the Selection of Supply Chains

4.2.3 Analysis of Sustainable Procurement Strategies

Having examined the impact of the drivers on sustainability practice within construction-contracting firms in the Republic of Ireland, and the level of clarity of sustainability requirements from the client. Also considered in the previous section is the importance attached by main contracting firms in the selection of their supply chains. Therefore, this section focuses on creating a further understanding of the various sustainability delivery strategies that firms adopt to enable them to gain a competitive advantage. Five-point Likert scale questions were developed with the aid of a questionnaire (see Appendix A questions 10-12). The questions asked the respondents about the level of importance that their organisation place, and their performance. For example, the respondents were asked to rank how important was the recruitment of experienced staff; education and training; and employee empowerment is to the organisation. At the same time, they were asked to rank how the organisation has performed in the factors identified. The strategies as shown in Table 6 (page 106) include:

- Human Resource Strategy

- Technology Strategy
- Finance Strategy
- Knowledge Strategy
- Capacity Development Strategy, and
- Environmental Pro-activeness Strategy

Developing and utilising these strategies builds the organisations capabilities which enable them to gain a competitive advantage (Barney, 1991; Hart, 1995). These strategies as identified by Powmya et al. (2017) were empirically analysed and categorised into three different capabilities. These capabilities as suggested by Barton (1995) are supplemental capabilities, enabling capabilities, and core capabilities. Analysing the various strategies provided a good understanding and a snapshot on the level of performance of the top fifty construction-contracting firms in driving sustainable procurement.

Three different analysis was carried out. First, the Cronbach's alpha test of reliability was carried out. This was to ensure the suitability and internal consistency of the questions, as explained in section 4.2.2. Second, factor analysis (FA) using Principal Component Analysis (PCA) was used for data reduction. The third analysis was performing the Importance Performance Analysis (IPA). The IPA was performed to evaluate and to provide a snapshot on the level of performance of firms in utilising the various strategies that could be developed to form organisation capabilities (Abalo et al., 2007; R.-d. Chang et al., 2017; Martilla & James, 1977; Ormanovic et al., 2017; Rial et al., 2008).

The Principal Component Analysis

The 22 sustainable delivery strategies were subjected to PCA using IBM SPSS statistics version 26. Before performing the PCA, the suitability of data for factor analysis was assessed. First, the reliability analysis was carried out on the 22 items. Cronbach's alpha showed the questionnaire to reach acceptability, reliability, $\alpha = 0.957$, as shown in Table 21. All the items appeared worthy of retention without any deletion (see Appendix C5 for item-total statistics).

Table 21: Reliability Statistics for Level of Importance

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N of Items
0.957	0.959	22

The second phase of the analysis was the inspection of the correlation matrix (see Appendix C5) which revealed the presence of many coefficients of .3 and above. The Kaiser-Meyer-Olkin (KMO) value was 0.882 as shown in Table 22 which Field (2017, p. 1156) described as a "Meritorious", and exceeding the recommended value of 0.6 (Tabachnick & Fidell, 2013). The Bartlett's Test of Sphericity reached statistical Significance ($P < .000$), indicating that there are adequate inter-correlations between the items which allow the use of factor analysis.

Table 22: KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.882
Bartlett's Test of Sphericity	Approx. Chi-Square	1089.167
	df	231
	Sig.	0.000

The PCA analysis revealed the presence of three components as represented in Table 23 with eigenvalues exceeding one, explaining 53.95%, 7.91%, and 6.51% of the variance, respectively. An inspection of the scree plot revealed a clear break after the third component. Using Catell's scree test, as shown in Figure 35, it was decided to retain three components. To aid in the interpretation of the three components, the Oblimin with Kaiser Normalization rotation was performed with the rotation converging after 18 iterations.

Table 23: Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	11.868	53.947	53.947	11.868	53.947	53.95	9.140
2	1.739	7.906	61.853	1.739	7.906	61.85	7.454
3	1.432	6.510	68.363	1.432	6.510	68.36	7.868
4	0.927	4.216	72.579				
5	0.824	3.744	76.322				
6	0.691	3.139	79.462				
7	0.565	2.568	82.030				
8	0.526	2.393	84.423				
9	0.516	2.346	86.769				
10	0.463	2.107	88.875				
11	0.378	1.718	90.593				
12	0.350	1.591	92.184				
13	0.280	1.273	93.457				
14	0.260	1.182	94.639				
15	0.250	1.138	95.776				
16	0.194	0.880	96.657				
17	0.178	0.811	97.468				
18	0.175	0.797	98.264				
19	0.126	0.573	98.838				
20	0.104	0.471	99.309				
21	0.099	0.449	99.758				
22	0.053	0.242	100.000				

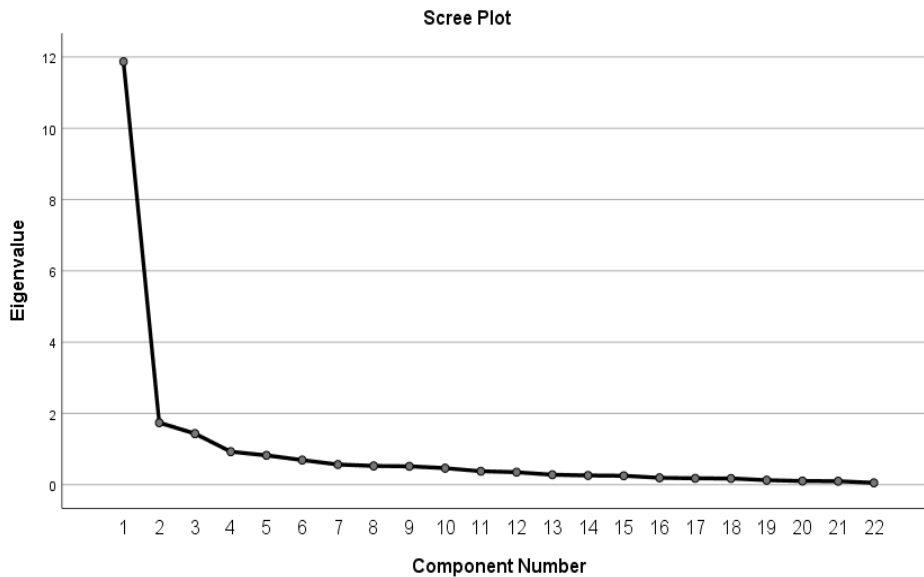


Figure 35: Scree Plot

The rotated solution revealed the presence of a simple structure with the three components showing several strong loadings. The interpretation of the three components, as shown in Table 24, was consistent with Barton (1995) classification of capabilities. The items that cluster on the same factor suggest that factor 1 represents supplemental capabilities, factor 2 represents enabling capabilities, and factor 3 represents core capabilities.

Table 24: Pattern Matrix and Communalities

FACTOR 1: SUPPLEMENTAL CAPABILITIES		
	Pattern Matrix	Communalities
Project and Client requirement	0.966	0.83
Stakeholders engagement	0.836	0.76
Compliance with sustainability legislation	0.728	0.6
Monitoring and evaluation of projects	0.675	0.74
Post-project evaluation and review	0.651	0.75
Compliance with the voluntary rating and Environmental Management System (EMS)	0.565	0.630
Surety, bonds, and insurance policies	0.551	0.52
Partnering with suppliers	0.528	0.66
Industrialised Building Systems (IBS)_ Prefabricated building units	0.500	0.670
Collaboration amongst the various teams in your organisation	0.487	0.73
FACTOR 2: ENABLING CAPABILITIES		
Collaboration with international sustainable construction firms	0.864	0.77
Collaboration with international bodies	0.854	0.78
Collaboration with international sustainable construction body	0.821	0.74
Collaboration with varying size contractors	0.609	0.6
Research and Development	0.468	0.56
FACTOR 3: CORE CAPABILITIES		
Improving communication system through information technology	0.797	0.69
Employee reward system	0.765	0.63
Employee empowerment	0.706	0.71
Education and training	0.671	0.8
Continual professional development	0.498	0.68
Inter-firm collaboration	0.468	0.56
Recruitment of experienced technical staff	0.448	0.62

The Importance-Performance Analysis (IPA)

After reducing the data to three groups, the IPA analysis was carried out, as explained in chapter 4. The means of performance and importance were determined; the gap (discrepancies) of each of the strategy was also determined. The gap was determined by subtracting the means of performance factors from the means of important factors. Tables 25, 26, and 27 presents the IPA results for the three groups of the capabilities identified. The IPA graph in Figure 37 shows the positioning of the various factors as perceived by the respondents. Figure 38 shows the graph for the gaps (discrepancies) of the 22 factors calculated. From the results shown on Table 25 factor one (supplemental capabilities), the performance gaps in most of the items were quite low (keep up the good work), except for items S5 (Post-project evaluation and review) and S9 (Industrialised Building Systems (IBS)/Prefabricated building units) that are perceived to be of low priority. Also, Items S7 (Surety, bonds, and insurance policies), and S10 (Collaboration amongst the various teams in your organisation) were perceived to be a possible waste of resources. Looking closely at the IPA graph in figure 29, item S8 (Partnering with suppliers), is on the "Keep up the good work" axis but it is at a borderline with possible over waste of resources axis. It will be of importance to note that small performance gap in an aspect does not mean that firms do not need to improve that aspect, but rather it means the firms have similar importance and performance levels on these aspects (R.-d. Chang et al., 2017).

Furthermore, the results on Table 25 supports earlier studies that firms will only focus on practices that will enable them gain legitimacy and competitive advantage than practices that will enable them disclose their sustainability performance (Rietbergen et al., 2015; Russell et al., 2018; Upstill-Goddard et al., 2015). The low priority score on post project evaluation is not surprising because earlier studies have shown that such practice is quite challenging in the AEC sector (Anbari et al., 2008; Opoku & Fortune, 2011).

Table 25: Importance-Performance Analysis -Supplemental Capabilities

Code	FACTOR 1: SUPPLEMENTAL CAPABILITIES	Mean of Performance	Mean of Importance	GAP	Focus
S1	Project and Client requirement	4.37	4.52	-0.15	Keep up the good work
S2	Stakeholders engagement	4.18	4.23	-0.05	Keep up the good work
S3	Compliance with sustainability legislation	4.18	4.34	-0.16	Keep up the good work
S4	Monitoring and evaluation of projects	4.16	4.26	-0.10	Keep up the good work
S5	Post-project evaluation and review	3.73	3.81	-0.08	Low Priority
S6	Compliance with the voluntary rating and Environmental Management System (EMS)	3.89	4.00	-0.11	Keep up the good work
S7	Surety, bonds, and insurance policies	3.97	3.87	0.10	Possible waste of resources
S8	Partnering with suppliers	3.85	3.89	-0.03	Keep up the good work
S9	Industrialised Building Systems (IBS)_ Prefabricated building units	3.71	3.76	-0.05	Low Priority
S10	Collaboration amongst the various teams in your organisation	3.90	3.87	0.03	Possible waste of resources

The second factor, Factor 2: (enabling capabilities), shown in table 26, have five items that are desirable by firms to support their normal operations and core capabilities. However, enabling capabilities do not convey any competitive advantage (Barton, 1995; Butler & Pyke, 2003). The results shown on Table 26, indicate that performance and importance mean of all the five items in that category are below 4.0, and their location in figure 29, are mostly at the lower left of the quadrant. Apart from item E2 (Collaboration with international bodies) requires improvement, all the remaining four items are under the low priority axis. Although, enabling capabilities do not contribute much in driving a firm's competitive advantage, therefore, this could likely be the reason for the low scores. Also, the poor sustainability performance of the AEC sector (Ageron et al., 2012; Papadonikolaki, 2018; Ruparathna & Hewage, 2015a; Russell et al., 2018) could be attributed to their inability in collaborating with the various international bodies (RobecoSAM, 2019).

Likewise, factor 3 (core capabilities), have seven different items, as shown in table 27. From the table and as represented on figures 36 and 37, item C1 (Improving communication system through information technology) level of performance is lower than the level of importance as perceived by the respondents. This result indicates there is a need for improvement on item C1. The results are in agreement with the report of the McKinsey group that explained the low level of utilisation digitisation in the AEC sector (Agarwal et al., 2018). Items C2 (Employee reward system), C3 (Employee empowerment), and C6 (Inter-firm collaboration) are perceived to be of low priority, which implies that there is no big pressure for improvement. Such capabilities could be attributed to the social complexity of the firms which are products of long organisational learning (Barney, 1991; Barton, 1995). On the other hand, items C4 (Education and training), C5 (Continual professional development), and C7 (Recruitment of experienced technical staff) are found to be satisfactory (keep up the good work). These findings

support earlier research that emphasised the importance of developing an organisation human resources firm (Eilers et al., 2016; Kannan, 2021; Meehan & Bryde, 2011; Opoku & Fortune, 2015; Qi et al., 2010; Rickaby & Glass, 2017). However, the gap in C7 (Recruitment of experienced technical staff) shows that despite the high level of importance and performance, attention needs to be paid to that aspect for improvement.

Table 26: Importance-Performance Analysis -Enabling Capabilities

Code	FACTOR 2: ENABLING CAPABILITIES	Mean of Performance	Mean of Importance	GAP	Focus
E1	Collaboration with international sustainable construction firms	3.10	3.10	0.00	Low Priority
E2	Collaboration with international bodies	3.19	3.34	-0.15	Areas to Improve
E3	Collaboration with international sustainable construction body	3.34	3.48	-0.15	Low Priority
E4	Collaboration with varying size contractors	3.52	3.40	0.11	Low Priority
E5	Research and Development	3.40	3.55	-0.15	Low Priority

Table 27: Importance-Performance Analysis -Core Capabilities

Code	FACTOR 3: CORE CAPABILITIES	Mean of Performance	Mean of Importance	GAP	Focus
C1	Improving communication system through information technology	3.94	4.26	-0.32	Area to Improve
C2	Employee reward system	3.45	3.44	0.02	Low Priority
C3	Employee empowerment	3.74	3.89	-0.15	Low Priority
C4	Education and training	4.19	4.39	-0.19	Keep up the good work
C5	Continual professional development	3.98	4.15	-0.16	Keep up the good work
C6	Inter-firm collaboration	3.48	3.63	-0.15	Low Priority
C7	Recruitment of experienced technical staff	4.03	4.32	-0.29	Keep up the good work
	GRAND MEAN	3.79	3.88	-0.10	

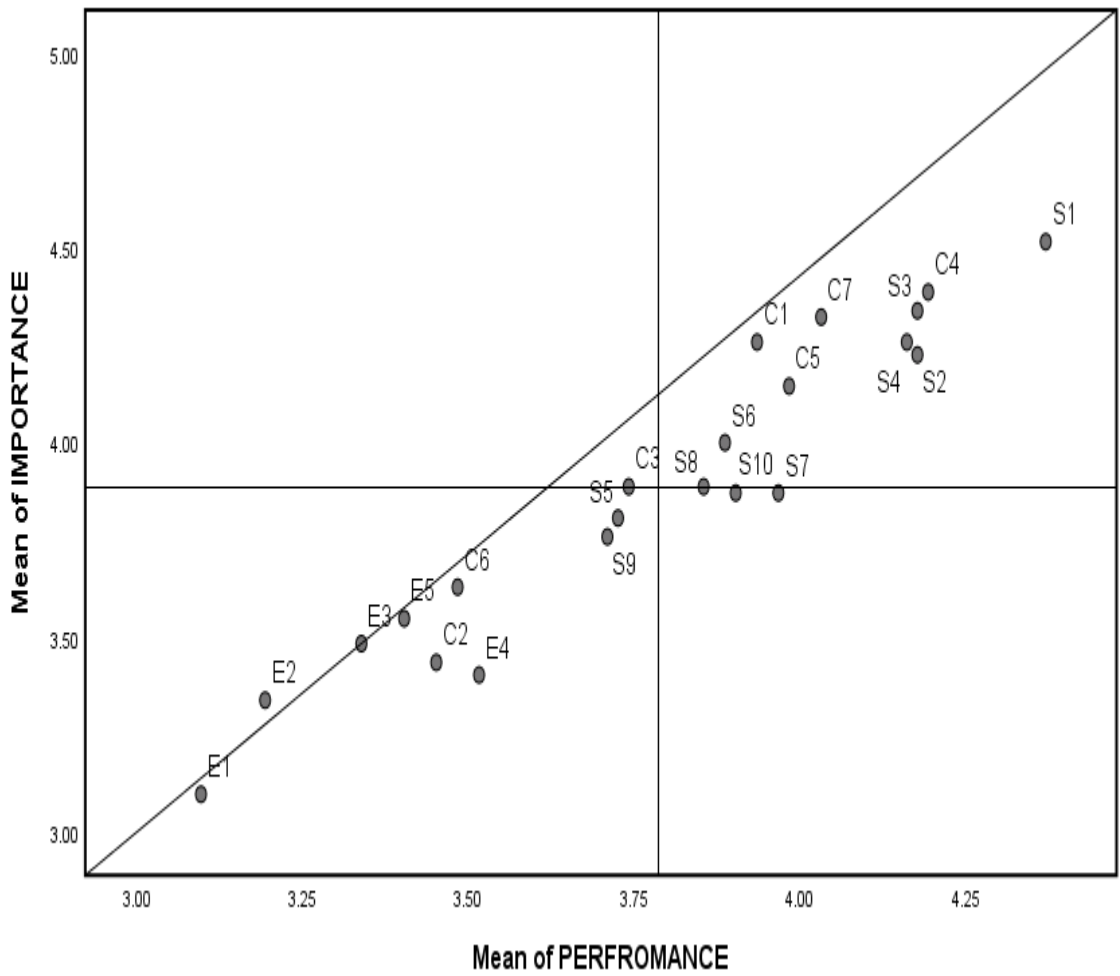


Figure 36: IPA Graph with Empirical Means and Diagonal line

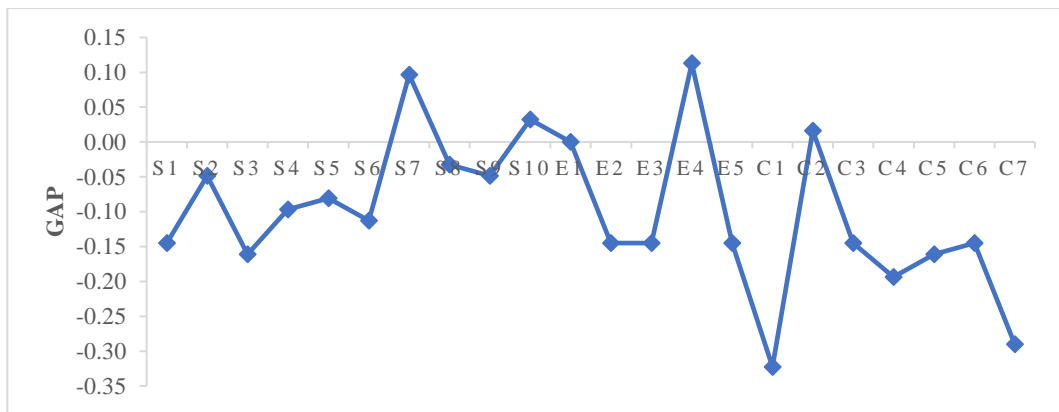


Figure 37: Gaps for the 22 Elements of Sustainability Delivery Strategies

4.3 Influencing Supply Chains by Main Contracting firms

This section sets to answer sub-research question 2 and objective 2 of the study that assesses how main contracting firms in Ireland influences their supply chains in embedding sustainable construction practice. The various level of collaboration was examined to provide a better understanding of contracting firms supply chain management. Descriptive statistics in form of tables and chats are used, and the relative importance index (RII) is used to rank the various factors identified in influencing supply chains.

The first question in understanding how main contracting firms influence their supply chains was to understand at what phase in the procurement process do firms engage their supply chains. Table 28 shows that 42% (26) of the respondents relate with their supply chains at all the three phases, while 15% (9) relate with their supply chains at two phases, and 44% (27) relates with their supply chains in only one phase during their procurement process. Noorizadeh et al. (2018), explained that the level at which the supply chains are engaged are contributes to their social capital and trust building.

Table 28: Phase of Engaging Supply Chains

Phase	Frequency	Per cent
Contract phase	9	15%
Pre-contract phase	5	8%
Tender Phase	13	21%
Pre-contract phase, Contract phase	1	2%
Tender Phase, Contract phase	2	3%
Tender Phase, Pre-contract phase	6	10%
Tender Phase, Pre-contract phase, Contract phase	26	42%
Total	62	100%

Having identified the phase at which the various firms engage their supply chains, the next part of the analysis was to assess the factors that enhance the long-term relationship between main contracting firms and their supply chains. The eleven factors identified by Adetunji et al. (2008), as shown in Figure 12 in chapter 2, provided the basis for analysis in understanding the factors that enhances the long-term relationship with supply chains. The questions were in the form of a 5-point Likert scale from very high to not at all. The reliability of the questions was checked on the 11 items. Cronbach's alpha showed the questionnaire to reach acceptability, with reliability, $\alpha = 0.842$. All the items appeared worthy of retention without any deletion (see Appendix C6). The RII was calculated and presented in Table 29. From the results, all the items were highly ranked and were above 0.70, which indicates a significant level of importance. However, the respondents ranked trust, high Knowledge of construction process, and level of commitment as the top three factors that enhance a long-lasting relationship. These three factors have been found to enhance collaboration and drive sustainable procurement performance (De Melo & Da Alves, 2010; Vurro et al., 2009). Likewise, regularity of workload, sharing of information, internal and external alignment (through coordinated teams and cross-functional integration) were ranked 9th, 10th and 11th. There was a tie between items 4 (A common goal and mutual support), and 5 (Effective communication), therefore the mid-rank method was used by assigning the average rank positions to the values. It would be allocated as if there were no ties (Amerise & Tarsitano, 2015). For example, Noorizadeh et al. (2018), explained that regular engagement of supply chains enhances their social capital and builds trust between the various parties. How the various factors drive sustainable procurement is further explore at the case study phase.

Table 29 Long-term Relationship with Supply Chains

Factors	Very High	High	Moderately High	Low	Not at all	Total respondents (N)	Weighted total	RII	Rank
Trust	42	18	2			62	288	0.929	1
High Knowledge of construction process	33	27	2			62	279	0.900	2
Level of commitment	31	29	2			62	277	0.894	3
A common goal and mutual support	25	29	8			62	265	0.855	4
Effective communication	23	33	6			62	265	0.855	4
Win-win situation	18	37	6	1		62	258	0.832	6
High purchasing power	21	27	14			62	255	0.823	7
Continuous innovation	14	37	9	2		62	249	0.803	8
Regularity of workload	12	34	16			62	244	0.787	9
Sharing of information	12	30	20			62	240	0.774	10
Internal and External alignment (through coordinated teams and cross-functional integration)	7	37	18			62	237	0.765	11

Furthermore, after assessing the factors that enhance the long-term relationship between the main contracting firms and their supply chains, the next analysis was on the supplier's development strategies. Also, a five-point Likert scale was used to analyse the frequency of utilising the various mechanism identified for improved performance. Table 30 shows the various mechanism and the results of the relative importance index (RII). The reliability of the five items measured, returned a Cronbach's alpha $\alpha=0.775$. Furthermore, all the items appeared worthy of retention without any deletion (see Appendix C6). The RII has the highest score of 0.768, which is the supplier's assessment. While the 2nd and 3rd highest ranked mechanism with an RII of 0.694 and 0.623 was instigating competition amongst supply chains, and training of supply chain members. These findings are indicative on the importance placed by contracting firms in enhancing the performance of their supply chains. Also, the findings are in agreement with the works of Sancha et al. (2016) and Kumar and Rahman (2016) that collaborating and assessing suppliers performance has a positive impact in driving sustainability performance. Furthermore, mechanisms like providing incentives for improved performance and helping in organisational restructuring/investing resources in supply chain organisation had an RII of 0.561 and 0.545, which ranked 4th and 5th, respectively. The last three mechanisms/strategies (ranked 3rd, 4th and 5th) have been suggested by different authors as they key elements to be considered in influencing supply chains in the delivering of sustainable projects (De Giacomo et al., 2018; Meehan & Bryde, 2015; Polat et al., 2017)

Table 30: Mechanism for Improving Supply Chain Performance

Factors	Always	Very Often	Sometimes	Rarely	Never	Total respondents (N)	Weighted total	RII	Rank
Suppliers assessment	13	31	14	3	1	62	238	0.768	1
Instigating competition amongst supply chains	10	23	17	10	2	62	215	0.694	2
Training of Supply chains members	4	14	30	13	1	62	193	0.623	3
Providing incentives for improved performance	1	8	35	14	4	62	174	0.561	4
Helping in organisational restructuring/ Investing resources in supply chain organisation	2	11	23	20	6	62	169	0.545	5

4.4 Level of Adoption of Digital Technology

The last organisational resources to be examined in this study is the digital technology tools and resources. As it was explained earlier that the adoption of digital technology by an organisation does not enhance its competitive advantage, rather the managerial capabilities of the firm through an effective process of organising and managing the digital tools in the firm is what enhances competitive advantage (Mata et al., 1995; Powell & Dent-Micallef, 1997). This section addresses objective four (4) of the study and research question three (3). The objective and research question are aimed at assessing the level and potentials of adopting digital technologies in driving sustainable procurement practice. In addition, the level of compliance of the various supply chains in adopting digital technologies is also examined in this section.

4.4.1. General Level of Adoption of Digital technologies

In assessing the level of adoption of digital technology, the respondents were asked on the impact of digital technology on their procurement process in the delivery of sustainable projects. The result of the findings is shown in figure 38. From the results, it is evident that digital technology tools and resources have a significant impact on the procurement practice of contracting firms. The results show that 29% (18) and 37% (23) of the respondents indicated highly significant and significant. While 24% (15) showed it was fairly significant and only 10% (6) indicated not any significant improvement. These results are not surprising, because earlier studies have predicted that collaboration and construction operations would be largely dependent on the utilisation of digital technology (Farmer, 2017; Roland Berger, 2016).

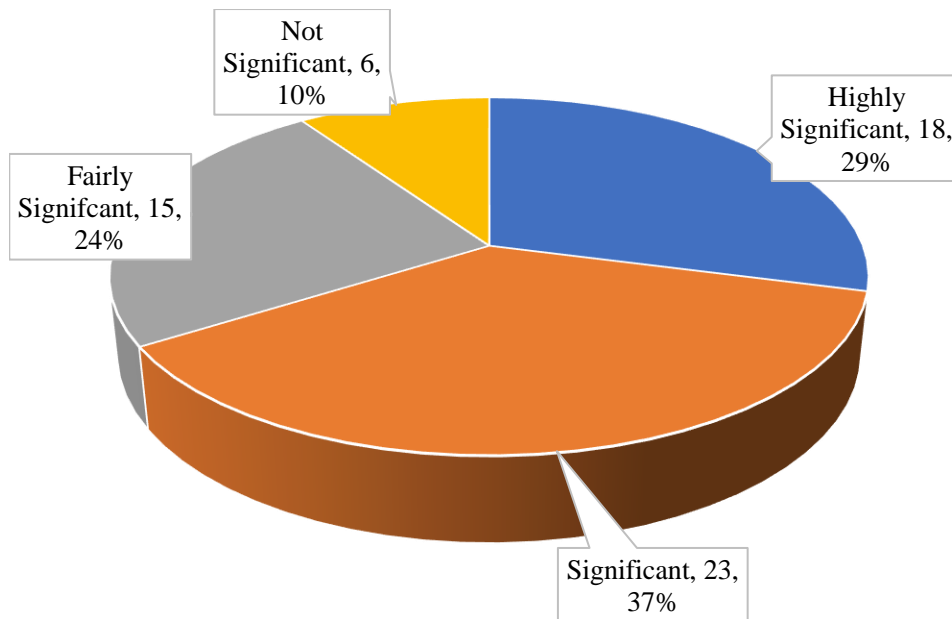


Figure 38: Impact of Digital Technology in the Procurement Process

Furthermore, in terms of the level of adoption of digital technologies by the various supply chains, the respondents shared different views. The summary of the results presented in figure 39 showed that 48% (30) of the respondents rated the level of compliance as average. While 15% (9), and 34% (21) had a rating of very high and high, respectively. Lastly, only 3% (2) gave a rating of low. Generally, from the results observed, it can be said the supply chains have different levels of compliance in adopting and utilising digital technologies. Such variability could be assumed to be due to their financial resources and size of their organisation (Adetunji et al., 2003; Bohari et al., 2016; Boyd & Schweber, 2012; Chang, Zuo, et al., 2016).

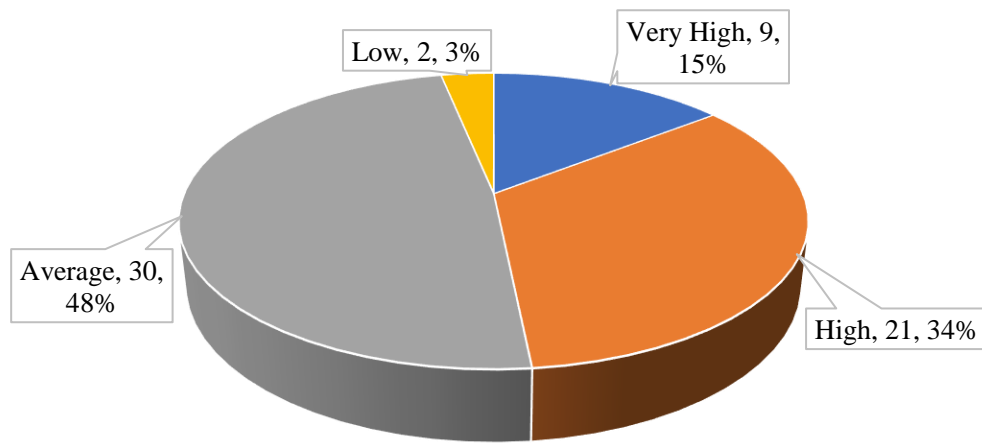


Figure 39: Level of Compliance by Supply chains in adopting Digital Technology

After examining the general impact of utilising digital technologies and the level of adoption of digital technologies by supply chains, the study further examined the areas that contracting firms have utilised digital technologies. The areas identified by the Mckinsey group, Roland Berger consulting and World Economic Forum, as explained in chapter two are:

- i. Higher-definition surveying and geolocation,
- ii. Building Information Modelling (BIM),
- iii. Digital collaboration and mobility
- iv. The Internet of Things (IoT) and advanced analytics, and
- v. Future-proof design and construction.

The respondents were asked to indicate areas that they have utilised the various digital technology tools and resources in driving sustainable procurement practice. The results are shown in figure 40, reveals different areas that firms have utilised digital technologies in driving sustainable procurement. Figure 40 shows that most of the respondents have used their digital technology resources in either three different areas 26% (16), or two

different areas 27% (17), or only one area 21% (13). Likewise, only 15% (9) and 5% (3) have used their digital technology resources in any four areas and all the areas, respectively. Remarkably, 6% (4) of the respondents showed that they do not use digital technologies in those areas. Also, other areas identified by the respondents were in collaboration like using field view, viewpoint (4P) projects, and engineering technology for heavy civil works.

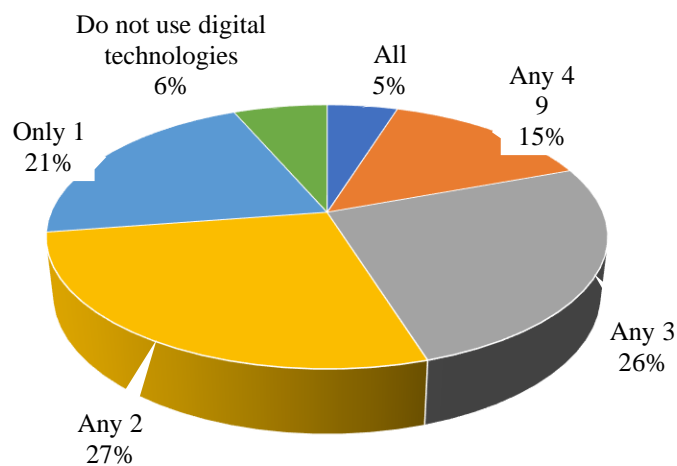


Figure 40: Areas of Application of Digital Technology

4.4.2. Utilisation and Potential of Digital Technology in Sustainable Procurement

In terms of the utilisation of digital technologies in implementing sustainable procurement practice, six areas identified from the literature in the study were examined. These areas are material selection, energy savings analysis, recycling and material recovery, construction demolition, life-cycle costing, and calculation of carbon emission. The respondents were asked to rate how often their organisations utilise digital technology tools to carry out the six listed areas. The questions were in the form of a 5-point Likert scale, and the reliability of the questions returned a Cronbach's alpha of $\alpha=$

0.830. Also, all the items appeared worthy of retention without any deletion (see Appendix C7). The RII analysis was used, as shown in table 31.

Table 31: Level of Utilisation of Digital Technology on Sustainable Procurement Practice

Activities	Always	Often	Sometimes	Rarely	Never	Total respondents (N)	Weighted total	RII	Rank
Material Selection	8	30	18	4	2	62	224	0.723	1
Energy savings analysis	9	19	25	8	1	62	213	0.687	2
Recycling and material recovery	8	22	23	6	3	62	212	0.684	3
Construction Demolition	8	23	17	9	5	62	206	0.665	4
Life-cycle costing	3	21	24	12	2	62	197	0.635	5
Calculation of Carbon Emission	2	18	23	15	4	62	185	0.597	6

The results presented in Table 31 evaluate the level of utilisation of digital technology in an organisation's sustainable procurement practice. The results show that material selection is the most frequent activities being carried out by an organisation using their digital technology tools and resources with an RII of 0.723. The RII of the 2nd to 5th items was so close with energy savings analysis (0.687), recycling and material recovery (0.687), construction demolition (0.665), and life-cycle costing (0.635). The least of which is the calculation of carbon emission which has an RII score of 0.597. The results with regards to life-cycle costing agree with an earlier study by Opoku (2013), on the low level of application of whole life-cycle costing in the AEC sector. Also, it sheds more light on the results on Table 20 section 5.2.2, where life-cycle technology was ranked the 7th although the results indicated a high impact with an RII of 0.716. Furthermore, with regards to enhancing sustainability performance, the results indicate that firms tend to concentrate more on activities that focuses on site operations. Therefore, in driving sustainable procurement performance, maximising the potential of digital technologies could provide the best value to clients and enhance disclosing of sustainability performance (Naoum & Egbu, 2016; Saieg et al., 2018).

Furthermore, the perception of the participants on how important digital technology will promote sustainable procurement in their organisation was examined. The questions were in the form of a 5-point Likert scale, and the reliability of the questions returned a Cronbach's alpha of $\alpha = 0.888$, and all the items appeared worthy of retention without any deletion (see Appendix C7). The results, as shown in Table 32, have an RII all above 0.7, which indicates that all the activities examined are quite important. However, energy savings analysis was ranked the highest with an RII of 0.855. While reality capturing, material selection, recycling and material recovery, and calculation of carbon emission all have an RII above 0.8 and ranked 2nd, 3rd, 4th, and 5th respectively. Again, just like the previous results life costing was ranked 6th with an RII of 0.781, and construction

demolition was ranked 7th with an RII score of 0.735. In addition, obtaining such a high score confirms earlier studies on the increase in the level of awareness of practitioners with regards to sustainability practice (Adetunji et al., 2003; Akotia et al., 2016; Chang, Zuo, et al., 2016; Higham et al., 2016; Opoku & Ahmed, 2013).

Table 32: Level of Importance in Utilising Digital Technology in Sustainable Procurement Practice

Activities	Very Important	Important	Moderately Important	Slightly Important	Not Important	Total respondents (N)	Weighted total	RII	Rank
Energy savings analysis	30	22	8	1	1	62	265	0.855	1
Reality capturing	25	23	12	2	1	63	258	0.832	2
Material Selection	23	25	12	2	0	62	255	0.823	3
Recycling and material recovery	24	23	11	3	1	62	252	0.813	4
Calculation of Carbon Emission	24	24	9	3	2	62	251	0.810	5
Life-cycle costing	15	31	11	5	0	62	242	0.781	6
Construction Demolition	17	22	13	6	4	62	228	0.735	7

4.5 Chapter Summary

This chapter has presented the outcome of the questionnaire survey carried out during the study. In analysing the questionnaire survey to answer the research questions of the study and outlined objectives, several statistical analyses were carried out. Descriptive statistics in the form of tables and charts were used. Inferential statistics like the chi-square, factor analysis, relative importance index, and important performance analysis were utilised in analysing the data. The first part of the analysis was to present the general background of the respondents in terms of their organisations' size, which are financial turnover, years in business, number of employees and nature of work undertaking. In achieving objective two of the study, which was to evaluate the current level of adoption/performance of sustainable procurement by contracting firms. The following were examined: the level of compliance with organisations sustainability policies, the impact of sustainability drivers (the seven revolutions of sustainability), and the sustainable procurement delivery strategies. In addressing objective three, which is related to research question two on how main contracting firms influence their supply chains in embedding sustainability practices. In addressing this objective, the phase of engaging supply chains was examined, also factors that improve the long-term relationship with supply chains, and the mechanism for improving the performance of supply chains was critically examined. The last part of this chapter was to examine the level of adoption and potentials of digital technology. This part of the research addresses objective four of the study and research question three. The general level of adoption of digital technology and the level of adoption of the various supply chains in adopting or using digital technology were assessed. Also, the frequency of usage of digital technologies in the procurement processes, and the potential levels of importance of digital technology were equally examined.

Overall, the findings from the questionnaire survey provided deep insight into how large construction-contracting firms utilise their organisational resources in driving their sustainable procurement practice. It was evident that from the results of the Importance-Performance Analysis (IPA) that most firms invest resources in their core capabilities. Trust, high knowledge of construction processes, and commitment were found to enhance the long-term relationship between contracting firms and their supply chains. Besides, contracting firms have developed the various mechanism of improving and supporting their supply chains. Regarding utilising digital technologies, the results show that digital technologies have a significant impact in their procurement process and have greater potentials in promoting sustainable procurement. The continuous and effective utilisation of the various organisational resources makes it difficult for competitors to understand and imitate the firm's strategies (Barney, 1991; Hart, 1995; Ruivo et al., 2015)

The next chapter presents the findings from the case study that will provide an in-depth understanding of the research question of this study which is to understand how large contracting firms embed sustainability in their procurement practice.

CHAPTER 5
CASE STUDY- ORGANISATIONAL LEVEL

5.0 Introduction

This chapter reports the outcome of the findings from the case study carried out in the study. As explained in the methodology chapter and depicted in Figure 41, the case study was carried out in two different phases. The first phase was at the organisational level, while the second phase is at the project level.

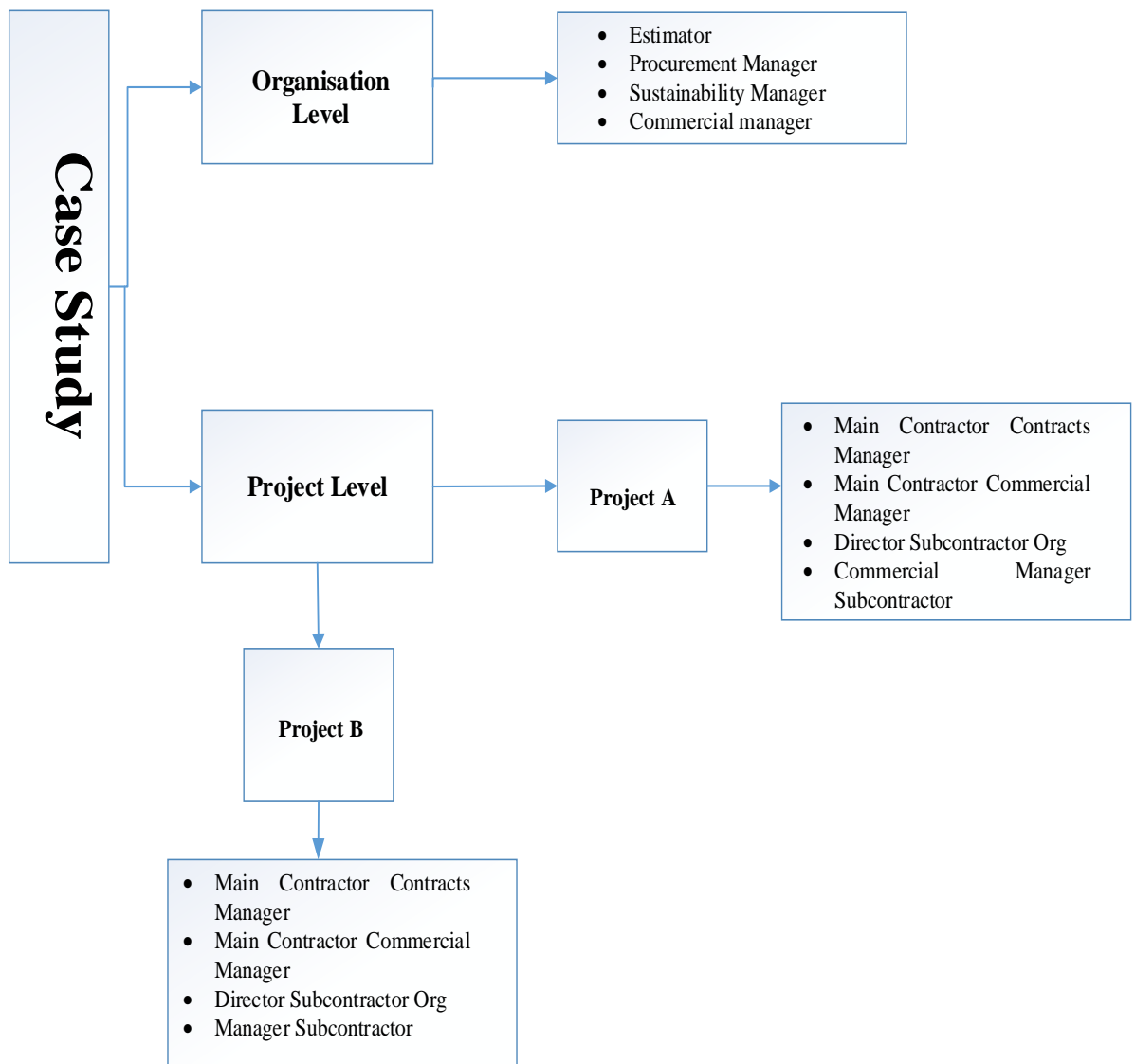


Figure 41: Case Study Layout (Source: Author)

This chapter reports findings from the organisational level. In conducting the case study, related documents like organisational policies, sustainability policies, sustainable procurement policies, anti-bribery policy, digital project delivery policy, and sub-

contractor performance reports guidance were examined. In addition, interviews were conducted with four participants in the different units of the organisation that are involved in the procurement of goods and services (procurement unit, pre-construction unit, project unit, and sustainability unit). The findings at the project level (phase 2) are reported in the next chapter (chapter 7).

5.1 Structure of the Findings

In addressing a research problem from qualitative data, different approaches are used to analyse the data. Approaches like content analysis, discourse analysis, interpretative phenomenological analysis, and thematic analysis (Braun & Clarke, 2006; Yin, 2009). Thematic analysis was found to be appropriate in this study because of the advantage it provides in allowing the researcher to reflect reality and to unpack or unravel the surface of reality. Thematic analysis can be carried out in the form of inductive process or through a theoretical lens (Braun & Clarke, 2006). The inductive analysis codes data without trying to fit it into a pre-existing coding frame, while the theoretical thematic analysis is driven by the researcher's underpinning theoretical or analytical interest in the study area. The theoretical thematic analysis was used in analysing the data in this study. The NVivo 24 qualitative data analysis software was used in analysing the data (see appendix D) for example of themes and nodes created. The conceptual framework in Chapter 3 provided a guide in addressing the research questions and objective of the study.

The findings in this chapter and the next chapter are presented thematically to aid in addressing the study research questions and objectives as depicted in Figure 42. The chapter is divided into three sections. Section 6.2 addresses objective two, where the findings report how sustainable procurement is implemented within the firm. Also, how the firm addresses government and external stakeholders' requirements, and how they

implement client requirements and collaborate with the client's team is reported in this section.

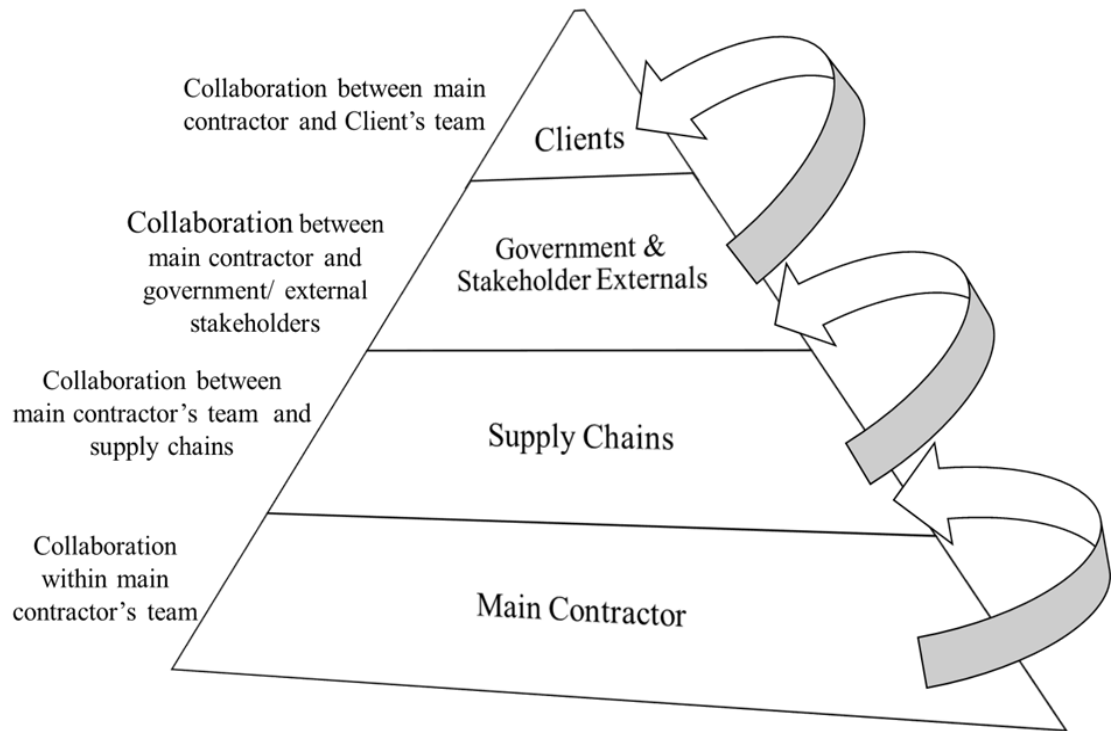


Figure 42: Structure of Findings (Source: Author)

Section 6.3 addresses objective three of the study, on how the firm studied influences their supply chains in embedding sustainable practices. Lastly, section 6.4 reports findings on the utilisation of digital technology tools and resources. A summary of the chapter is provided at the end of the section.

5.2 Implementation within the firm

In this section, the findings that address sub-research question one that states how do contracting firms implement sustainable procurement practice in their organisation is reported. In addressing the research question, objective two guided the investigation. The objective seeks to evaluate the current level of adoption/performance of sustainable procurement practice in the Irish construction industry. Therefore, from the interviews

and documents analysed, it was revealed that the implementation of sustainable procurement practice within the firm could be understood in three different aspects. These are collaboration within teams, implementing government laws and regulations and collaborating with external stakeholders, and thirdly collaborating with client's and client's team. The findings of each of the identified themes are reported below.

5.2.1 Collaboration within the firm

This section seeks to understand how collaboration is carried out within the various units in the organisation. First in understanding the level of collaboration the company organisational and sustainability policies were critically examined. The findings revealed that the organisation understands the importance and participation of the workers in achieving the company's sustainability goals. Part of the sustainability policies states that:

"...the policy will be communicated across the organisation, and will be regularly reviewed and updated..."

The respondents were asked how the policies are communicated across the organisation. From the various response, it was observed that communicating sustainability policies in the organisation was carried out both formally and informally. Formally is done through organised pieces of training and workshops, while informally it is through informal meetings, using tags, posters, and billboards. The firm organises training on the different aspect relating to sustainable procurement through an online channel or physically. The respondents (Estimator) explained that staff undergo mandatory pieces of training in areas of responsible sourcing such as bribery, child labour, anti-slavery and health and safety.

"With regards to training, we are obliged or were obligated to carry out specific sustainability training like on bribery, child labour, anti-slavery and health and safety. The training courses are online with the company intranet".

Apart from the internal training organised by the organisation, it was found that the company also collaborate with other external bodies to organise training to all level of staff with regards to sustainable procurement. One of the respondents (Sustainability Manager) at the time of the interview, explained that the company, in conjunction with the Construction Industry Federation (CIF) are planning a training focusing on sustainability practice. The respondent (Sustainability Manager) further explained that their apprentices in the past were trained in collaboration with the CIF. He explained that the essence of the training was to make the apprentices conversant with the issues of sustainability and responsible sourcing. He stated that:

"The workshop we have here is for the apprentice carpenters, so we are looking to get the workshop certified as well. This is because when they get timber in if they are making a cabinet or whatever, then we can put the FSC mark on it.....but we are just showing all right we are sustainable we want to have an only sustainable source of timber".

Likewise, with regards to the informal communication of sustainability practice, from the interviews conducted, it was observed that changing the psychic of workers is one of the strategies adopted. As mentioned earlier, such a strategy is carried out with the use of tags, posters, and informal discussions. A respondent (Commercial Manager) admitted

that such informal approach creates awareness that makes sustainability to be a usual practice within the firm.

"It is like getting little slowly into the psychic of recycling, reduce, reuse. That was one kind of tag line we had, so it is always kind of building on that".

Furthermore, during the interviews, it was noted that the firm studied developed a strategy for collaborating with their supply chains in promoting sustainable procurement. This was evident in their sustainability policy that shows the company is desirous of implementing sustainable procurement practice in all aspects of their operations. The company sustainable procurement policy states that:

"the company will strive to ensure that decisions taken regarding the procurement and engagement of any organisations, individuals, goods or services are governed by integrating environmental, legal, social and economic considerations into all stages of the procurement process."

Therefore, the respondents were asked how these policies are communicated to the supply chains. The explained that they collaborate with their supply chains to share the company sustainability requirements and expectations. Such communication is carried out both formally and informally. In communicating formally, they explained that meetings are organised with their supply chains to educate them and exchange ideas with regards to products or methods of construction. The Sustainability Manager revealed that:

"...So, for one meeting we had with one of our major suppliers we went through the top 70 materials that we procure from them we told them right, we want

what is top use, top purchases that we have and we want a green alternative as well".

Additionally, communicating their sustainability requirements informally, given an instance of material selection, a respondent (Commercial Manager) explained that informal discussion is usually carried with their supply chains. Such discussions, as explained, is around alternative and better products.

"We then asked a simple question can you bring anything better than this? You know in some jobs we might end up using the better system, more zero energy rated."

With regards to collaboration within the various units in the organisation, the respondents were asked how feedbacks and products information are shared or communicated. They explained that information is shared amongst the various units by sending enquiries, checking supply chain performance reports, or through informal enquiry. On the effectiveness of sharing the relevant information amongst the units in the organisation, different views and opinions were shared by the respondents. Two of the respondents explained that they relied on the knowledge of the buying team in the procurement unit. The respondents further explained that because the buying team deals with many suppliers, they will have better knowledge and information about the right product and source of the products. One of the respondents (Commercial Manager) said:

"Yes, the buyers are excellent. They would know better the product that I need.

For instance, if I order timbers that they know the suppliers, they have information about the product because they are all the time buying materials or sourcing materials. So, if I say to the buyer, I need to get concrete, so they have

all the knowledge a lot of knowledge. A lot of knowledge about what is good material or bad material and sustainable materials".

However, another respondent (Supply Chain Manager) observed that in terms of making enquiries and placing orders or requisition through the buying team, he/she noted that the approach to some extent is cumbersome. This the respondent explained that there are instances where detail specification of a product is not provided, which requires the buyers to assume that the sustainability requirement of the product is not very important.

"For example, a requisition will come through for timber product. If it does not state FSC, well then, the assumption would be from the buyer that FSC is not required. So, the buyer will not actively try to go back to project and say I think you should buy FSC because it will be more expensive. From the viewpoint of the buying team, it is upon the requisition of the project to tell them exactly what they want. So, they will not make any wrong request".

With regards to receiving and sharing feedback on the performance of a product or supply chains, different views amongst the respondents were shared as well. The respondents explained that sub-contractor's performance is shared amongst the various units and stored in the company database. Nevertheless, one of the respondents (Estimator) revealed that obtaining information from the site team has always been very difficult.

"Sometimes, we struggle to get information from site teams. It is a struggle because I am not directly involved in the project".

Also, another respondent noted that most of the time, feedbacks obtain are mostly related to supplier's performance relating to logistics rather than the performance of the product. The respondent (Supply Chain Manager) stated that:

"To be honest, you will not hear anything back until something is bad. So, you know, you will not get positive feedback on everything that you supply. You will not even be told these twenty things are perfect or they match sustainability criteria. You will only hear something not even the product itself but the performance of the company that you are dealing with. We at the central office are contacted only when there is a problem".

Reflecting on how collaboration is undertaking within the firm in driving sustainable procurement, it is evident that the different strategies and mechanisms are utilised. Findings from documents and interviews revealed that the firm sustainability policies guide the implementation and adoption of sustainable procurement. Also, the policies were designed by highlighting the importance and the need for the participation of the various actors (workers, supply chains and stakeholders) that are key in driving sustainability practice. One of the key requirements for the successful adoption and implementation of sustainable procurement is the clarity of the various sustainability policies of the organisation (Iles & Ryall, 2016). Also, Rickaby and Glass (2017) argued that aligning organisational policies with workers value could enhance sustainability performance.

Furthermore, how such policies are communicated to the various actors is key in realising the organisations sustainability objectives. This is necessary because delivering sustainable construction requires a high level of teamwork and effective communication (Demaid & Quintas, 2006; Fellows, 2006). From the findings, the policies are communicated

both formally and informally to all the actors. Such a strategy is necessary because it will be illogical if a firm's adoption of sustainability practices at the corporate level is not entirely infused into the entire organisation and its process (Schulz & Flanigan, 2016). Regarding sharing of information, different approaches are used by employees in obtaining information about a product or supply chains. However, the process, as noted by some of the respondents, is quite cumbersome. Successful information sharing amongst team members has been a critical factor in enhancing collaboration (Woo et al., 2016). Also, as mentioned earlier, the successful delivery of sustainable projects depends on a high level of teamwork and effective communication (Demaid & Quintas, 2006; Fellows, 2006). Such communication will require equal access to all information and obtaining relevant feedback from the various teams and units in the organisation.

Having presented the findings on how collaboration within the organisation studied is carried out in promoting sustainable procurement practice, there is a need to understand further how the firm collaborate and addresses government laws and regulations. Also, on how they communicate and collaborate with the external stakeholders. Section 6.2.2 report the findings from the organisational level on how the firm addresses the issues raised.

5.2.2 Implementing Government and External Stakeholders Requirements

Organisations, in strategizing to gain a competitive advantage, usually develop policies that address external challenges or factors. However, the focus of this study is to understand the internal organisational strategies adopted by construction contracting firms in implementing sustainable procurement. But it will be rewarding to have an insight into how the organisation addresses government and stakeholders' requirements. This section further addresses research questions one and four. The findings revealed that the firm had developed various strategies to comply with government laws and regulations and mechanisms for collaborating with external stakeholders.

Different views were observed with regards to complying with government laws and regulations and collaborating with external stakeholders. From the interviews, it was observed that the firm makes considerable effort during their procurement process to ensure that each of their projects complies and meets with the statutory laws and regulations. One of the strategies developed in the company procedure is to have and keep a legal register that is regularly updated to ensure that the company comply with all the statutory requirements. Also, the respondents explained that as part of the company policies, the firm is always open to adjust to new regulations and engage the relevant authorities during the planning phase of any project. With regards to being open in adjusting to laws and regulations, one of the respondents (Sustainability Manager) said:

"Every year, the policy is reviewed. So, whatever comes out from our targets if we are hitting our environmental sustainability targets, we put it in there as well. But you can see, it is all about the information. We must make sure that the information first is correct, and it is measurable".

Furthermore, the respondents explained that some of the regulations that promote sustainable procurement are the Environmental Product Declaration (EPD) that expect designers to source product with EPD declarations. Also, another driver is the laws from the Sustainable Energy Authority of Ireland (SEAI) that promotes supplying energy from a renewable source. A respondent (Commercial Manager) stated that:

"like in this country, we have the Environmental Protection Agency (EPA). So, they manage to make sure that if we are starting a site, there is a watercourse besides us, we get in touch with them to make sure we are not polluting the watercourse".

It was further noted during the interview that the company developed some innovative practices in complying with the laws and regulations. Some of the innovations noted as revealed by the respondents were procuring and using electric cars, using the SMART waste management system to record the energy usage from fuel and electricity, timber usage, water usage, and waste. Also, one of the respondents further explained that the government declaration of environmental emergency for climate change and the level two BIM requirement for all government projects had altered the way of doing business in their company. However, another respondent (Supply Chain Manager) shared a different view. He noted that complying with government regulations was primarily to avoid being fined and promote their image to the public. Reflecting on his experience in the construction sector, he stated that:

".... the construction sector in Ireland 23 years ago, where health and safety issues, holidays, having railings on site were not observed, but now because of the enforcement of laws and regulations, everything has changed today".

The respondents were further asked how they ensure the products from their supply chains comply with the government laws and regulations. From the response received, it was found that complying with government laws and regulations with regards to supply chains was assumed by the certification of the products. For instance, with regards to verifying the Forest Stewardship Council (FSC) stamp on timber products, some of the respondents believed the FSC are expected to do their job well and ensure all the timbers supplied to them could be traced to their origin (actual forest). Similarly, with regards to building merchant products, a respondent explained that some of the existing environmental laws make it difficult for the buyer or project team to have complete

information about the production process of a component or a machine. Given an example of a building merchant product, the respondent (Supply Chain Management) stated that:

"take an example of a builder's merchant that has a pump on the shelf, the copper and the steel wood in the pump will come from maybe Turkey or China. You can have legislation or specifications that will say to a certain extent that this product meets this specification, but you can only see so far back. Therefore, I do not know that a Child has not mined copper in China. In addition, currently, there might be anti-slavery legislation, but it does not put requirements as far as I am aware, it only puts limited requirements on the end-user".

Finally, in terms of disclosing their sustainability practices to the external stakeholders, the respondents explained that they create awareness to the public on their practices through social media platforms like Twitter, LinkedIn, and the company website. Also, posters and banners are placed on their sites to create awareness to the public. Another essential point revealed was that the company is one of the first companies in Ireland to register their projects with the Considerate Constructors Scheme (CCS). The respondents explained that registering their projects with the CCS is to provide confidence to the client and the public. Also, to create awareness that the company is mindful and care about the community, the environment, and their workers.

In as much as government laws and regulations drive the adoption and implementation of sustainable procurement, a respondent (Sustainability Manager) noted that sustainability practice in the company is mostly self-driven and promoted by the client.

He noted that the company set-up strategies to enable them to gain a competitive advantage while meeting their sustainability targets.

"We must ensure that we are compliant with all the regulations. So, as we know, they are essential. But it looks like the clients that we were working with, the big clients the big blue-chip clients and they are the ones that are drivers. They want the most energy-efficient building. They want to make sure that in 50 years in 100 years this building can be taken down and the material can be reused somewhere; you know the full life cycle analysis".

Explaining further how the company are self-driven with regards to their sustainability performance, the respondent (Sustainability Manager) said:

"..... for instance, like what now we have done this year, we have done a full carbon disclosure on the CDP-Carbon Disclosure Project on all our projects. All big companies in the world are all involved in that. So, it is kind of like a strategy we have put in place to reduce our energy. So, what have done is that we procure electricity from renewable sources".

Although, the self-driven approach in driving sustainability as found in the interview is consistent with earlier studies (Rietbergen et al., 2015; Russell et al., 2018; Upstill-Goddard et al., 2015). However, these findings need to be interpreted with caution because the motivation behind the self-driven is not well understood. Earlier studies have argued that firms adopt sustainability practices only to enable them to gain legitimacy and competitive advantage (Rietbergen et al., 2015; Russell et al., 2018; Upstill-Goddard et al., 2015). Also, as Myers (2005) suggested, construction firms should go beyond public

relations but rather have the capabilities to disclose their performance to their clients and the public.

Therefore, to further explore research question one, which states how construction-contracting firms in Ireland embed sustainability in their procurement process, the next section reports findings on collaboration and implementing the client's requirements.

5.2.3 Collaborating and Implementing Client's Requirements

Government laws and regulation as it was noted in section 6.2.2 are one of the significant drivers in driving the implementation and adoption of sustainable procurement by construction-contracting firms. However, earlier findings reported in the last section, and evident in the literature review (Kumar & Rahman, 2016; Ruparathna & Hewage, 2015a), showed that the client's demand is a significant driver to sustainable procurement practice. How the firm studied addresses and collaborate in meeting the client's requirement is reported in this section. In meeting their clients' requirements and demands it was revealed from the interviews that the nature and type of client, the nature and type of project, and the geographical location or origin of the client business determine their disposition towards sustainability and the level of collaboration. Therefore, different strategies have been developed in addressing each client demands and requirements.

In understanding how the client's demands and requirements are addressed, the sustainability policies of the firm were first examined. It was noted that the firm placed importance in meeting their clients' demands. This was shown by their commitments in recognising and accepting their actions with regards to sustainable procurement.

"We recognise and accept our actions can have consequences on others and will strive to ensure that decisions taken regarding the procurement and engagement of any organisations, individuals, goods or services are governed by integrating environmental, legal, social and economic considerations into all stages of the procurement process".

Also, the policy seeks to collaborate with their clients and the client's team to develop a supply chain that will be mindful of their sustainable procurement requirements.

"We will seek to collaborate with clients, consultants, specialist contractors and suppliers to develop integrated supply chains which respect biodiversity and human rights and promote fair employment practice".

With regards to the nature and type of client, the findings revealed that different clients have different sustainability requirements. The respondents explained that the demands of big multi-national clients with regards to sustainability requirements differ from other clients. This is because the multi-national clients usually insist on some specific products and materials. Such products and materials usually are recyclable, sustainable, local, and have a less environmental impact. Also, some of the requirements require the main contractor to source for products and materials from a specific location. They further explained that most of the time, the clients insist on using some specific supply chain companies because of their long-term relationship and have high sustainability performance. A Commercial Manager explained that:

"The clients might sometimes insist on certain supply chains but in my experience, you know, the selection of a type of sub-contractors or supplier for the likes of Amazon or Google, they will already have the sub-contractors that they have or used on previous European or even American projects. They will have selected those supply chains, and their environmental criteria will have been high, I think, and they will insist on their use or something similar be used for their project".

Secondly, with regards to the nature and type of project, it was revealed that the project specificity influences the clients demand requiring or demanding a building that is LEED or BREAM certified. The respondents explained that such demand from the client is a result that the value of the property could be enhanced by the building having a high certification. Explaining, the Commercial Manager said:

"So, they will say I want to have LEED gold, LEED platinum. I want to have the highest environmental conforming building that we possibly get. So they are the ones that drive that because they are driving that because when they get the team to come in, they can say all right, we have this efficient building here that is perfect for your needs, and they will be able to rent it out quite easily".

Thirdly, the findings from the interviews further revealed that of recent, there had been some foreign direct investment (FDI) in the Republic of Ireland. Therefore, most of the foreign companies or investors will want to have a building to meet the sustainability requirement standards of their home country. They noted that the sustainability requirements and standards from clients coming from the USA, Germany, UK, and France are always very high compared to clients in Ireland. An Estimator said:

"American clients are very conscious of sustainability. Also, like big clients from France, they would be kind of aware of being sustainable". ".....like in some of my dealings with just say for example American companies, they have been talking about sustainability and they have quite strict requirements regards to sustainability like Google and Amazon".

Although, a respondent (Commercial Manager) explained that private Irish property developers that would rent out their property to foreign firms would insist on their buildings meeting the LEED or BREEAM certification requirements.

"..... we would have Irish clients who will want an office block and hope to sell or rent on to the end-user an American multi-national so that they would be very conscious of that. They wanted maybe LEED or BREEAM project".

These clients demand and requirements, as noted by the respondents, have changed the way the firm tender for projects. Innovative ways of tendering for projects have been developed that have changed the focus, which was primarily based on the cost to a more sustainable approach. With regards to the strategies developed in collaborating with their client's and client's team, the respondents revealed that several strategies like being proactive, collaboration at the planning stage, and educating their clients with regards to construction methodology and alternative materials. In being proactive, the respondents explained that in a situation where the sustainability criteria or requirements is not very clear during the tendering process, the nature and type of clients determines the assumptions to be made. They explained that from their experience, the disposition of

the client towards sustainability would determine how they go about tendering for the project. Sharing his view, the Estimator explained:

"..... yes, it does happen sometimes, and it depends on the client, and if we feel that the client favours sustainability, we go for products that are more sustainable or whatever and are source from certain locations. We would put that in our technical submission, so the client is aware of it. So, if they see that, some items or prices are more expensive, they know that we are sourcing from a better location, or our products are LEED certified."

Also, the respondents explained that they usually provide a suggestion for alternative materials or construction methods if they see that the specification provided will not meet the minimum requirement. However, they noted that most of the time, the client's willingness to accepting the alternatives is dependent on cost or quality of the product. In a situation that the client is not willing to pay for a better alternative, a Commercial Manager explained that the company adjust its budget and provide the best alternative at extra cost to them.

"Well, they will be open to it if it is cost-neutral. It depends on the client; some clients will pay for it while some clients will not..... we would tell the client that we have a better product that will enhance your energy rating or whatever reason. But if the client doesn't want to pay for it, but we believe the right product, we sometimes say right we adjust our budget and proceed with it, and we often have the client will say right, I am happy with that If it is the right product."

The respondents (Commercial Manager) further explained that they bring in their knowledge and expertise when suggesting alternative materials or construction method.

"We had different initiatives over the years if a client specified a one-ply roofing system we will say no we are not doing this we need to have two- or three-ply system. This is because if the project fails, it is ours for nearly forever until the defects liability period is finished".

Also, they educate their clients and their team with regards to emission, wastage, reducing waste on-site. This they explained is achieved by using a checklist just like the legal register to keep an up to date records as it relates to sustainability. They also collaborate with the client's team in showing them how they will go about metering electricity, water usage, source of energy and electricity and heating.

The respondents were asked their experience with regards to the disposition of the client's team as it relates to accepting suggestions on alternative materials or construction methods. In response, they revealed that they have the advantage of being one of the oldest and top construction companies in Ireland. Therefore, their long years in business and experience have provided them with an advantage. Advantage of influencing the decisions of the client and his/her team, the Commercial Manager revealed that:

"Oh, yes, they would be I suppose we have an advantage here because we are one of the biggest companies in Ireland. So, many clients might take us on because we have this knowledge because we will be what used to be class Master Builders. We do have different teams to help with that. So yes, I would say we are in a lucky position to be one of the biggest companies, and we can lead the way".

Also, registering their projects with the considerate constructors' scheme is another way to show the client that they are mindful of their practice in protecting the environment, their workers, and the community in which they operate. But the respondents noted that there are specific projects that they could only do less in influencing design decisions. This is because much of the design decisions have been taking or completed before the contractor is engaged. Also, they noted that there are planning issues that could affect their input.

These findings have important implications for construction firms in collaborating and understanding the need of their clients in delivering sustainable projects. This is because there is an increase in awareness among private and public clients in demanding sustainable buildings (Robichaud & Anantatmula, 2010). Similarly, understanding the type of construction client's and their disposition to innovative practice effectively meets their needs (Boyd & Chinyio, 2008; Newcombe, 2003). Furthermore, another interesting finding was the historical condition of the firm that enabled them to influence their clients on alternative products or solutions. Barney (1991) explained that early entrants or the unique historical condition of a firm are an important determinant to the long term performance of a firm.

Going further, having reported the findings on the firm's performance in the adoption and implementation of sustainable procurement, the next section report findings that address sub-research question two. The research question seeks to unveil how main contracting firms influences their supply chains in adopting sustainability practices. Objective three will aid in answering the research question.

5.3 Influencing Supply Chains

This section reports the findings that address sub-question two that states, "how do construction firms influence their supply chains in driving sustainable construction practices?" Objective three helped to explore how the research question will be answered. The objective is to assess how contracting firms in Ireland influence their supply chains in embedding sustainable construction practice. In investigating the way, the main contractor's organisation influences their supply chains; a two-level approach was used. The first approach examined how supply chains are selected or appointed by the firm. Then the second approach examined the various strategies adopted by the firm in collaborating with supply chains.

5.3.1 Selection and Appointment of Supply Chains

In examining how supply chains are engaged in the organisation, the respondents were asked about the appointment and selection criteria. The respondents explained that for any supply chain to be appointed in the company's list, there are specific company standards and requirements that supply chains will have to meet. These requirements are mostly focused on sustainability criteria.

"There are certain company standard, health and safety policies that we sent out to the sub-contractors when we are tendering a project. So, then you must meet these requirements before engaging them".

Also, further checks are carried out to ensure that the products that will be supplied have the necessary certifications and registration. However, another respondent (Supply Chain Manager) was of the view that the engagement of some supply chains is reactive to what the existing laws or regulations stipulate, in the sense that patronising such a supply chain company will assume that the products meet all the requirements.

"...the reasons why we would use a supplier or a subcontractor in my experience, it is reactive to whatever the existing legislation is on whatever the existing specification of a product. So, the assumption is that if I am purchasing a product from Gyproc dry-lining products, the assumption is that it is legally in line with whatever environmental standards like ISO or whatever."

The respondent (Supply Chain Manager) further revealed that interactions with the supply chains would be primarily focused on performance in terms of pricing and deliverable timing. Selecting the right supply chain in an organisation has been found to positively impact achieving sustainability objectives (Ageron et al., 2012; Kumar & Rahman, 2016). Such objectives could be achieved when organisations develop a clear purchasing and supply policy (Roy et al., 2018).

Furthermore, after listing the supply chains on their company list, the respondents were further asked how they go about collaborating with the supply chains in driving sustainability. Section 6.3.2 report the findings on collaboration with supply chains.

5.3.2 Collaborating with Supply Chains

Leading contracting firms depend on their supply chains in the delivery of their projects (London, 2008; Oyegoke et al., 2010). The findings on how they collaborate and the disposition of their supply chains in adopting sustainability practices are reported in this section. Also, the findings on the various strategies implemented by the firm in collaborating with their supply chains towards promoting sustainable procurement are reported. From the interviews, conducted findings showed that two factors determine the level of collaboration and disposition of supply chains in promoting sustainable

procurement. These are the size of the supply chain organisation and the nature of the project to be undertaken. These findings is consistent with other researchers works that showed that the size of a firm is a likely motivating factor in the adoption of sustainability practice (Mulligan et al., 2014; Ruparathna & Hewage, 2015a; Upstill-Goddard et al., 2016).

With regards to the size of the supply chain organisation, the respondents explained that bigger supply chains like cladding, insulation, glazing, roofing, and concrete trade contractors have higher sustainability performance compared to smaller trades. Smaller trades like the fitter, Fischer Joiner, and the bricklayers are not always very proactive towards adopting sustainability practice. The Commercial Manager explained that, the main contracting firm guides the smaller trades by engaging them in undertaking a small task like waste management and other health and safety practices.

"As I said, it depends on the package of work the cladding guys, glazing guys, the roofing guys, the concrete guys are excellent. Some of the smaller subcontractors like a fitter or a joiner might not understand as much sustainability and might not care, you know but if you can explain to them to do well once, as to introduce the waste, you know, we would have a plan, and they would not realise that we were making the plan for them, you know."

In addition, with regards to the nature or type of project, the respondents revealed that specific type of projects influences the type of supply chains to be engaged. The client's requirements and demand mostly determine such influence. Also, some of the clients have a long-term relationship with certain supply chains, so they will want the main contractor's firm to use them.

"The selection of a type of sub-contractors or supplier for the likes of Amazon or Google, they will already have the sub-contractors that they have or used on previous European or even American projects".

They further explained that some certain materials would have to be sourced from specific locations. Likewise, some packages will have to be executed by specific sub-contractors. Such requirements, as explained by the respondents, will make the firm only to engage supply chains that have proven records of high sustainability performance. Although, the respondents explained that the company always try to ensure that the source for their materials locally and engage local sub-contractors. However, they clarified that some certain products could not be sourced locally; therefore, it must be sourced abroad. A respondent (Commercial Manager) further noted that sourcing abroad is mostly related to materials than the trades.

"Well, we try to source locally where required. Generally, it gets to do with the products. In my opinion a lot of product we do source locally but the majority for larger projects you cannot source locally like steel reinforcement all that sort of stuff that all comes from abroad."

A respondent (Estimator) further gave an example of how the project or a client requirement influences the collaboration between the main contractor's Firm and that of their supply chains. He explained that there are situations where the project requirements or demand from the client will want the building to meet a certain LEED or BREEAM certification. In this situation, some of the supply chains might not be qualified to be engaged in the project because they would not have the capacity to deliver the project.

"For example, they would want the job to be a LEED-certified project, or they wanted the project to be a BIM project. In this case, certain subcontractors cannot meet those requirements due to their resources, or they are a small company or whatever. So, it depends on the job, but there are certain client requirements call for the need for specific subcontractors".

However, irrespective of the size of the supply chains organisation or the nature of the project, further findings revealed that the main contracting firm has developed and implemented different strategies in influencing their supply chains in promoting sustainability practice. Such strategies in procurement as noted by Walker et al. (2008), have changed the focus of procurement from the short-term cost minimisation to long term value creation and delivery. Therefore, the strategies observed are developing trust and long-term relationship, instigating competition amongst the various supply chains, and utilising the supplier's development mechanism.

a. Level of Trust and Long-Term Relationship

In building trust and long-term relationship, how the level of commitment, sharing of information, opportunities for new entrants, unethical practices, and regularity of workload enhances trust and the long-term relationship was examined.

Examining the level of commitment of supply chains, the respondents revealed that over the years, they had built a long-term relationship with their supply chains. The long-term relationship has enabled the supply chains to understand the operations of the company and always willing to positively projecting their image. They project the image of the company by behaving appropriately in their operations. Such a positive attitude by the

supply chains, as explained by a respondent (Commercial Manager), will always make the main contracting firm to engage them regularly.

"So that might be an advantage to us to have a subcontractor who would kind have gone with you on the journey for the better job for the clients. Also, the subcontractors we would use, and reuse would be somebody who would make us look good".

Secondly, the findings with regards to the willingness of supply chains to share information with regards to their products or methods of improvement, the respondents revealed that the type of information been sought determines their willingness. Also, when asked the type of information been sought from supply chains, a respondent (Estimator) explained that the exchange of information is a two-way thing. That sometimes the supply chains come to educate them about their products which are mostly promotional to improve their public relations. On the alternative, the company organises a meeting where the supply chains come to give a talk about their product or construction processes.

"For example, I have had many suppliers come in, and I would call suppliers and said, hey, I would like you to give a talk on your company and what you supply, and they are like, oh you are ABC company? Yes, of course, we will come in here. They are always very willing to work with our company".

Furthermore, sharing a contrary opinion, a respondent (Supply Chain Manager) noted that some of the supply chains irrespective of size are poor in providing information as it relates to sustainability. In comparison, some supply chains are always willing to provide information. Giving an example as it relates to Brexit, he noted that some small

supply chains have useful data, while some of the bigger supply chains do not have any data to share.

"I am sure if you wanted the same type of information in terms of environmental sustainability, they would have the information, but some are very poor, and even some of the biggest wealthiest companies in the country are very poor. We asked our companies about Brexit, and many companies will have very good high-quality information, very specific data to give us straight away. Sometimes small companies do that, and sometimes big companies have nothing".

Also, the respondent (Supply Chain Manager) noted that there is a need for the supply chains to develop a mechanism for promoting their most sustainable products by providing detailed information to their customers.

Thirdly, the question of how the company creates opportunities for engaging new supply chain members was asked. The respondents revealed that the company relate typically with potential supply chain members and examined their company information before formally listing them in the firm's supply chain list. Creating an opportunity for new entrants could be seen as a strategy adopted by the firm to widen their suppliers alternative in order to promote innovation and commitment (Adetunji et al., 2008; Stannack, 1996). The fourth issue examined during the interview in understanding how the firm develops long-term relationship and trust was the issue of unethical practice. The unethical practice was viewed from two perspectives. First by the project team patronising specific supply chains, and second by the behaviour of supply chains colluding among themselves when requested to submit quotation is sent to them from the main contractor's office. In answering the first question, the findings revealed that so many factors determine the appointment of a supply chain on a project. The respondents

explained that in planning a project, the commercial manager or the project team consider the closest quarry, project specifications, transportation and logistics advantage and other fundamental sustainability issues. The Commercial explained that:

"The nature of the job, the location of the job. You know, if it is a BREEAM job or LEED job, you will have to look at where the job is, where your suppliers are, where is the quarry? You know all these come into factors for the BREEAM for the LEED you get graded. Like where is the nearest bus stop to the job gets a mark. So, it is all about been kind of making sure there is a less footprint and the building is done and the next job, you know".

Furthermore, with regards to informal relationship, the findings revealed that informal relationship exists between the staff of the Firm and their supply chains. But the main contractor's staff are aware of the limit of their relationship and are conversant with the organisation's anti-bribery policy. Explaining, the Estimator said:

"It is a good idea, I guess. Yes, if they are not going on holidays if they are not bribing that sort of thing. I do not think there is anything wrong with building relationships with people".

Equally, concerning unethical behaviour of the supply chains to collude during tendering, a respondent (Estimator) revealed that because of the trust and long-term relationship they have with their supply chains, such practices are controlled. Although, he noted that sometimes it is challenging to stop the supply chains from talking to each other but because of the prospect of the regularity of work supply chains would not want to damage their reputation.

"Yes, we do have a good relationship with our sub-contractors in general; we do have long-lasting relationships. So that helps prevent a lot of what you are talking about. There are people conspiring or whatever you want to call this, but I think just having the good, long-lasting relationships might prevent that, and we know that a sub-contractor will not want to damage a good relationship with a company like ours".

It is therefore likely to assume that the social complexity and structural dominance position of the contracting firm influences the behaviour of their supply chains (Adetunji et al., 2008; Barney, 1991).

In addition, another strategy noted was that early payments to supply chains were ensured in the company. Also, supply chains that perform well are listed in the preferred supplier's agreement list of the company. The preferred supplier's agreement assured supply chains of the regularity of work from the main contractor. Regular engagement of a supplier or sub-contractor contributes to their social capital accumulation and trust building (Noorizadeh et al., 2018). A respondent (Commercial Manager) explained that developing such mechanism was very important because, with the increase in the volume of construction activities in Ireland, it will be essential to have supply chains that will be ready and available to do their work.

"For instance, nowadays there are many jobs out there, and the biggest thing now is to get subcontractors available to do your job when you need them".

"You treat them right, and you treat them with respect, you pay them. Our company have always treated their subcontractors with respect. You know, they

have always pay them on time, or you know, they have always been very respectful and fairer ".

b. Instigating competition amongst the Supply Chains

Another way the construction-contracting firm enhances collaboration is by instigating competition amongst their supply chains. Instigating competition enhances supply chains performance in its sustainability practice (Gosling et al., 2015; Krause et al., 2000). In exploring this aspect of the organisation's strategies, the sub-contractor performance guidance document of the firm was critically examined. After examining the document, interviews were conducted with various respondents. The performance guidance document explains that the company usually assess active sub-contractor on-site every two-months and their performance registered with the procurement department. The sub-contractors are scored based on eleven criteria ranging from site management, health and safety issues, environmental issues, quality issues and other pre-contract and design input/innovation. Each of the criteria is scored between 1-5, with a score of 3 indicating complying with the company's expected standard and procedures. While a score of 2 or 1 indicates weakness and caution for anyone planning to use them in the future. Moreover, a score of 4 and 5 shows that the performance of the sub-contractor is beyond the expected standard of the company.

After examining the performance guidance document for supply chain assessment, interviews were conducted with the various respondents. The respondents were asked questions relating to the benefit of high performance, feedback mechanism, and reward system. From the findings, it was revealed that the results of the assessment guide the company in engaging supply chain in future projects. In addition, supply chains that

perform well are listed in the preferred sub-contractors tendering list. Two of the respondents (Estimator and Supply Chain Manager) stated that:

"There is a score I guess against each subcontractor to tell you how they performed, their reliability and order aspects regard to sustainability or environmental on how the guard against waste management. How our supply chains manage waste is a big thing in this company". (Estimator view)

"Well, subcontractors who perform well would be put onto our company's preferred tendering list. So, we normally use the list for our preferred subcontractors or suppliers most of the times". (Supply Chain Manager view)

With regards to the feedback mechanism as it relates to the performance of supply chains, the findings revealed that each member of the supply chain gets a report on their performance after every assessment. The essence of the feedback is to enable the supply chains to identify areas that they will need to improve and areas they are doing well. Such practice of providing feedback as noted by Noorizadeh et al. (2018), improves the performance of the supply chains.

Apart from providing the assessment report, the main-contracting firm informally engages the supply chains to discuss their performance and suggest possible improvement solutions. The Estimator revealed that:

"Well, we have the same data that we provide internally to the management that the same data will go to the sub-contractors themselves. So, we have been able to say to sub-contractors, you know, you are performing poorly in this category that category".

Communicating informally to supply chains have been found to enhance collaboration and helps in achieving the project sustainability objectives (Hojem et al., 2014; Rizzi et al., 2014). However, from the findings, it was noted that the feedbacks are mostly focused on the performance of materials than the sustainability of the products. One of the respondents (Supply Chain Manager) explained that feedbacks on sustainability are very rare. He stated that:

"The problem in terms of sustainability or environmental issue, you know, let us say for instance dry lining was going to site and there was a lot of plastic waste, that would be communicated back to the supplier only because it is a workload problem on the project not because it is an environmental issue as far as my experience. Therefore, the only feedback that the supplier will get will be for a performance of the product for construction reasons, not for environmental reasons".

Finally, to recognise and motivate the supply chains, the company organises a supply chain award night for all their supply chains. All best performing supply chains are recognised and given an award. Hardie (2010), explained that motivating supply chains has the potential in driving sustainability performance. Also, the respondents believe that such awards and recognition motivate the supply chains to perform better. Also, supply chains that do better, as stated earlier, are listed in the preferred supply chain agreement list, which could enable them to increase their productivity and competitive advantage. All the respondents agreed that the supply chain award influences the performance of the supply chains, and it provides the opportunity for them to improve their public image. A respondent (Estimator) said:

"But we do have supply chain awards, which is nice, you know such occasion for sub-contractors shines them on good light and gives them good exposure to certain sub-contractors if they perform well then, they will be recognised for their performance".

To further understand how the main contracting firm provides support to their supply chains, the next section report findings on supplier's development. Supplier's development is another organisational strategy that firms adopt to help their supply chains to improve their performance.

c. Suppliers Development

The third strategy the firm developed to enhance collaboration and sustainability performance of their supply chains is the supplier's development strategy. The findings from the interviews revealed that the main contractor's firm utilises different approaches in developing their supplier's capacity. The three main approaches are on the job training, formal training, and education, and creating an opportunity for supply chains to move from a lower level to a higher level. The respondents explained that on the job training is aimed at guiding supply chains in producing a workable plan on how to manage health and safety issues, waste management issues, and risk assessment. Also, it creates awareness on the supply chains not too supply prohibited products like formaldehyde. On how they go about guiding the supply chains, a respondent (Commercial Manager) said:

"Well, I suppose about the job we do. At the pre-appointment meeting with the supply chain, we say you must give us safety statements and risk assessment. So, we kind of guide them by kind of say this is what we needed you to do. These steps we need you to take and that would be on-going, and that would

constantly be it safety or whatever risks they have, but a whole kind desire is to guide them".

In terms of formal training, the respondents explained that workshops usually are organised to develop the supply chains, the workshops are organised through in-house webinars and seminars. Also, the company creates the opportunity for their tradesmen to collaborate with some of their product manufacturers; such collaboration creates a better understanding of the products the tradesmen will use. Furthermore, the Commercial Manager explained that:

"I suppose if you had a good tradesman in flooring, we could introduce him to like BASF, who is one of these technical leaders in products manufacturing. The flooring contractor and BASF get to talk or collaborate or join forces with one another".

As earlier observed on the increase in construction activities of late in the Republic of Ireland, which has led to high demand for supply chains. In strategizing on how to manage the high demand for supply chains, the respondents revealed that the firm creates opportunities for the lower tier supply chains to move to a higher tier. A respondent (Estimator) explained that a sub-contractor in the lower tier would be allowed to carry out a work that is probably above their capacity.

"I think that is a good point and just like today in these times, there is a minimal supply chain now. There is minimal Tier 1 supply chain that this company generally uses, so we do look at speaking to these suppliers and subcontractors

that are maybe a bit smaller, and you might give them a chance and try and help walk them through certain projects".

Further findings from the Estimator revealed that the main contractor's organisation assign their workers to support their supply chains in moving to a higher tier and improving their performance.

"We try to bring them up to that next level, and they would learn from our expertise and help on certain projects. What we do is that we would give a sub-contractor a job, and we would say okay, we are going to give you this contract. It is bigger than what you are used to getting, but we are going to help you with it. We are going to give you a lot more support in getting the job done and administratively as well. Our site team would lend a hand at least then we can bring that sub-contractor to the next level".

Lastly, the respondents were asked about the disposition of their supply chains in improving their performance and moving to a higher tier. It was revealed that the disposition and willingness of a sub-contractor or supplier is mostly dependant on the size and capacity of the supply chains organisation. The respondents explained that the bigger supply chains are always open for improvement. The Commercial Manager further revealed that smaller are reactive because of their low level of resources are always reactive into improving and adopting new practices.

"Some subcontractors will be all for it like the bigger sub-contractors that we have but once you like go to the smaller guys where they are stretched within that is where they could be few kinds of issues with that. In this company, we

would try to bring them along with us. We will tell them how we can help you out with this, you know if you give us this information, that will help you make this better".

In summary, this section reported findings on the mechanisms and strategies utilised by the firm in influencing their supply chains in the adoption of sustainability practice. First, it was found that the firm engages supply chains that meet their company's criteria and have the required certification for their products. Also, the level of collaboration was found to be determined by the nature of the project, and the size of the supply chain organisation. Irrespective of the nature of the project or size of the supply chains organisation, it was found out that the firm developed several strategies in enhancing their collaboration with their supply chains. Some of the strategies identified are developing trust and long-term relationship, instigating competition amongst supply chains, and implementing a supplier's development strategy. Finally, it was found that the size of the supply chain organisation determines their willingness and disposition towards adopting innovation and improving their performance.

So far, sections 6.2 and 6.3 has provided insight from the organisational level on how the main contracting firm utilises their human resources and organisational capital resources (supply chains). The last organisational resources to be considered in this study is the physical capital resources of the firm. The digital tools and resources of the firm are the physical capital resources considered in this study. How it is utilised in promoting sustainable procurement is reported in the next section.

5.4 Utilisation of Digital Technology

This section addresses research question four that seeks to explore and understand the current level of digital technologies application in driving successful sustainable

procurement. In addressing the research question, the firm's digital project delivery management procedure (DPD) document was examined. The document was examined to provide an understanding of the various strategies developed by the firm in adopting and implementing digital technology procedures. Also, interviews conducted focuses on the current usage of digital technologies, the disposition of the supply chains in adopting the use of digital technologies, the potentials and future benefits, government influence, and possible areas of improvement.

Examining the DPD document, it was noted that the DPD enables the digitisation of the processes in which the organisation's projects are designed, constructed, and handed over through collaboration and innovative technology. The strategy is enabled by three key areas which are information management, building information modelling (BIM), and innovative technology. Information management focuses on central database management, and document control using Viewpoint for Project (VFP) applications. While, BIM focuses on 3D, 4D modelling requirements to be used at the pre-construction stage for logistics and site planning. Innovative technology ensures the provision and use of tablets for site task, audio/video conferencing system, use of cameras, drone footage service (internal and external), open BIM desktop with all BIM software or BIM station on the site, a large screen or interactive touch screen and in-built mini pc system. In addition, the DPD strategy provides for the supply chain digital capability (SCDC) scoring guidance where potential gaps are identified amongst the supply chain and enable the firm to support their supply chain with appropriate training and guidance at the start of a project.

Having examined the DPD document, the next phase examined how the areas identified in the DPD are utilised in driving sustainable procurement. The respondents revealed that currently, digital technologies are utilised for internet for emails exchange, field view and viewpoint (4P) applications. Also, the online intranet set-up and the internal

management system is used for selecting subcontractors. Other applications used is the SMART waste system, and the BIM technology is mostly used for presentations at the pre-construction stage. The respondents further explained that some benefits were derived from the application of digital technology resources such as reducing wastage and less use of papers. The Estimator explaining the benefits of utilising digital technologies explained that:

"We are trying to go digital, and I guess regards to less paper is one element. So, bringing a new software on-site, for example, 4P, field view in a way it does away with much paper and things like that and even my estimating software Conquest it helps. It is all done digitally so you do not need to send like in the old days or a few years ago you will be sending out packages to different sub-contractor whereas this is done digitally now".

With regards to the disposition of the supply chains in adopting and using digital technologies, like earlier findings, the utilisation of digital technologies is mostly determined by the size of the supply chain organisation and the nature of the project (Upstill-Goddard et al., 2016). The respondents explained that bigger supply chains are well established in the use of different digital technology tools and resources compared to the smaller ones that are still struggling. However, the Commercial Manager noted that the firm usually has a strategy for managing the smaller supply chains. The Commercial Manager noted:

"A lot of the bigger sub-contractors would have that capacity as well, and they put their model in, and you can see the windows whatever it is, but that is for bigger jobs, you know any of the jobs I have will be saying 15 million or under I have not seen that".

While another respondent (Estimator) said :

"It depends on the subcontractor. Some sub-contractors are not as digitally evolved as other sub-contractors. Some of the subcontractors would find it difficult to deal with some of the packages. So, it is important then for us to understand that and deal with them differently. So, we must recognise which suppliers and subcontractors are like that and cater to their needs and their requirements. In general, most sub-contractors deal with us fine".

The third aspect explored is the potential areas of importance in utilising digital technologies in promoting sustainable procurement. Some of the potential areas identified by the respondents are in the use of the BIM model. They explained that BIM technology could be used to visualise the building to give a real feel and to populate quantities, and to reduce waste in terms of ordering of materials. Another area identified was that BIM technology could be utilised in the calculation of the carbon footprint in the building. In addition, utilising digital technology in the procurement process will enable the firm to carry whole-cycle analysis. The respondents noted that carrying a whole life cycle analysis will enable the firm to gain a competitive advantage. However, it is pertinent to note that possession of digital technology tools does not enhance a competitive advantage (Mata et al., 1995; Powell & Dent-Micallef, 1997). Therefore, for effective utilisation of digital technology in promoting sustainable procurement, the availability of information and data is vital (Ahmadian et al., 2017; Häkkinen et al., 2015). Such information availability and managerial capabilities is what drives a competitive advantage for the organisation (Mata et al., 1995; Powell & Dent-Micallef, 1997).

In addition, the respondents noted that digital technologies have the potential to create an opportunity for the construction client to have full information on the expected energy

usage, water usage and other sustainability issues. Such information as revealed by the Estimator will enable the client to plan appropriately in managing the property.

"All that is important for the client who will have this building forever, now post-construction cost information that the BIM model or whatever can give them that is beneficial to him. So as a company if we can show him all this information, it will give us an advantage".

Furthermore, other areas identified are the use of computer applications in controlling the lighting and heating system in a building and developing an automatic control solar panel is another potential area identified. In terms of the waste management system, one of the respondents (Sustainability Manager) said that there is a need to explore further the use of the SMART system where the firm can compare jobs against each other. The Sustainability Manager stated that:

"Using the environmental SMART waste system, we can compare jobs against each other and see. For example, comparing the same value job, why are they producing more waste, why are they using more energy and they should be quite similar".

The fourth aspect of understanding the utilisation of digital technology in promoting sustainable procurement was to understand the influence of government laws and regulations. Some of the respondents agreed that government laws and regulations have to some extent, influenced their level of adoption of digital technology. For instance, they said it is now mandatory and a requirement in the Republic of Ireland that all government jobs should incorporate a level 2 BIM.

Finally, on possible areas of improvement of current practice in using digital technologies, the respondents revealed that the current practice could be improved and be more collaborative if the information is shared and made available in a central platform. Such a platform they explained will need to be fed regularly with data to keep everyone in the various unit updated with the current situation on the project site and the market. A respondent (Estimator) noted that such innovation would reduce wastage because currently for him/her to get information or an opinion about a supply chain, he/she will have to go to the procurement unit to seek their views.

"Well, it will be a good idea what I do generally go to the procurement team and ask them for their opinions on certain sub-contractors or suppliers that I am proposing to make sure that they meet the requirement of the company.

They will review their database and get back to me".

In addition, with regards to getting information, another respondent explained that they struggle to get information from the site team to update their records. He noted that such challenges become so cumbersome in trying to get the information needed. Therefore, for such an improvement to happen, a respondent (Supply Chain Manager) noted that it would have to be an IT change.

"It is an IT change because it is about information access and we do not get the information early. If we got the information at the very start in terms of the tender, you know what is within the time and what the requirement is all about. This will enable us to allocate time and resource to say okay they are looking at all these, but from an environmental point of view, maybe this is better, and we can feed that in very early. That is not currently the way it happens."

Hence, it could be conceivably be hypothesised that the poor sharing of information amongst team members is one of the likely reasons affecting the AEC sector in disclosing their sustainability performance. Information sharing amongst the project teams is a critical factor in motivating collaboration (Woo et al., 2016).

In brief, this section reported the findings on the utilisation of digital technology tools and resources by the firm. The findings revealed that the digital project delivery management procedure (DPD) provided a road map for the adoption and implementation of digital technology tools and resources. Findings from the interviews revealed that several digital tools are used in the firm at both planning and project stage. Also, the nature and type of projects determine the disposition of the supply chains in adopting and utilising digital technologies. The laws and regulations provided by the government for the adoption of level two BIM has been found to influence the behaviour of the contracting firm.

6.5 Summary of the Chapter

The findings at the organisational level were reported in this chapter. Understanding the level of sustainable procurement practice at the organisational level provides the foundation for understanding the implementation at the project level. Therefore, in addressing the central research question on how construction-contracting firms embed sustainability in their procurement process, different strategies were adopted. Several documents were examined, and interviews were conducted with respondents from different units in the company. Findings revealed that the firm had developed various strategies in the implementation of sustainable procurement. These are implementation within the firm, influencing supply chains and the utilisation of digital technology tools. How are the various identified strategies shown in Figure 43 at the organisational level transferred and implemented at the project level? The next chapter report findings on how the various strategies were implemented on two completed projects in the Republic of Ireland.

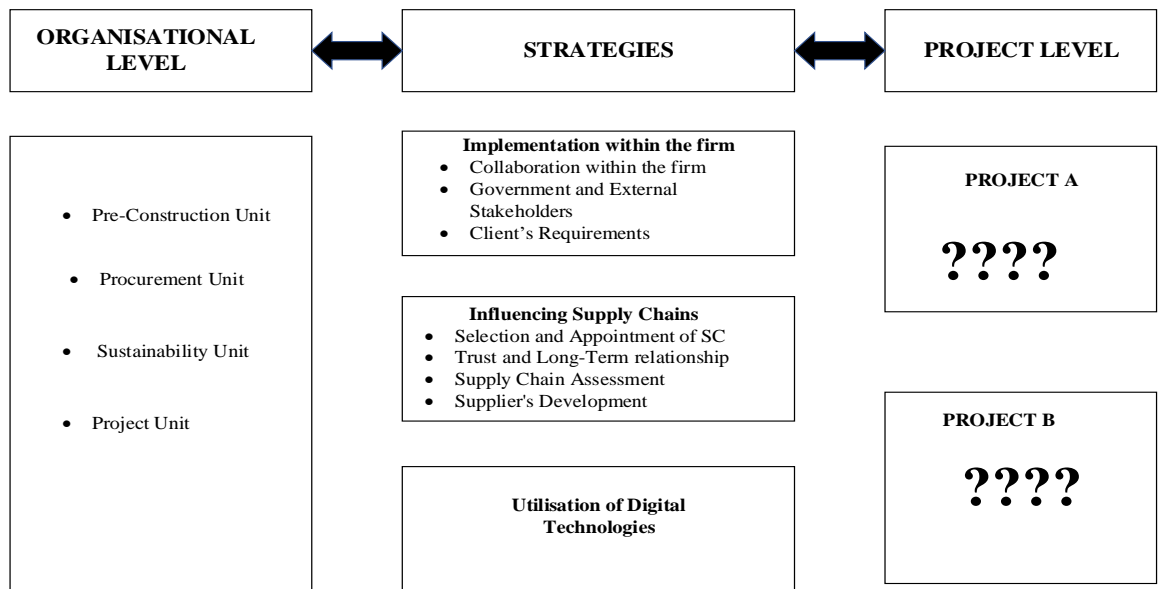


Figure 43: Summary at Organisational Level

CHAPTER 6

CASE STUDY- PROJECT LEVEL

6.0 Introduction

This chapter reports the findings from the case study at the project level. Having explored how sustainable procurement is embedded at the organisational level, this chapter report findings on how the various strategies identified in Chapter 6 and depicted in Figure 42 is implemented at the project level. Due to the commercial sensitivity of the organisation, access was given to only two projects. The two completed projects are of different characteristics but unique nature. They were deemed adequate because first, the study is a cross-sectional study that is time-bound, and the availability of resources was considered. Secondly, and most importantly, why the two projects were found adequate was the methodological approach adopted in the study. The set objectives of the study influence the methodological approach. Adopting the abductive logic reasoning and the single case study approach to understand the sustainable procurement of construction-contracting firms requires a systematic combination. The systematic combination considers the case study not as a linear process, but rather as an intertwined method (Dubois & Gadde, 2002). Although, there have been strong debates and arguments on the adequacy on the number of cases in generating a robust theory in a case study (Eisenhardt, 1989; Yin, 2009). But, Dubois and Gadde (2002), suggested that any benefits gained by increasing the number of cases are countered by certain disadvantages. They further explained that researching a greater number of cases with same resources will result in greater breadth yet reduced depth of analysis (Dubois & Gadde, 2002). Therefore, the two projects provided the opportunity for an in-depth understanding of the sustainable procurement practice of large Irish construction-contracting firms. This understanding will aid in achieving the aim of the study, which is to develop a sustainable procurement framework.

Due to the confidential nature of the projects, the projects are labelled Project A, and Project B. Project documents were analysed, and interviews were conducted with the main contractor's team and the supply chains team as shown in Chapter 6. This chapter is organised into four different sections. Section 7.1 provides a background on the projects studied. Sections 7.2 and 7.3 report findings on Projects A and B, while Section 7.4 provides a summary of the chapter. The findings of each of the project, report the implementation of sustainable procurement within the main contractor's team, influencing supply chains, and the utilisation of digital technologies.

6.1 Background of the Case study

Project A

Project A is a privately owned mixed-used development erected on a brownfield site in the city centre of Dublin around the Liffey. The construction started in 2016 and was completed in 2019 (3 years). It is one of the tallest building in Ireland with over 15 floors, and the structure is in a confined urban space with lots of commercial buildings, international organisations, and residential buildings around the site. The project is made of six different buildings; three blocks were commercial while the remaining three were residential. The total area of the land is approximately 5 acres, while the total gross area of the building is approximately 30,000m² comprising of residential units, office space, public parking space, and a double level basement. The building was designed and built to comply with the Leadership in Energy and Environmental Design (LEED) rating. The office building was reported to have achieved a LEED gold standard. At the same time, the residential units achieved an A3 Building Energy Rating (BER) certificate. One of the unique features of the project was that the end-users of the commercial buildings got engaged during the construction stage. From the records made available a considerable amount of labour and material resources were

procured. The total number of construction workers based on-site was approximately 1,300, while materials are: over 200,000 tons of concrete, 15,000 tons of steel, and 7,500 panes of glass were utilised during the whole project. The project was executed using the management form of contract, which enabled the main contractor's early engagement on the project. The total cost of the project was reported to be above €200 million. As shown in Figure 35, interviews were carried out with the contract's manager, commercial manager, façade sub-contractor, and the pre-cast sub-contractor.

Project B

The project is a privately developed holiday and tourism resort. It is located around the midlands of Ireland within a forest area with some sensitive watercourses that contribute to a river which is a salmon spawning river. It is a wildlife forest with the deer as the most prevalent. The total duration of the project from pre-construction to completion was 74 weeks, starting from early 2018 to the first quarter of 2019. The project consists of indoor and outdoor activities, aqua Sana spa, restaurants, and lots of other recreational facilities. It is erected on a 400-acres site, with about eight different types of houses that comprise over 400 self-catering lodges and 30 apartments. It is estimated that the overall project can accommodate up to 2,500 guests each night. The project cost roughly over €200 million. The self-catering lodges were A3-energy- rated buildings (BER) and the whole project was expected to comply with the Building Research Establishment Environmental Assessment Method (BREEAM) standard. The project was projected to employ circa 1,000 people when completed and, over 750 during construction. The main-contracting firm engaged over 100 supply chains comprising of different trade subcontractors and materials suppliers. For example, the estimated quantities of materials

procured in the construction of the lodges were about 30,000m² of timber cladding, 57,000m² of roof felt, and about 600,000 roof tiles were procured. Also, the labour force at peak for only the lodges was 350 people. The project was executed using the design and build procurement method.

A summary of the key project's characteristics is shown in table 33 below

Table 33: Project Characteristics

CHARACTERISTICS	PROJECT A	PROJECT B
Type of Client	Private	Private
Nature of Project	Mixed Used	Tourist and Recreational
Location	City Centre	Forest Area (Countryside)
Value	Over €200million	Over €200million
Sustainability requirements	LEED	BREEAM
Duration	3 years	1.5 years
Size of land	5acres	400acres
Procurement Method	Management System	Design and Build

6.2 PROJECT A-FINDINGS

This sub-section report findings from Project A. How the various organisational resources were utilised in the delivery of the project are reported. In exploring how the various organisational resources were utilised, the findings focused on the three major themes identified in Chapter 5. These are implementation within the main contractor's team, influencing supply chains, and utilisation of digital technologies. The various themes help in addressing the research questions that state how construction-contracting firms embed sustainability in their procurement practice.

6.2.1 Implementation within the Main Contractor's Team

How the main contracting firm addresses and communicates its sustainability requirements to their workers is reported in this section. In unveiling how the sustainability requirements are addressed, the research explored the level of collaboration within the contractor's team, and how government regulations and external stakeholders' requirements are equally addressed. Also, findings on how the project team collaborate in meeting the client's requirement are reported in this section as well.

6.2.1.1 Collaboration Within the Contractor's Team

In planning on how the project was going to be executed, the respondents explained that the level of collaboration was dependent on the procurement method, type of client, and project requirements. The project was executed under the management form of procurement, and a private property developer owns it. The client desires to have the building completed on time and to meet the LEED rating requirement. Early completion was of importance to the client because of the high demand for commercial buildings in Dublin. The respondents further explained that the project was massive, to be erected on

a confined brownfield site in the city centre of Dublin. Also, the client has a budget in place, but they must work within their budget.

In exploring how collaboration was undertaken within the main contractor's team at the start of the project, the respondents were asked how the organisation's sustainability policies and the nature of the project influenced their planning. The respondents explained that there is a high level of understanding amongst the company staff with regards to the organisation's sustainability policies. Therefore, sustainability has become a norm in the company and every member of staff hold sustainability practice as a core responsibility. Furthermore, with regards to the nature of the project, the respondents revealed that different strategies and approaches were used during the planning phase of the project. First, they explained that after the formal handing over of the project from the pre-construction team to the project team, the team had to understand the impact of the procurement method before mobilising to site. The procurement method, as noted by the Commercial Manager, made them not to rely on all the tender information. Hence, they agreed to jointly procure all the work packages with the client and his team. This is because the initial contract signed was just a basis for entering a legal relationship. The Commercial Manager said:

"At the end of the takeover of the tender information that we had; we did not build on all the tender information because it was a management contract. Every package was supposed to be procured jointly with the client. So, the information that we signed to was just a basis for a contract because it was subject to re-measurements".

Utilising the right procurement strategy has been noted to enhance collaboration and leads to better articulation and activation of commitments (Love et al., 1998; Oyegoke et al., 2010).

Furthermore, the respondents explained that during the planning stage, they regularly refer to the estimating and procurement unit for clarification and more information. However, they noted that getting such information was quite challenging because, from experience, the estimating and procurement team have an awful lot of information which it is always challenging to share during handing over. Sharing his experience, the Contracts Manager said:

"For example, one team procures the project, and then another team takes it over. So, these guys would have an awful lot of information and very difficult to get that information over to a completely new team because this team has just finished up other jobs".

After planning and agreeing on how the project will be executed, the respondents were asked how information was communicated and shared amongst the various team members. The findings revealed that the complexity and nature of the project, made the project team to divide the building into different blocks with different teams for managing each block. The respondents further explained that the ground floor was divided into three units with three different teams managing it. After the ground floor was completed, the buildings were further divided into six different units having different teams. Each team comprises of Contracts Manager, Engineers, Quantity Surveyors, and Foremen. Also, each team was further divided and assigned to manage different packages like reinforced concrete, façade, and other elements of the building. Such a strategy, as

explained by the respondents (Commercial and Contracts Manager), enable the various team members to understand the construction process and type of materials used for the project.

"....but each team became a specialist like an engineer he could just be focused only on the façade so that he will have enough time to review and to share his knowledge with the opposite partners around or with other colleagues on the opposite side like the design team".(Contracts Manager view).

Such strategies adopted by the contracting firm leads to knowledge development and expertise. Meehan and Bryde (2015), explained that for an effective delivery of sustainable construction projects, firms will have to develop mechanism to transfer knowledge and the requisite skills to individuals. In addition, further findings revealed that regular meetings on procurement, variations, and progress of work were carried out. Also, every morning for about half an hour whiteboard meeting was held. The essence of the whiteboard meeting was to discuss the plan for the day and the expected deliveries coming and going out of the site. In attendance will be all the heads of each of the subcontractors, all the engineers, and all the foremen. Another area that was developed was in the adoption of the unmanned aerial vehicle (UAV), which is known as drones. The respondents explained that due to the complexity of the project, the company specifically trained their logistic manager in the use of drones and 3D modelling. They explained that the drone driver flies the drone once or twice a week to produce footage that was used in the early morning whiteboard meetings. Such managerial and technological capabilities has been noted to drive the sustainability performance of the firm (Li et al., 2013).

Lastly, with regards to the performance of the project team, the head office provides feedback typically regularly. The respondents explained that regular meetings were usually held to provide feedback on the team's performance. The meetings were usually made up of the project director, regional directors, procurement manager, and other senior team members who will provide feedback on areas to improve and where they are succeeding. However, with regards to post-project evaluation, it was noted from the interviews that post-project evaluation was only carried out at the managerial level. One of the respondents (Commercial Manager) noted that it would have been beneficial if all the experiences and knowledge gained during the project is shared amongst all the team members from all the levels. Anbari et al. (2008), explained that post-project reviews are a vehicle for continual learning and improvement in organisations. However, the Commercial Manager noted that the nature of the construction industry has made it very difficult for all the team members to be present from the start to the completion phase of the project. He suggested that a mechanism could be developed for post-project evaluation at the various phases of the project.

"It is unfortunate with the nature of our industry by the time the project is finished; maybe only two people will be left on the project because we phased out people as the project gets finished. But it will be ideal to be good to say, okay when the project is almost 95% complete call-back everybody and say we were on this project come, let us have an overview of what happened. Let us share our mistakes, let us hammer on the mistakes only and mention a few good things".

Having reported how the project team collaborate in managing the project, a further understanding was explored. How government and external stakeholder's requirements

were addressed is reported in the next section. Section 6.2.1.2 report findings on how the project team addressed government and external stakeholder's requirements.

6.2.1.2 Addressing Government Regulations and External Stakeholders' Requirements

Addressing government laws and regulations, and external stakeholder's requirements are vital in driving sustainable procurement. The findings from the interviews revealed that the organisational sustainability policies of the firm guided the project team in addressing government laws and stakeholder's requirements. A respondent explained that during the planning and procurement phase of the project, they ensured that all sustainability issues are taken into consideration. For example, in controlling the noise from the site, the respondents explained that a noise control monitor was installed around the site. Installing the noise monitor was to ensure that they did not exceed the government regulation level of 80 decibels. While in the disposal and pumping of water out of the site, they explained that the water was pumped directly into the sewer or the main, where it will be filtered, monitored, and metered. Similarly, the SMART waste system was used in managing the waste from the project site. However, these findings raise the question whether such practices undertaken by the firm is to seek legitimacy and competitive advantage or really complying to government laws and regulations (Rietbergen et al., 2015; Russell et al., 2018; Upstill-Goddard et al., 2015).

With regards to collaborating and managing the external stakeholders, the respondents explained that at the start of the project, the firm appointed a senior contracts manager who was saddled with the responsibility of engaging the external stakeholders. They explained that regular meetings were carried out with various groups to inform them about the progress and development of the project. At the same time, the company will

receive feedback from the stakeholders, which enabled them to address any issues arising during the execution of the project. A respondent (Contracts Manager) stated:

"The company policy will be interacting with your neighbours, and part of the feedback we got from the neighbours is that they did not want the activity to affect their workers. An international financial institution, for example, that works 24 hours a day, their key thing was noise and disruption".

In addition, the respondents revealed that they meet with their nearest neighbours every two-weeks to talk through what was happening on the project. Also, flyers and handbills were produced and shared to the community as a way of creating awareness. Such engagement of the various stakeholders through education and creating awareness on the benefits and impact of the project has been found to have a positive impact in the delivery of sustainable projects (Kashyap & Parida, 2017; Lim et al., 2015).

Further findings revealed that, the project was registered with the Considerate Constructors Scheme. Registering the project with the Considerate Constructors Scheme enable external scrutiny.

To further unveil how the contractor's team implemented their sustainable procurement plan, the next section reports findings on collaboration with the client and client's team.

6.2.1.3 Collaborating and Implementing Client's Requirements

As earlier noted, the client desired to have the building completed on time and a given budget. In meeting the initial completion target, the respondents explained that the nature of the procurement system enabled the team to be engaged early at the design stage of the project. Therefore, the project team were able to bring their expertise and knowledge

in providing solutions to early completion. One of the strategies adopted was in procuring all the packages collectively by both the client's team and the project team. This enabled them to engage their supply chains early. Also, to ensure close collaboration between the teams was effective, the Package Information Gathering (PIG) meeting was regularly carried out to ensure that all sustainability requirements are addressed before tenders are sent out. Furthermore, the Commercial Manager revealed that they worked very closely with the design team in the selection and appointment of the various sub-contractors. However, the main contractor's team carried out due diligence because the client's team recommended some of the supply chains. The Commercial Manager explained that:

"So, what we decided to do is we worked in partnership with the design team and the procurement of the subcontractors. So, we would jointly put the tender documents together and send them out and agree on the packages with the subcontractors. Our company will do their due diligence with subcontractors first before sitting down with the Consultants. So, we go through the subcontractor's submissions and would even decide on other alternatives that we could give back value to the client".

Furthermore, in considering the complexity of the project which is to be erected in a confined space in a city centre area, where noise is to be regulated, and many resources especially labour and plants will be required. The respondents revealed that considering all those factors and going through the working drawings, they suggested alternative construction methodology to the design team and the client. The alternative method suggested was expected to enhance the speedy completion of the project and reducing the noise level significantly. Therefore, the proposed that the form of construction of the commercial block be changed from reinforced concrete to structural steel and pre-cast

elements. Also, the Contracts Manager explained that they suggested an alternative to the construction of the cores from jump form to the slip form.

"So, we advise them to change the form of construction to the steel structure and pre-cast as opposed to RC, and we were able to save a couple of months of the programme and give that to them earlier".

The respondents were asked the disposition of the client's team and the client with regards to their suggestions on alternative methods of construction and materials. The respondents noted that the design team had to be convinced to change their design because they sometimes believe that the alternative suggested was for the sake of cost or a more manageable approach. It is likely that the influence enjoyed by the main contracting firm was due to their historical condition. Barney (1991) explained that early entrants or the unique historical condition of a firm are an important determinant to the long term performance of a firm.

However, they noted that the challenges with the design team in accepting alternatives were not much of a problem during the project. Besides, they noted that the client was mostly involved in the big meetings that have to do with changes. Also, the Commercial Manager revealed that the management form of procurement is an open book accounting system. Therefore, the main contracting firm appointed a senior quantity surveyor who was responsible for carrying out value engineering and cost comparison exercise. The value engineering and cost comparison exercise enable the contractor's team to give the client value for his money and not to exceed the budget. Also, the value engineering team ensured that all the alternatives complied with the LEED requirements.

"We had to bring another Senior QS that was dealing with value engineering. He was identifying all those packages and making sure that they are value engineered. Also complying with the LEED requirements."

On the way they arrive and agree on a workable solution, the Commercial Manager revealed that decisions were taken jointly with all the various team members. They will sit down with the client's team and compare the proposals by going through alternatives based on cost and time savings.

"We did it jointly because the client did have his consultants. So, when things like the slip form, we said, okay, it might look like it is going to cost more, but it is going to save us time. We suggested the slip form, we gave proposals and try to come up with the cost-effectiveness among proposals".

One of the interesting points about these findings is that it demonstrated the flexibility of how collaborative procurement strategy can be utilised in promoting sustainable practice. Such arrangements would have not be possible under traditional, design and build procurement arrangement, because designing environmentally sensitive buildings might be a very challenging task (Hamza & Greenwood, 2007). Hamza and Greenwood (2007), further explained that using the traditional, design and build procurement arrangement, requires iterations that are at odds with the contractor's incentive to avoid delays and extra cost.

Finally, in promoting teamwork and collaboration, the respondents revealed that the client's project manager organised a workshop on team building. The project manager invited one of the top rugby coaches to talk to the construction team about teamwork. The purpose of inviting the coach was to understand how his knowledge and skills can be transferred to the project team in a construction project. A respondent (Commercial

Manager) noted that learning from the experience of the coach was quite beneficial to the project.

"..... in one of the workshops, we had to call in one of the rugby team coaches here. I think they have won several trophies and we brought him in as a team. I think they were over 200 people in the room asking him to explain to us how he achieved that and how we could transfer his skills to projects".

Productivity, learning, innovation and collaboration can significantly be improved through social learning amongst the project teams (Hojem et al., 2014).

In brief, in reporting the findings that address research question one and four, how sustainable procurement is promoted within the main contractor's team on the project was reported. From the findings, it was shown that regular meetings, whiteboard meetings, installing of noise monitor, metering of water disposal, and engaging and meeting with external stakeholders were some of the strategies adopted by the project team. Other strategies adopted were early engagement of supply chains, value engineering, breaking the work into several packages, suggesting alternative solutions to the client, and the open book accounting system. It was also found that the client played a role in enhancing teamwork and collaboration by organising a workshop on team building. Having explored how the organisational human resources were utilised during the project, the next section reports how the organisation capital resources (supply chains) were utilised during the delivery of the project.

6.2.2. Influencing Supply Chains

The supply chains are the company's organisational capital resources. Therefore, the main contracting firm takes responsibility for the behaviour of their supply chains (Lin & Tseng, 2016; Sancha, Gimenez, et al., 2016; Wu & Barnes, 2016). The findings on how the main contracting firm influences their supply chains to adopt sustainability practices in the project studied are reported in this section. Interviews were carried out with the main contractor's team and the supply chains, as shown in Chapter Six. The findings attempt to answer research question two and four. The findings report the various strategies adopted by the firm in influencing their supply chains. The findings are reported in two different sections. The first section report findings on how collaboration was carried out at the planning and delivery stage. Then the second section report findings on supply chain assessment mechanism.

6.2.2.1 Collaboration at Planning and Delivery Phase

How the main contracting firm and its supply chains collaborate at the planning and delivery stage is reported in this section. The findings on the strategies adopted for the selection and appointment of supply chains and responsible sourcing is equally reported. This section is divided into two parts: the first part reports collaboration at the planning stage while the second part reports collaboration at the delivery stage.

a. Collaboration at Planning Phase

In planning for the project, the main contractor's team explained that the first step they took was the early engagement of some supply chain members at the design stage. The early engagement was to enhance close collaboration and enable the supply chains to share their experiences on the sustainability of the various products while also checking for other alternatives. The further noted that the client's demand to have a building that

was LEED compliant was also a significant driver that enhanced collaboration at the planning stage. The Commercial Manager discussing on early engagement explained:

"We even brought in the facade subcontractors well in advance they were the first ones to be appointed. We only appointed them in portions then we say, we will appoint you for the design purposes, and once we are set with the design then we can appoint you for the full package so that helped us so that they could bring in knowledge on sustainability on the project".

Furthermore, on how the supply chains were selected, the respondents explained that most of the supply chains engaged have worked for the firm, and they have a long-lasting relationship. These findings confirmed Walker et al. (2008) claim that the focus of procurement have changed from the short-term cost minimisation to long term value creation and delivery. Also, they noted that except for some few foreign supply chains, most of the supply chains were locally based, and opportunity for new entrants was created. In addition, to enhance collaboration, the respondents explained that the project team organised a workshop that enabled supply chains to make presentations and to demonstrate how sustainability issues will be addressed. However, sharing their experience, the sub-contractors acknowledged the benefit of early engagement because they were involved six to twelve months before the start of the project. Nevertheless, they revealed that the engagement was mostly centred around the area of cost and less of the technical and buildability aspect of the project. A sub-contractor (Pre-Cast Concrete Sub-Contractor) noted:

".....all the early engagement was around the area of the cost; it was a QS type of engagement. There was no re-engagement regarding the area of buildability and use of craneage and stuff like that".

Another sub-contractor (Façade Sub-Contractor) said:

"At the tender stage, we initially did some cost plans for the PQS, who passed that to the client, and once the planning permission was approved, we then tender with more detailed cost plan. So, the tender process at early stages was with a range of cost planning before the final tender was done".

With regards to how responsible sourcing was planned and executed, the respondents explained that most of the products procured were sourced locally except for some products like the bathroom pods, toilets system, louvres, glass, aluminium, and stone cladding that were procured abroad from different countries like England, Belgium, Lithuania, Scotland, Portugal, Italy, and China. The reason for procuring the products abroad the respondents explained was because of the quality and availability in large quantity, also, because of the clients and end-users demand and specification. As noted in the review of previous studies, that in driving sustainability clients and end-users have a significant role in influencing the design and specifications (Robichaud and Anantatmula 2010; Mulville et al. 2016; Ofek et al. 2018). Furthermore, it was that the procurement plan was altered because the end-users of the commercial buildings were brought in early, which affected some of the earlier decisions. Although, the findings revealed that as a proactive measure in ensuring that all the products are procured from a sustainable source, the project team set up a quality cycle. The quality cycle ensures that all samples must be checked and approved by the client's team and the main contractor's team before the supply chain places an order. In terms of bigger elements, that the samples cannot be brought to the site, the respondent (Contracts Manager)

explained that arrangement was made with the design team to visit the production factory.

"One of the first parts of the quality cycles are samples. So, we must write the client or the design team to specify something, and we either get a working sample brought to site or if it is a big element works like the façade we will go to the factory."

Lastly, in enhancing collaboration at the planning stage, the main-contracting team explained that training was provided to the various sub-contractors on the use of the viewpoint for project software (4P). The aim of using the 4P software was to facilitate the dissemination and receiving of drawings or any relevant information to the subcontractor's team. The decision in training staff of the subcontractor's team as revealed by one of the respondents (Commercial Manager) was agreed at the pre-appointment meeting, and it was part of the contract signed.

"It has to do with the training because when you are pulling them, you tell them your vision right from the beginning and say we need you to appoint someone who is going to be receiving and sending information. So, it was part of the contract, that at pre-appointment you say who is going to look at the 4P and they bring the individual for training before they start on-site."

Having explored how the project team developed their plan, the next question focused on how the various plan was implemented.

b. Collaboration at the Delivery Phase

The respondents, explaining how the various plan was implemented, revealed that the client rented the commercial side of the building during the construction stage of the project. Renting the commercial side of the building enabled the end-users to be involved in the decision-making process. The respondents noted that the involvement of the end-users increased the scope of their work. This is because they will have to meet the expectations of the client's team and that of the end-users. Although, they explained that the management system of procurement was quite flexible, which enabled the project team to adjust their plan and adopt new suggestions. However, one of the sub-contractors (Façade Sub-Contractor) revealed that the project was designed heavy because of the changes experienced. The Sub-Contractor explained that some of the drawings used at the tendering stage were different from the ones used at the construction stage. The Façade Sub-Contractor noted that the changes affected their program of work which required their organisation to submit claims for a variation.

"It is design-heavy a lot of design work. It makes it difficult to deliver the project because the project will be designed at the tendering stage, and sometimes it is changed during construction which makes the program difficult to achieve. It also means that there is going to be a lot of variation".

Such challenges as noted by De Melo and Da Alves (2010) are likely to lead to adversarial relationship and lack of trust.

With regards to responsible sourcing, the main contractor's team explained that the end-user's requirements were built into the quality cycle developed. They further explained that at the start of the project, it was collectively agreed that all information with regards to a product should be submitted to the design team for approval before the order is placed. This was done to ensure that all products are sourced from a sustainable location.

One of the sub-contractors (Façade Sub-Contractor) noted that they had to seek approval from the design team and the main contractor's team before ordering any materials. In a situation, where the approval is rejected, the sub-contractor (Façade Sub-Contractor) explained that the design team or main contractor's team provided alternative sources.

"What happens is that we never order for any materials until it is approved. To get approval, we send off brochures, tests sheet, datasheets of a product. Once the Architect approved that we are good then to order that material. It is only approved once. If they reject it, they might look for an alternative, for example, if the louvre does not achieve the required airflow, they might reject that louvre proposal and look for a different one".

Also, sharing their experience of responsible sourcing, one of the supply chains (Pre-Cast Concrete Sub-Contractor) interviewed revealed that they have been in a business relationship with the main contractor for over 60 years. Therefore, the Sub-Contractor explained that because of the long business relationship with the main contracting firm, their organisation aligns its sustainability practice to that of the main contractor. Furthermore, on how information was shared and communicated with regards to responsible sourcing, the main contracting team observed that some of the supply chains like keeping information to themselves. But one of the sub-contractors (Pre-Cast Concrete) revealed that most of the time, nobody asked them about their production processes or sourcing arrangement; however, they try as much as possible to be environmentally friendly. He noted that to show their company compliance to sustainability practice, they regularly present their ISO certificate, CE marks, and their environmental rating to the main contractor's organisation. Furthermore, the respondent (Pre-Cast Concrete Sub-Contractor) explained that as a concrete product manufacturing

company they have their environmental statement, and environmental process, which enables them to measure their air pollution, dust, and adhere to strict health and safety policy. These findings are consistent to earlier research that sustainability is mostly self-driven in an organisation to enable them seek legitimacy (Rietbergen et al., 2015; Russell et al., 2018; Upstill-Goddard et al., 2015). Additionally, the Pre-Cast Concrete Sub-Contractor explained that their factory employs around 300 people within the community.

"I suppose we operate our factory, we have full planning permission, and we have an environmental statement and environmental process. We measure air pollution, we measure dust, we have strict health and safety policy, and in terms of sustainability we are in the very rural part of Ireland's, and as a group, we employ around 300 people. So, we are a vital industry sustaining jobs in a rural part of Ireland".

Furthermore, highlighting their responsible sourcing strategy, the sub-contractor revealed that in sourcing for their materials for production, they are always mindful of the haulage of the materials from their suppliers to their factory. This is to ensure a reduction in the carbon footprint. Also, the Pre-Cast Sub-Contractor revealed that they ensure that their steel products meet the safety quality and assessment system (SQAS) criteria. At the same time, the cement will have to meet all the necessary quality checks.

"There are three cement factories in the country; the nearest cement plant to us is less than an hour's drive away. Well, the steel must be Safety Quality and Assessment Systems (SQAS) certified and the cement producers producing to his quality standard and had to certify their products".

Finally, in exploring how collaboration was undertaken at the delivery stage, the respondents were asked how the nature and complexity of the project influenced their plan. In response, the main contractor's team explained that that the project was one of the first iconic projects that started in the country after the economic recession. As a result, the construction sector lost many labour resources which made it so difficult for some of the sub-contractors to cope with the delivery of the project. Although they noted that the challenges provided an opportunity for some sub-contractors to step-up while others were stretched and struggled in the delivery of the project. One of the primary reasons for the challenges as revealed by the sub-contractors was that government policies and actions like the Sectoral Employment Order (SEO) which led to an increase in labour cost, which affected the project, and currently affecting the construction sector in Ireland. The Pre-Cast Concrete Sub-Contractor said:

"The Sectoral Employment Order (SEO) results to labour rate increase which affected us. Moreover, when people know that there is a shortage in labour supply, they see it as an opportunity to raise their rate because they have an opportunity to make more money".

Also, another sub-contractor (Façade Sub-Contractor), revealed that why they faced the challenges was due to heavy workload in their organisation and low availability of labour which made them struggle in meeting the timeline. On the other hand, The Pre-Cast Concrete Sub-Contractor explained that it was the first time the main contracting firm engaged their company in carrying a vast and complex project. He noted that the project was a high-risk project located in the city centre and confined space, this made their operations to be difficult because some of their pre-cast elements section were quite heavy for the crane to lift.

"Well, it was a huge contract. But I supposed that operating in a city site is very tricky and that you need to price that risk into the project. For instance, I do not think we should have been fitting maybe four loads or whatever it takes because the access was too narrow".

To understand how the main contracting firm supported their supply chains with some of the challenges identified. The respondents from the main contracting firm explained that it is a trend in the company that every team working with sub-contractors will try and help in the delivery of the project. Therefore, what they did to support the sub-contractors that are struggling was that they had to go through the program of work of the sub-contractors, engaging with their directors and recommending other labour sources like the hiring of expatriates. Given an example of one of the facade sub-contractors, the respondent (Contracts Manager) stated:

"So, our facade manager would have done an awful lot of work with the facades besides the key part of all the buildings, and he would have had been involved in managing more than he would have envisaged. So, we would have gone into their program we would have looked at how many men they have, seen where they were putting it on was it on the critical path as per program? We bring in their directors and often lot every week just to make sure they know that we are aware of what is going on-site that some of them are performing".

A sub-contractor (Pre-Cast Concrete Sub-Contractor) providing a contrary opinion mentioned that the risk of the project was mostly transferred to them, which made some of the strategies adopted by the main contracting firm not to be helpful. For instance, the

early morning whiteboard meetings he noted was more of briefing and planning for the day's job. The Sub-Contractor noted that it is always very difficult to start resolving technical problems when the contract has been signed. He, therefore, suggested that having a meeting that will enable a detailed risk analysis at the planning phase of the project would have addressed most of the challenges faced. Illustrating how the lean manufacturing failure mode analysis would have helped in analysing the risk involved in the project and will enable the team to concentrate on the weaknesses. The Pre-Cast Concrete Sub-contractor stated:

"But if you have a specific meeting with regards failure mode analysis if this is going to be a problem, how is it going to be a problem then you look at the problem. This enables a plan to be done at the pre-contract stage with your preferred bidders. So, it enables us to ensure that issues are discussed and resolved at the planning stage. Doing that avoid conflict most especially in the complex project".

The sub-contractor (Pre-Cast Concrete) further explained that such early meetings or engagements would have created an opportunity for a technical workshop where several issues and solutions would have been addressed or suggested. He believed that doing that would have reduced conflict and adversarial relationship during the execution of the project.

"If there were an early engagement and technical workshop meeting to say how we are doing this, how are you going to that and a lot of whole questions before you can contract on it. This is because the most important thing in the procurement of large projects from a supplier point of view is that we feel that

there is a partnership. But for the partnership to work there will have to be trust and a good relationship, a personal relationship".

Such collaboration would have been effective if there was a vertical integration where the main contracting firms will have the opportunity to assess the resources available to their supply chains. Although the cyclical nature of the industry might be one the reasons that might discourage large construction firms to integrate vertically with their supply chains (Linesight, 2018b; McKinsey Global Institute, 2017).

Finally, with regards to the disposition of the supply chains in accepting new ideas and suggestions, the main contractor's team revealed that some of the sub-contractors were resistant in accepting new ideas. Also, they never wanted the main contracting team to be involved in their operations. But the main contracting team explained that they had to be involved because they were behind schedule, which would have affected the project negatively. However, a sub-contractor explained that they experienced delay because they had to wait for other packages to complete their work before commencing with theirs. In exploring further on how the main contracting firm influences their supply chains, the next section report findings on supply chain assessment mechanism.

6.2.2.2 Supply Chain Assessment Mechanism

Supply chain assessment is one of the critical issues on the main contractor's company policies. The sub-contractor performance guidance, feedback mechanism, and the incentives provided for good performance were critically examined.

The performance guidance report explained that supply chain assessment on project sites are to be carried out bi-monthly or quarterly depending on the complexity of the project. In the project under review, the main contractor's team explained that supply chain

assessment was carried out bi-monthly. They revealed that the performance assessment was a pro-active strategy against the failure of sub-contractors. The activities assessed as clarified are the quality of their work, health and safety, the program of works, and their attitude. Assessing supply chains performance enhances the sustainability performance of the project (Gosling et al., 2015; Krause et al., 2000). The Contracts Manager further explained that performance is recorded on a league table that will help in tracking the supply chain performance.

"So, it is a live process, and it is score like what is your quality like, what is your safety like, what is the program like, and what is their attitude things like that. So, we would always know there is a kind of a league table there, so whenever there is a problem we dip in and out of that".

The next question discussed was on the feedback mechanism to supply chains with regards to their performance. With regards to sending feedback to supply chains, the main contractor's team explained that every supply chain is provided with a copy of their performance. They further explained that another way of providing feedback is during the directors' tour, where all the directors of the supply chains meet with the main contractor's team to discuss their progress and performance. Also, during the meeting, milestones are set that is expected to be met before the next meeting. The Contracts Manager shedding more light said:

"In a room with our team, we would kind of highlights what the good contractors were doing as in their work to make sure that their quality and safety is high. What we will do then is that the guys that are not doing well we would give them a kind of a task to say next time we meet we would like you to be doing something else in this kind of area".

Additionally, in communicating feedback, they noted that the informal approach tends to be more effective and beneficial. Some of the benefits of the informal approach, as revealed by the respondents, was that it enables the main contractor's team to understand the challenges of their supply chains. Such an informal approach as noted by , Hojem et al.(2014), enables the collective act of exploration, discovery, and analysis, which improve the project objectives and enhances innovation. Additionally, the Contracts Manager explained that it enables free communication amongst the various team members because the meeting is not recorded and is carried out outside the meeting room.

"So, it is not something that it is always recorded; it is more on an informal basis and can sometimes have a very good effect because it is not a sit-down meeting with everybody around the room. Some people might be afraid to stand up and say we have a problem here so you might find out from the informal meetings more than sometimes what you find in the formal meetings".

Lastly, with regards to rewards and incentives for good performance, the main contracting team explained that they ensured all the supply chains are paid early and provided an opportunity for some supply chains to step up to a higher tier. Also, they revealed that supply chains that do well are assured of future engagements and continuous workload. However, the sub-contractors interviewed revealed that even though they were paid early, but they lost so much money because of some of the challenges discussed in the previous section. Despite the loss and challenges experienced by the sub-contractors interviewed, they still find it a privilege to be involved in such an iconic project. One of the sub-contractors (Pre-Cast Concrete) explained that the project

provided an opportunity for them to learn because, despite their long years of working relationship with the main contractor, it was their first time working on such a large project.

"Well, we learned a lot from it. So, we did the job we got paid we did not get paid what we wanted to get paid. I felt that we were hard done by, to be honest with you. We have learned to be very careful the way we do business, especially larger projects".

Another sub-contractor (Façade Sub-Contractor) revealed that despite the challenges, being part of such an iconic project owned by a reputable client, their company image has significantly been improved.

"First the money was not good; we lost much money which is a pity. The enjoyment side of it was that it was one of the tallest building in Ireland and excellent client and nice to be involved in such a high-profile project and a big landmark in Dublin, and it was very nice to be involved in that kind of scale of a project. To be able to do such a large project, it was very nice, and that was the reward".

The sub-contractors' perception of rewards and incentives was the privilege of being part of the project, and it was an opportunity to improve their company image. The views of the supply chains could be assumed to be influenced by the structural dominance position occupied by the main contractor. As Adetunji et al. (2008) noted that the structural dominance position occupied by the main contracting firm enabled them to use their purchasing power and regularity of workload advantage.

The third organisational resources studied was the physical capital resources of the firm (digital technology tools and resources). The next section reports findings on how digital technology resources were utilised in promoting sustainable procurement in the planning and delivery of the project.

6.2.3 Utilisation of Digital Technologies

How the organisation's physical capital resources were utilised during the project is reported in this section. Also, findings on the disposition of the supply chains in the adoption and utilisation of digital resources are presented in this section. During the interview, potential areas that digital technology could be utilised was also explored.

First, the findings, on how digital technology tools and resources were utilised at the procurement and planning phase was explored. The main contractor's team explained that as part of their company digital technology policy, the adoption and utilisation of digital technology is a fundamental requirement, and all the parties were expected to comply. Therefore, at the start of the project, they explained, that all drawings and relevant information were shared through the viewpoint (4P) application. The adoption of the viewpoint for project as noted by one of the respondents helped to reduce the use of papers and made drawings to be easily accessible through different electronic or computer devices. However, one of the sub-contractor's (Pre-Cast Concrete) acknowledged the benefit of the viewpoint for project application but noted that some of the drawings that were shared on the platform were not relevant to what the need.

"You see it is not about sharing information because it was an inconsiderate file with a lot of drawings 5000 pages given you everything right, but we do not need everything. They are given us soil investigation report it makes it difficult for you to find the page that you needed. The information should be relevant to what the specialist subcontractor need".

With regards to the use of BIM technology the respondents explained that the client was not interested in utilising the technology, therefore, BIM technology was only used at

the pre-planning stage by the main contractor's team. Another technology used as revealed by the respondents during the project was the unmanned aerial vehicle (UAV) which is popularly referred to as drones. They explained that drones were used to capture different parts of the jobs and site to enable good planning, and the drone footage was used as part of the morning whiteboard meetings. In addition, computer tablets for signing off the quality and safety on-site and sharing information daily to other team members, including the various supply chains were utilised.

Secondly, with regards to the disposition of their supply chains in utilising digital technologies, the main contractor's team explained that the level of adoption of the supply chains is mostly dependent on their size and nature of work undertaking. They revealed that adoption and utilisation of digital technology in larger supply chain organisations are better than the smaller ones. The Contracts Manager explained that they had to work very hard to convince the smaller sub-contractors to see the benefit of using tablets during the project.

"Anything new is usually resisted at the start. Some smaller subcontractors did not want to get tablets. Tablets could be up to nine hundred or a thousand Euro for a good tablet, and we would always kind of say look this is a very small figure in the overall scheme of things. Your package would be x amount hundreds of thousands this is going to help you to free up time for your snagging. You do not have to print paper and you are going to save you money. So, we tried to come from a view of trying to explain to them that this is a good change for the better that they need to embrace it".

On the other hand, one of the sub-contractor's (Pre-Cast Concrete Sub-Contractor) explained that they are up to date with regards to the adoption and utilisation of digital technology tools and resources. The Pre-Cast Concrete Sub-Contractor further explained

that they provide training opportunities to their workers to train in different applications and software packages.

"We use BIM every day; we use Tekla structural engineering software for our design package. Most of our projects are 3D models, so we are very up to date on that. We train our workers ahead with the best technology and BIM. We have a design office in Poland, and all the information goes back. It is all 3D modelling. We are at the cutting age of that technology".

These findings revealed that digital technologies utilisation is more focused on-site operations and activities. Firms focusing on only site operations and activities could only experience a competitive parity. This is because such activities using digital technology are simultaneously implemented by other construction-contracting firms (Mata et al., 1995).

However, the respondents identified other areas that that digital technology could be used in promoting sustainable procurement. The respondents noted that some of the potential areas that could be explored are creating a common platform for data or information sharing, and life-cycle costing. Other areas noted are calculating energy usage, carbon footprint emissions, and water usage. Explaining the benefit of a common platform, the Contracts Manager explained that the platform would ease the challenges of obtaining information from the head office.

"These people might be working on that job for months, weeks, years, you know. So, I suppose a better way of handing over from procurement to the site team would be key I supposed".

Similarly, another respondent (Commercial Manager) explained that the effectiveness of the platform would require the exchange of information from the head office to project at the site and back from the site team to the head office. Therefore, he suggested that such practice should start from the estimating team because they have gotten an awful lot of information.

"It should start with the estimating team because money is either made or lost when you sign the contract. So, considering what you price, those who are going to deliver the project need as much information as they can before they start with the project. So that they are aware of any problems and get prepared for that".

The Commercial Manager further noted that sharing of such information should be a continuous process.

"I keep on going back to the estimating department because we identify their problem and mistakes when we are managing the project. So that information should be shared with them. I remember when we were on this project an estimator phone me asking about rates for contaminated material because we are already on-site and we knew how much it cost it was easy to share that information, and that is the information that we need to share continuously".

Overall, on the benefits of adopting the use of digital technology, all the respondents acknowledged the benefits derived in the adoption of digital technology on the project.

The Commercial Manager rounded the discussion up by saying:

"We would not have achieved this without digital technology. I think the age of the iPad did help us. There is a further development to that because you could easily share information when you walk into the room. If you want to advise someone, you just put it on, and with the iPad, you take a photograph and send it. And even the 4P project did help a lot because gone are those days when you go and look for a drawing, and you flip through several drawings. Now, this is available on your phone or desk".

Summarily, this section reported the findings on Project A, which is in the city centre of Dublin erected on a brownfield site in a confined space. It is also one of the tallest building in Dublin and a mixed-used building. Findings unveiled how collaboration was carried out within the team members, and how the team addresses government and external stakeholder's requirements. In addition, how the team collaborate with the client's team in addressing the client's requirement was also explored.

Addressing sub-research question two on how the main-contracting firm influences their supply chains, two significant issues were explored. The first issue to be addressed was to understand how collaboration at the planning and delivery stage of the project was implemented. While, the second part explored the supply chain assessment mechanism, performance, and reward system. Lastly, how the organisation's physical capital resources were utilised (digital technology tools and resources) was examined. The findings reported the level of utilisation of digital technologies and the disposition of the various supply chains in the adoption and utilisation. The potential and future areas that the firm can utilise digital technologies were examined.

The next phase of the study identified a second project with unique characteristics which could allow lessons to be drawn with regards to the firm sustainable procurement

practices. The findings for the second case study (Project B) is reported in the next section.

6.3 PROJECT B-FINDINGS

The findings of Project B are reported in this section. As it was reported in Section 6.3, this section also unveils how the various organisational resources were utilised during the delivery of the project. The three areas explored were implementation within the main contractor's team, influencing supply chains, and utilisation of digital technologies. Studying Project B provides an opportunity for a comparison to be made with Project A in understanding the firm sustainable procurement practice.

6.3.1 Implementation within the Main Contractor's Team

In understanding how sustainable procurement was addressed within the main contractor's team, the study explores how collaboration was carried out within team members, and how government and external stakeholder's requirements were addressed. Also, how the main contractor's team collaborate with the client's team in addressing the client's requirement was explored and reported in this section.

6.3.1.1 Collaboration Within the Contractor's Team

The collaboration within the firm explored how the organisational sustainability policies guided the project team at the planning phase of the project. Also, explored was how communication, knowledge and feedback were shared within the project team. The project, as earlier stated in Section 6.1, was procured under the design, and build procurement arrangement. The procurement arrangement enabled the contracting firm to manage the design process. Mollaoglu-Korkmaz et al. (2013) noted that Design-Build (DB) procurement methods have better chances of facilitating integration. Nevertheless, the client appointed an independent design advisor on the project.

In explaining how the procurement method influenced their planning, the respondent noted that using the design and build type of procurement entails them planning the work

in different phases (procurement phase, program phase, execution phase, and handing over phase). Also, time was of the essence in the delivery of the project; therefore, the contracting firm had six weeks of pre-construction period that allowed them to plan. The pre-construction period, as noted by one of the respondents (Contracts Manager), was a very important period to the team, unlike other types of projects that short notice is given for planning.

"We won the project, and then there were six weeks of a pre-construction period to allow us to do most of this planning. That was the key period. Sometimes what happens is we will win a job, and we will have to mobilise shortly afterwards, and it does not allow that kind of pre-planning".

Additionally, the nature of the project, which was the first of its kind in the Republic of Ireland and the largest amongst the projects owned by the client, made the project team to plan and coordinate the project carefully. The respondents explained that similar projects had been executed in the UK by the client. For instance, the lodges were expected to achieve the A3 BER rating, and the whole project was to comply with BREEAM certification standard. Likewise, managing the watercourse and the forest area was quite critical to the success of the project.

Explaining the implementation strategy, the respondents explained that at the start of the project, the project team was set up to work closely together in delivering the project. Working together as a team was essential because three other major contractors were engaged on the same site. Therefore, the first step they took was to undertake research on previous projects completed and to visit other live facilities under construction in the UK. The respondents explained that such exercise was necessary because the largest project is always the most difficult project. Also, the nature of the site in Ireland poses

several challenges for managing and controlling construction activities. After addressing and understanding the key success indicators of the project, the respondents explained that the next step, they took was to procure reputable sub-contractors and supply chains. Other strategies developed are setting-up environmental practices to eliminate any risk of contamination from oil spills, prevention of debris into watercourse tributary levels and waste management.

Furthermore, the respondents revealed that the team undertook a risk analysis to identify the potential risks that could likely affect the project. The Contracts Manager explained that delivering the project on 400 acres of land requires planning for logistics and delivery of the materials.

"As you must understand, the site was 400 acres of land. It meant that when the material was being delivered. It was being delivered to the correct part of the site to suit construction at that stage".

Also, the project team arranged a formal pre-award and pre-appointment meeting with all their supply chains. Although some of the sub-contractors had a long-term working relationship with the contractor's organisation. Therefore, are conversant with company's sustainability policies and practice. The Commercial Manager said:

"However, at a higher level, we also have supply chains that we use in the company. So, we are aware that the people we are contacting they are people that we can use because they comply with the system we have in place".

On how the various plans were implemented, they respondents explained that the team took a structure of a single lodge and broke it down to a minute level of details. Breaking

the structure down, the respondents revealed that it enabled them to determine the exact quantities of materials for each of the elements of the building for erecting a specific lodge. A respondent (Contracts Manager) explained that it also allowed them to have complete control of the amount of materials required.

"So, we have to understand for example exactly how many roof tiles required to build a roof or exactly how many sheets of plasterboard were required to fill the lodge etc. So, we had a clear understanding, and we have complete control over the amount of each item that was required to build a lot. We completely understood the optimum sequence to build the lot. That might sound simple, but when you get into the detail and it is quite intricate".

Additionally, the respondents revealed that having the right knowledge about the quantities of the materials empowered their operatives to know exactly what they are expected to do for the day and the quantity of materials required. The plan also enabled the quantity surveyor to set-up an effective call order for the materials and could forecast six months in advance. At the same time, the engineers knew the exact sequence of work that enables them to plan for all inspections, quality test, and the necessary documentation. Finally, the foreman was able to know what is to be achieved every day and plan for all the housekeeping procedures. The plan was constantly monitored through the early morning whiteboard meetings and regular site meetings. Such innovative strategies were adopted to ensure that the project meet the TBL requirement. The findings further confirmed Eiadat et al. (2008) claim that environmental innovation strategy is associated with the business performance of the firm.

A further question was asked on how the plan developed was communicated to the whole project team members. The respondents noted that training and staff development is one

of the primary issues in their company's sustainability policies. Therefore, as a company, they noted there are procedures in place that on every new project, it is usually a combination of older and new staff. The long-term company staff will be forty per cent while the new staff that will be coming to the company will be sixty per cent. They further explained that the new staff would need to understand the company procedures and processes, so as a team they took them through the plan and ensured that everyone understands the whole procedure about the project and the company requirements. One of the respondents (Contracts Manager) explained that a series of lean construction training sessions were provided to the project team.

"It is a mixed we would normally try to operate with a minimum of 40% of long-term company staff, and then we would supplement them with the balance. So, we try to get the best to enhance our team. When they come on board, we aligned and brought everyone through the plan, and we test it all. We also carry out a number of lean construction training sessions with our people, so the principles of lean construction are fundamental to the project".

The commercial manager sharing his experience on how training was provided to his team members, explained that during the planning of the project, the primary challenge was to get the whole job procured. Therefore, in achieving this task, he explained that members of his team were assigned responsibilities to enable them to understand the job through the different packages and the cost plan. Then he went through the whole processes with them and ensured that each person understands the task involved. After understanding the whole process, the next phase was managing the job and each package. Also, managing sub-contractors' package, raising payments, and ensuring the pre-appointment insurance documentation is in place. Transferring of knowledge and

developing the requisite skills is key in driving sustainable procurement (De Giacomo et al., 2018).

The last part of understanding collaboration within the main contractor's team was to explore how communication and feedback from the head office were managed. With regards to communication and getting feedback from the head office, the respondents revealed that from the onset of the project, the company understood that the project was an unusual project with high risk. Therefore, in planning for the project, there was a high-level of pre-planning and due diligence which was led by the chief executive officer of the company and other key members of management. Also, the sustainability team of the company provided its expertise, which saw the company using electric vehicles during the delivery of the project. The Contract Manager explained that during the delivery of the project, the head office team were regularly brought to the site to understand the progress, and it was an opportunity for providing feedback.

"Particularly earlier on, we brought many people to the site to show them what we are doing. I supposed they had learned some stuff that we were doing. But also, we were able to draw on their information to improve what we are doing".

Finally, the Commercial Manager revealed that his team was always in touch with the accounts and procurement units in the head office by providing an update of their activities. However, the Commercial Manager noted that it was not possible to provide all the information.

"We had someone in the accounts and purchasing department to ensure that they knew exactly what is going on, the accounts person was very helpful because I always speak to them a lot about payments and different things like

invoice query. We did not share as much information, we did not give them everything, but we gave them much stuff".

The next section further unveils how the project team addresses government and stakeholder's requirements.

6.3.1.2 Addressing Government Regulations and External Stakeholders' Requirements

The government regulations addressed during the project, as revealed by the respondents was complying to the inland fisheries regulations. The inland fisheries are the government agency saddled with the responsibilities of auditing the design weekly and monitoring the environmental practice of the contractor. Therefore, the Contracts Manager explained that a strategy was developed in addressing and engaging the government agency.

"I mean inland fisheries when they were on the project; they audited the design weekly. I mean they look at nothing else only eco and to look at the impact to the environment, and of course, at some points, there were some issues identified minor one. But typically, we had an approach were If they raise something, they will engage with us and understand."

In maintaining the forest, the respondents explained that the team ensured that, water pollution was prevented, little disruption to the wildlife, felling a little number of trees, and minimisation of waste to the landfill. It is possible, therefore, that the contracting firm complying with government laws and regulations is to protect their image to the public and society (To et al., 2015).

With regards to collaborating and engaging the external stakeholders, the respondents revealed that they developed a mechanism for engaging and educating the community. The engagement and education were intended to create awareness on what the project was all about and to get them to support what they are doing and cooperate with them. In addition, in creating an impact on the community, the respondents explained that the project team with their supply chains produced Christmas toys which were delivered to a local school. Also, produced was the seating arrangement for gardens for the local communities. The project team in managing the natural habitats produced back boxes for the animals in the forest. The revealed that the client was so impressed by that gesture. The respondents believed that such gesture created an excellent image of the company in the communities the project took place. How the client's requirements were implemented is reported in the next section.

6.3.1.3 Collaborating and Implementing Client's Requirements

The client's requirements, as noted in the earlier findings, were significant to the success of the project. Early completion and meeting sustainability criteria of the project were essential to the client. Understanding the client's needs and objectives has been noted to be key in the successful delivery of a project (Boyd & Chinyio, 2008; Newcombe, 2003). Explaining how the client's requirements were managed and implemented, the respondents revealed that the client's demand was one of the primary drivers in the design and construction process. However, the respondents noted that as the main contracting firm, they were mindful of their organisational procedures, so they had to collaborate closely with the client's team in achieving a sustainable design. In achieving a sustainable design, a respondent (Contracts Manager) explained that as a firm, they could only improve the demands of the client.

"I suppose we cannot control client demand we can try to improve it. But we need to come to a place where we do not compromise on our procedures while we try to satisfy our client.

"Client demand is a major driver, and I suppose there is an onus on us to work with our client and to either allow them to understand why we have our procedures in place or at least to work with them and collaborate".

On how collaboration on the design was carried out, the respondents revealed that the design proposal from the client complied with UK regulations and requirements. So, the first assignment of their design team was to work on the proposal to align with the Irish design requirements and regulations.

"So, the regulations were the biggest thing the Irish regulations and how they differ from the UK and their job was to ensure that these buildings comply fully with all parts of the Irish regulation". (Contracts Manager)

After that, the respondents further explained that the contractor's design team would submit comments and observations to the client's design team. Then they the two teams will meet to work out a workable solution for the design. The Commercial Manager noted that to speedily resolved the design problems, a technical workshop was held to address all the challenges noted and seek approval from the client to enable early start.

"We requested that we hold a workshop because there was no point flying of drawings over time by email. We held a workshop to help us understand what we need to find out and approved so that we can progress with the work".

Additionally, on the respondents were asked how the client's sustainability requirements aligned with their company's sustainability policies. The respondents make clear that the issue of sustainability has become more of a norm in their company procedures, and all sustainability requirements were addressed during the design and planning of the project.

The Contracts Manager explained:

"Yes, that is not a challenge. That is an item we encompass all the time, and typically I do not see a huge problem with it. We work with LEED, BREAM clients. Well, sustainability is a matter of alignment what does need to happen was addressed on the front end of the project".

In conclusion, this section reported findings on how the implementation of sustainable procurement within the main contractor's team was carried in the project. In exploring how the implementation was carried out, collaboration within the team, collaboration in addressing government and external stakeholder's requirements were unveiled. Also, how the main contractor's team collaborates with the client's team was explored in this section. Going further, the next section report findings that addresses sub-research two, which focuses on how the main contractor's team collaborate with their supply chains.

6.3.2. Influencing Supply Chains

Just as demonstrated on Project A, this section report findings how collaboration was carried out at the planning and the delivery stage of the project. Also, the section reported findings on supply chain assessment mechanism, feedback, and reward system.

6.3.2.1 Collaboration at Planning and Delivery Phase

Collaboration at planning and delivery stage is reported in two parts as done in Section 6.2.2 above.

a. Collaboration at Planning Phase

Collaborating with the organisation's supply chains was fundamental in the success of the project. First, the respondents were asked how the selection and appointment of supply chains were made. As it was stated earlier, the respondents explained that some of the supply chains engaged had long years of business relationship with the company. However, due diligence was carried out on the practices of most of the supply chains before their appointment. Explaining the need for collaborating with their supply chains, the respondents reported that the success in the delivery of the work was dependent on their supply chains. Therefore, there was a need for the main contractor's team to understand the needs of the supply chains and agree on plans that would work out for both teams. Such level of collaboration have been noted to create several benefits to the project team (Witjes & Lozano, 2016). Furthermore, the Contracts Manager believed that the success of the project is dependent on the success of the supply chains, and close collaboration reduces conflicts.

"Well, the first thing from my perspective is that we are dependent on our supply chains. When we go to a project, we need to understand what their needs are to allow them to succeed unless they succeed, we will not succeed. So, the first thing we need is to work with our subcontractors and suppliers and to agree to plans that work for both of us. Then we need to rely upon and coordinate and collaborate with them to deliver the project."

After understanding the needs of the supply chains, the respondents explained that the next step was to bring the sub-contractors through the work plan and agreeing on the various strategies of delivering the project. The respondents revealed that doing that enabled the sub-contractors to have a rich understanding of the team expectations in terms of the stages of the works and materials requirements for the project. These findings support Lönngren et al. (2010) assertion that strategic alliances are a crucial requisite for the successful management and integration of services and products within the construction industry.

Additionally, with regards to the collaboration with the supply chains, the respondents further explained that during their planning stage, they saw the availability of suppliers and labour as a huge risk. This, they explained, was due to the nature and location of the project because the project was in a remote area. However, the Contracts Manager noted that because of the close collaboration they had with the supply chains, they found out that the availability of labour and local suppliers would no longer be a risk.

"At the start of the project, we saw the availability of suppliers and labour as a huge risk to the project because of its remote area. We did a rough study but halfway through and it turned out that 55 per cent of the labour force was within a 60-kilometre radius of the site. So labour availability and local contractors it turned out not to be an issue".

Sharing their experience on their involvement in the planning of the project, one of the sub-contractors (Façade Sub-Contractor) said, right from the onset of the project they were briefed by both the client's and the main contractor's team on waste management. The sub-contractor (Façade) explained that they were told that wastages had been a major problem on previous projects. Therefore, they were instructed that only twenty per cent of waste on materials shall be allowed.

"We were told at a very early stage that the history of other completed projects that there was much waste in the cladding because all the lodges in the forest are timber. And of course, the whole environmental issues as well. So, the client and the site team told us that there is just going to be 20 percentage waste on the material".

Furthermore, in exploring the subcontractor's role and inputs in the design and construction process and planning, the respondents explained that one of the first things the main contractor's team did was to take them to the site. The Façade Sub-Contractor noted that they were taking to the site early to have a feel and provide inputs on a sample lodge that was already erected. The sub-contractor revealed that assessing the sample lodge constructed, and he noticed the need to increase the thickness of the timber sill because the height of the doors was quite high. Increasing the thickness was to prevent the timber from twisting. The Façade Sub-Contractor noted that such suggestion helped in adjusting the design, and the cost of the item.

"Typically, doors in some of the lodges were built so high, and it was carving above. So, there is a timber sill detailed just like a concrete sill, but it must be timber it was quite wide. So, I comment that I would not recommend using the ideal because, with time, it is going to twist or split because it is wide. We would have to join the board that was recommended, which would be suitable".

Furthermore, the Façade Sub-Contractor sharing their experience during the planning phase noted that because of the nature and large size of the site, they would require about twenty-five cabins on site, with the main compound having a canteen. However, considering the time it will take for workers on-site to walk to the canteen during break hours, many man-hours will be lost. Therefore, during their directors walk they agreed and proposed a lively mobile van which was converted into a mobile canteen. He further explained that the van was painted with the company logo and project title placed on the van; this innovation was the first of its kind in the history of the client's projects. Having the mobile canteen close to the workers, they noted to increase productivity, and everyone was happy.

"The main site compound is the canteen, and the lads are on break at 10 a.m., the break at one o'clock, you know it could take maybe 15 minutes to get to the canteen have the break sitting back half an hour a day in the morning alone would be waste by 30 minutes by 15 or more men multiply that by five days a week huge".

Another innovation that was suggested during the planning period, as noted by the respondents was the provision of a temporary tent to keep productivity to the maximum because of the constant rainfall in the site location. These findings are quite valuable in

understanding how the main contractor's organisation utilises the expertise and knowledge of their supply chains. Utilising such expertise created value as Kähkönen and Lintukangas (2012), noted that value can be created through the organisation's capabilities. These capabilities are through competing and responding to industry-level challenges, exploiting relationship capabilities, and understanding and responding to customers' needs.

The next stage was bringing the materials suppliers to understand the plan to enable them to plan their deliveries. The respondents explained that the suppliers were given details to the exact level of what is expected in the supply and delivery of materials. Such an approach enabled the suppliers to know the exact quantities of materials at each stage of the work and to plan their logistics, which helped in reducing wastage. With regards to responsible sourcing, the respondents explained that right from the planning phase, it was made clear that all materials shall be procured from a sustainable source. For example, they explained that all timbers and timber products supplied shall have the FSC logo stamp. Additionally, the Commercial Manager revealed that due to the large size of the project, they discovered that some of their supply chains would not have the financial capacity to supply the whole volume of the materials required. Therefore, the main contractor's firm decided to buy most of the materials for the project.

"We bought many materials that will normally not do because the subcontractors did not have the finances to do so, and the quantities of material are so great".

Furthermore, with regards to planning on waste management, the respondents explained that to minimise waste to the landfill and reduce disruption to wildlife, the main contractor's team took the responsibility of managing their materials. Also, the team managed the delivery of materials to site and movement of personnel on the site. The

Contracts Manager explained that an effective storage limit movement and minimises waste.

"The mechanism we took on the lodges was to manage our materials, to manage our movement of personnel but more so to manage the quantities of materials that were brought on to the site. The storage limit movement, but also minimises waste because the fewer materials we were wasting, or over-ordering leaves us with the risk of bulk disposal costs and waste to landfill".

Lastly, the main contractor's team were asked about the disposition and cooperation of their supply chains during the planning of the project. One of the respondents (Contracts Manager) explained that it was not easy convincing some of the sub-contractors. For example, the Contracts Manager explained that they had to convince the stone cladding sub-contractor to understand why the need to control the materials and resources to be brought to the site. However, he revealed that some of the sub-contractors understood the need for supporting the plan because success would be for everybody.

"We had a lot of stone facades in front of the lodges, and we had a big debate with the stonemason. He made it very clear that the resources he would assign he was concerned that at the end of the project as is normal we will be under pressure and will be looking for additional resources many times over. We had to bring him to our plans and give him the confidence that once we resolve early in the project the correct level of resources, they would have to stay with the project throughout. That there would be no peaks and troughs in the resource levels, and we would then never need a big push at the end".

Finally, on the benefits of early engagement and close collaboration in developing the work plan, one of the sub-contractors (Timber Frame Sub-Contractor) revealed that the process was found to be very good and quite proactive. Also, the Timber Frame Sub-Contractor noted that everyone contributed to the planning and understood their role and responsibility quite early, which helped in addressing much of the problem. Collaboration in a supply chain management relationship is built on trust (Koolwijk et al., 2018).

"We find the process very good and very proactive. Everybody contributed greatly, and there was respect. Everyone understands their responsibility from the development stage and supported the implementation of the project. Early involvement helped in addressing much of the problem".

How these plans are implemented is reported next.

b. Collaboration at Delivery Phase

In collaborating with their supply chains to deliver the project, a respondent revealed that the construction of the lodges was the largest of the whole project. The lodges had eight different types of housing units totalling four hundred and sixty-six lodges (466). The Contracts Manager explained that the design and build procurement method enabled work to start on site before the completion of the whole design. With regards to sharing information on sustainable materials and products, the respondents explained that the supply chains were good at sharing information and suggesting alternative products. For instance, they noted that the sawmills they contacted were able to guide them on the best timber products for cladding. A respondent (Commercial Manager) explained that the

perceptive nature of the sub-contractors pointed the team in the right direction and helped them to do the right thing.

"Yes, they were found very helpful. If you are looking to make a comparison between two sources, like cladding in external walls, there was a large quantity of about probably 30,000 square metres of cladding. So, we took samples and make samples on-site. We got the suppliers to come with their experience. We found generally they were good at sharing information that pointed us in the right direction and helped us to do the right things".

The disposition and willingness of the supply chains to share information could be attributed to the close collaboration established and the managerial capability of the team. Li *et al* (2013), explained that the managerial and technological abilities of a firm are related to the firms' sustainability performance.

With regards to ordering materials, the sub-contractors explained that approvals will be needed. They explained that they provide an approved declaration that the products meet all the certification requirements. The facade sub-contractor sharing his experience explained that they had to procure timber that was fully certified and provide evidence of the certification of the timber under treatment process. Also, the Façade Sub-Contractor noted that they had to provide evidence on certification of other materials and accessories like the pins, membrane, and cement board.

"I must get the timber that is fully certified. I must get certification under the treatment process. I must get certification on the supply of our pins that we were fixing the cladding with; we had a DPC, we had a cement board at the base acting as a plinth (kicker board) we had to get certification on that. So,

any product that we supplied we had to get the information on site first before you get approval and get the go-ahead".

Furthermore, the respondents were asked how they go about sourcing for materials and labour. They explained that the early planning and engagement of their supply chains enabled them to understand that the availability of labour and local suppliers was not going to be a risk. Therefore, they explained that most of their sub-contractors draw their resources, both materials and labour from the local community. Although, the respondents explained that due to the nature of the project, and the demand from the client, about sixty per cent of the materials were sourced abroad. The Commercial Manager revealed that materials were brought from the UK, Spain, and Sweden.

"The reason was mostly that specific product that the client wanted was from the UK or some factories coming from Spain where they virtually bought all their tiles and floor finish and the likes".

Also, the respondents further revealed that sourcing abroad was mostly influenced by the quality of the product and availability in large volume. For example, the Façade Sub-Contractor revealed that, the unsorted red deal (Scandinavian Pine) wood was what was specified for the claddings in the lodges. Nevertheless, it can only be sourced from the Scandinavians, while the common white deal wood is the most common wood available in Ireland.

"First, the volume is not there, and the red deal was the timber specified, and much timber sold in Ireland is the common white deal. So, the quality would

have been the main issue. We must get this quality this kind of unsorted red deal which is the highest”.

Even though most of the products were sourced from abroad, the respondents explained that they still patronise the local builders' merchant shop in the community. But they noted that because it is a large project, they usually give the merchants adequate notice to arrange supplies and delivery. The Commercial Manager explained:

"We are trying to buy local, and that was important because we want to support our local suppliers. There are many suppliers in the area that we were buying all our cement board; he would not have that in stock. So, let him know that we are going to need one or two thousand sheets and we are going to need it in the call of days".

With regards to material and waste management, the respondents explained that the just-in-time delivery approach was what was used. They noted that the just in time delivery enabled the right material inventory and quantity to be delivered and avoiding excessive materials on site. Such a strategy, as noted by one of the respondents, was effective because the suppliers were involved in the planning process. Another strategy adopted in controlling materials on site was the use of the tracker document. The tracker document, as explained by the respondents, provides each of the sub-contractor the actual quantity of materials they need for each of the lodges. Using the tracker document, the Contracts Manager said it enabled the storeman to monitor and have knowledge of the quantity of the materials required for each day's work.

"So, for example, if the tiling contractor comes, he will know how many square metres required for a 2-bed lodge. So, he walks down to the store early

morning, and he said give me five square metres because I am going to work on 2-bed lodges. So, we had all the quantities broken down and what to take. He asked our storeman to organise for that. So, that is how the fed into it by giving us what they needed, and we worked it out into the plan".

The findings further revealed that the materials used are recorded into the plan to track overall usage by each sub-contractor. One of the sub-contractors (Façade Sub-Contractor) expressed his views that the tracker document enabled them to follow the plan in the delivery of the project.

Providing further information with regards to waste management, the respondents informed that waste management was of significance to the client and the main contractor. Therefore, in managing and controlling waste on-site, each of the sub-contractor was provided with a waste bucket skips. The bucket skips were inspected monthly by the main contractor's team. Monitoring and assessing the activities and performance of supply chains promote realising the clients and project objectives (Gosling et al., 2015; Krause et al., 2000). Sharing their experience with regards to controlling and managing waste, the Façade Sub-contractor said the plan enabled them to have fewer off-cuts and sawdust around the site premises. .

"We had absolutely nothing left behind, no off-cuts even sawdust we had a waste buckets, so we had our skips because we are going to be cutting a lot, so we had our separate skips for our wood waste".

To further understand how the delivery phase was managed and the plan implemented, the next section report findings on the supply chain assessment mechanism.

6.3.2.2 Supply Chain Assessment Mechanism

This section report findings on the supply chain assessment mechanism utilised during the delivery of the project. The feedback mechanism, supplier's development, and reward system were explored.

The supply chain performance assessment, as revealed by the respondents, was carried out bi-monthly or every three months as it may be required. As it was explained earlier, the supply chains performance is assessed based on several factors related to sustainability practice. Following the performance assessment, the supply chains are provided with feedback to enable them to identify their area of strength and weaknesses. Feedbacks was noted to be provided both formally and informally. Formally is done through regular site meeting, early morning whiteboard meetings, and weekly progress meetings. While informally, is done through general discussion on site.

Furthermore, with regards to providing support to supply chains that are struggling, one of the respondents mentioned that supporting supply chains is part of the policy procedures and culture. The respondent explained that in supporting any struggling sub-contractor, they first approach the sub-contractor and review their program and suggest areas for improvement. The Commercial Manager sharing his experience revealed that there was a situation that a sub-contractor was not producing the required output. So, what they did was to get involved and review his work plan and then produced a motion study and a presentation was organised to help the sub-contractor improve their performance. Supporting supply chains by main contracting firms have been noted to have a significant contributions to the economic and environmental performance of an organisation (Hardie, 2010).

Additionally, the respondents explained that apart from helping the sub-contractors with their performance, pieces of training were organised for the supply chains. Also, the

respondent noted that the main contractor benefits from the knowledge of their supply chains. The training organised by the main contracting team was focused on providing updates on regulations, educating the supply chains on the various specifications and the project and company requirements. The respondents believed that having a close collaboration with their supply chains was another form of learning and training. The Contracts Manager explained:

"We do this by asking the right questions, by informing them of current and up-to-date regulations, for example, by advising them on the specifications that we need to achieve and given them client requirements. Also, like if we get them to look at something that we did not look at before. For example, the timber cladding we brought how durable is it going to be? Where is it to come from? The certifications of the product? all this of a kind stuff."

Expressing their satisfaction with the collaboration and training received from the main contractor's team, one of the sub-contractors (Timber Frame Sub-Contractor) revealed that it was a learning curve for their company. This is because it was their first time working on a massive project and for a tier one main contractor. The level of satisfaction of the sub-contractor is consistent with the findings of Noorizadeh et al., (2018), that supply chains will always want to improve their social capital by working for big firms. In addition, the Timber Frame Sub-Contractor explained that Contracts Manager was quite supportive by going through their plan and resources to identify areas of improvement and other construction methodology.

"The contracts manager will go through our plan and resources and would identify any sort of clashes. He will go through the program in details and then tell us areas of improvement, like in terms of location of our crane, lorries, and storage. Also, in terms of coordinating deliveries to avoid congestion on site.

Good job coordination and it also helps our development as a company".

Additionally, with regards to the disposition of sub-contractors in accepting innovative strategies, the respondents explained that some sub-contractors were open, but some were always very resistance to accept changes. Therefore, what that project team did was that if a sub-contractor is noticed to be struggling the contracts manager will always come to their aid by reviewing what they are doing and proffering better solutions or methods. Finally, with regards to rewards and incentives, the respondents explained that the project team provided different rewards and incentives to the site team. Also, there is always a general supply chain award ceremony organised by the head office annually. They explained that the project team provided awards to the local operatives on site, which was based on performance and safety compliance. Such an award was carried out every month, and a scoring system like a league table was provided, and vouchers or some form of recognition were provided to the direct operatives. The Contracts Manager further explained that the supply chains benefit from future projects with the company, and to motivate them early payments was ensured.

"We would have rewards for our local operatives on-site, and there would be a site league which is around performance and safety compliance, so that is every month there is a scoring system there. We had local rules we would often give vouchers or some feedback or recognition to the direct operatives on site.

While for supply chains we try to reward, but the ultimate reward is that they

are in a position where they went, they make money on the first job, or where the next job comes around, they are in a better position".

However, from the subcontractor's point of view, they considered participating in such a project as a big opportunity for their company, and a way of improving their profile. The Timber Frame Sub-Contractor noted that they learned a lot, and it was an award-winning project where they received some very good recommendations.

"It was a very interesting project. The whole experience gained was very helpful. We got some good recommendation, and the project was recognised, which I believe it is a privilege to our company to be part of the project".

On the other hand, the Façade Sub-Contractor expressed fulfilment in participating and delivering the project and the pleasure of having to be allowed to spend three nights in the accommodation and having a meal with the CEO of the client organisation.

"As a sub-contractor, we are very proud we have worn in the first place, and we were proud that it was delivered on time. I was at the contractors night I got to stay at one of the lodges for three nights which was lovely, and the client brought the contractors out we had a lovely meal with the CEO at night, and you know, I enjoyed it, and we mixed with all the lads".

Overall, the main contractors were asked whether the adoption of sustainable procurement practice had an impact on the project cost. The respondents stated that there was a little bit of increase in the cost of the project as it would have been expected. This because of some of the variations in some of the products which were a bit high.

Nevertheless, the Commercial Manager revealed that even though the products were expensive, but they were of high quality. Also, currently, there seems not to have many defects in the buildings, and snagging issues tend to be less.

"I would say that the initial cost was probably maybe possibly a little bit higher than you would expect. Sometimes I know certain product costs a little bit more, but in the long run, we do not have many defects. We are nearly almost one year ago finished and handed over, and we seem to have fewer snagging issues. This is because we used quality products, and we had our samples sign quite on time. We believed that helped not to have many issues".

In summary, the findings revealed that different strategies and approaches were used during the project to collaborate with the supply chains to adopt sustainable construction practice. Also, the findings demonstrate how collaboration and managerial capabilities led to the successful execution of the project. The last organisational resources examined was the organisation's physical capital resources, which is reported in the next section. It focuses on digital technology tools and resources.

6.3.3 Utilisation of Digital Technologies

How digital technology tools and resources were utilised, the benefits and the potential areas of improvement was critically examined and reported in this section.

The findings revealed that different digital technologies and resources were utilised during the delivery of the project from the planning to the delivery phase. The respondents revealed that BIM application and 4D technology was used for pre-planning activities. In comparison, the asta technology program was used in developing and

managing the work program. Other technologies utilised were the field view application for monitoring activities on site, and the viewpoint (4P) project platform was used for sharing of drawings and other relevant documents. Most of the applications were beneficial to the site team, as revealed by the respondents. This is because their operatives were able to use their phones or iPads for updating the progress of work on-site and feeding it into the master program.

Although the findings showed that digital technology tools and resources are mostly utilised for site operations, but some of the benefits like time reduction, wastage, and paper reduction are related to sustainability practice. However, with the current practice, the firm could only experience a competitive parity because such strategies in using digital technology are simultaneously implemented by other construction-contracting firms (Mata et al., 1995). Therefore, to enhance their sustainability performance firms will have to develop strategies that will enhance the availability of data and disclosing their sustainability performance to the public and their clients (Kibert, 2007; Myers, 2005).

Furthermore, some of the benefits of utilising digital technologies as identified by the respondents was in carrying out quality assessment and quality control (QA/QC). The main contractor's team further explained that the adoption of digital technology during the project was quite unusual and new, but the operatives were able to keep good control of the program of the project. But due to the size and nature of the project, it was impractical for the program of work to be updated by a single planner walking around the site that covers an area of about 400 acres with thousands of papers. The Contracts Manager explained that digital technology tools helped in coordinating and monitoring the plan, which made it possible not to use any paper.

"So that kept very good control on the program, and which was new and pretty unusual. Program updates are normally done by a planner where you walk a site but to walk a 400-acre site with a four thousand bar program that was impractical. So, we used technology for it, also for quality control; all our inspections were all done digitally; there were no paper inspections whatsoever. This was hugely advantageous, and all our checking auditing, environmental audits, safety audits were done digitally".

Secondly, revealing the disposition of the supply chains in the adoption and utilisation of digital technologies, the respondents explained that the use of digital technology is part of the pre-appointment requirements. Also, the explained that all the sub-contractors needed to have and use an iPad throughout the project duration. Such a positive attitude from the supply chains as argued by Iles and Ryall (2016) is likely to be related to the clear definition and demands of the project provided by the project team. However, the respondents explained that the positive attitude was developed by educating the supply chains on the benefits of using digital technology. This was done by organising pieces of training and demonstration exercise on the use of the various applications. A sub-contractor (Timber Frame Sub-Contractor) acknowledging the benefits of adopting digital technologies during the project said the exercise was quite innovative that enhanced communication and provided a regular update on any development on site.

"Such innovation was very good, and it enhances better communication between all parties and how quickly the communication information will travel and be available to all. You can keep an eye for any sort of changes. We found it very good and very useful".

Besides, the Façade Sub-Contractor expressed that the BIM technology was quite useful in the mechanical and electrical aspect of the project, he explained that the technology helped in snagging and reviewing drawings. Also, the technology was found to be cost-effective and made many activities easier. However, the Timber Frame Sub-Contractor clarified that their organisation has been up to date in the adoption and utilisation of digital technology. The Sub-Contractor explained that their organisation uses different tools and packages for planning their projects and waste management procedure.

"From our perspective, we would have used Microsoft Project in the actual program. We use a software called HSP chart that was able to generate all of materials waste, and we were able to record all the waste generated".

Finally, with regards to the potential area that digital technologies could be utilised in promoting sustainable procurement was examined. The respondent suggested that there is a need to develop a central database storage system that could provide access to real-time information. Such information will be on carbon footprints of materials and logistics. Also, they noted that waste is the enemy of the construction industry. Therefore, utilising digital technologies to generate accurate measurements and linked to the construction program, will create a huge benefit to the firm. Furthermore, doing that will enable team members to know the materials and vital activities to be carried out at each stage of the project.

6.4 Chapter Summary

This chapter builds on the findings of Chapter Six, where sustainable procurement practice was examined at the organisational level. This chapter reported findings from the project level, where two iconic and award-winning projects were studied. The findings showed that there is a high level of understanding amongst the main contractor's team with regards to understanding sustainability issues. Also, irrespective of the project characteristics and the procurement methods, the main contractor's team have developed several strategies for training and educating their workers. In addition, the findings revealed that in planning for projects, the main contracting firm ensured that, all government laws and regulations are properly addressed. Equally, strategies for engaging external stakeholders are equally developed. The firm was also found to collaborate very closely with its client's in addressing and understanding their requirements. In helping to address the client's requirement, suggestions on alternative materials and construction were made by the project team. With regards to influencing supply chains, the findings showed how different strategies and methods were used on the two projects studied. Also, most of the supply chains engaged had long years of business relationship with the main contractor. However, it was evident that close collaboration and early engagement of supply chains is critical to the success of the projects. Also, the findings further revealed that the supplier's development mechanism has a positive impact on the performance of the supply chains. With regards to the reward system on performance, it was found out that supply chains see rewards more as been involved in the project than receiving an award. The performance of the supply chains was found to be negatively impacted by government policies during the project. Lastly, the adoption and utilisation of digital technology tools and resources were found to be beneficial on all the projects. Also, the supply chains had to be convinced in adopting and utilising digital technology tools. The respondents identified potential areas that could be developed using digital

technologies to improved sustainable procurement, such as developing a central database, calculating carbon footprint, energy analysis and waste management system. Last, the findings found that the client also has a great impact in promoting collaboration and sustainable procurement.

CHAPTER 7

DISCUSSION OF FINDINGS

7.0 Introduction

This chapter discusses the overall findings of the study. The findings in chapters five, six, and seven are critically appraised in relation to the central research question and the research objectives of the study. The central research question seeks to address how Irish-construction-contracting firms embed sustainability in their procurement practices. Sub-research questions and objectives were developed to provide a comprehensive understanding of the research problem. The chapter is divided into five different sections that address each of the sub-research questions and objectives. The first two sections (7.1 and 7.2) address research question one and objective two of the study that evaluates the current level/performance of sustainable procurement in Irish construction firms. The third section (7.3) answers sub-research question two and objective three of the study. The section (7.3) addresses the question on how main-construction contracting firms motivate their supply chains in driving sustainability practice. While the fourth section (7.4) addresses sub-research question three and objective four. The section unveils the current level and potentials of utilising digital technologies in promoting sustainable procurement practice by contracting firms. The implication of the study (7.5) and the chapter summary (8.6) is also presented.

7.1 Strategy Development

In seeking to gain competitive advantage, organisations and businesses have developed different strategies. In the AEC sector, it has been noted that top construction firms have changed the way they operate based on new strategies developed (Berry & McCarthy, 2011). Also, construction firms have placed sustainable procurement as a primary focus in their firms' organisational policies (Bratt et al., 2013).

The findings from the survey showed that organisational sustainability policies are developed from the top management down to employees; it is also developed bottom-up from employees to top management. The survey results were further supported by the findings from the interviews at the organisational level. At that level, it was found that the policies were developed by top management down to the employees and are regularly review by obtaining feedback from workers of the company to the top management. Furthermore, there appears to be a high level of compliance amongst the firms with regards to implementing their organisation's sustainability policies. From the case study carried out, it was evident that the organisation's sustainability policies guide their procurement process at both the organisational and project levels. Although, the findings in chapter five revealed that there is a no significant relationship between the implementation of sustainable procurement policies and the size of the firm or nature of work carried out. The lack of relationship could suggest that the implementation of sustainable procurement varies according to firms (Boyd & Schweber, 2012; Zuo et al., 2012).

Furthermore, with regards to compliance and development of sustainable procurement policies, the academic literature is not clear on how such policies are implemented and how they lead to the firms gaining a sustained competitive advantage in the AEC sector. Although, earlier studies by Meehan and Bryde (2011) revealed that organisations sustainability policies were rarely reflected in their sustainable procurement practice. Nevertheless, the findings by Meehan and Bryde (2011) were focused on social housing development in the UK, and the study was a survey-based approach using a sample size of forty-four, which could be limited. Therefore, this study unveiled that sustainable procurement policies of large construction firms were developed to be flexible and addresses both internal and external factors. The findings from the case study showed that the organisation's sustainable procurement policies guide the workers in the

planning and procurement processes. Also, different strategies have been developed by the firm to guide the implementation of their sustainable procurement policies. Such strategies focus on developing their human resources, supply chains, and addressing government, and external stakeholder's requirements. Barney (1991) argued that developing such strategies is what could drive a firm to gain a sustained competitive advantage. In addition, the results support other studies that show that firms that align their organisational policies to their workers' values tend to improve their sustainability performance (Eilers et al., 2016; Meehan & Bryde, 2011; Opoku et al., 2015; Qi et al., 2010; Rickaby & Glass, 2017).

Additionally, further findings with regards to the impact of the factors that promote sustainable procurement practices by firms showed that time, corporate governance, markets, and values tend to be the main drivers. While partnership, transparency, and life-cycle technology ranked 5th, 6th, and 7th, although all the factors obtained a high relative importance index (RII) above 0.7. This result is an indication that all the seven factors identified by Elkington (1997), is having an impact on promoting sustainable procurement. However, the results tend to agree with earlier studies that, most firms are likely to focus on practices that will enable them to seek legitimacy and competitive advantage than adopting sustainable construction (Rietbergen et al., 2015; Russell et al., 2018; Upstill-Goddard et al., 2015). This is because the top factors ranked by the respondents focused more on gaining competitive advantage and legitimacy rather than disclosing their sustainability performance. The sustainability performance of the firm is dependent on the ability of the firm to demonstrate and disclose to their sustainability practices to their clients and external stakeholder's (Kibert, 2007; Myers, 2005). Although it is possible that the position of the respondents influenced these results because they are working in the main contractor's organisation. Likewise, the position of the main contractor in the construction process, where their involvement in the design

process are limited. Another possible explanation for the low ranking of transparency and life-cycle technology might be that the organisation's strategy might be at odds with retaining its competitive advantage in the pursuit of profit (Glover et al., 2014). The findings from the interviews and literature showed that the client and their design team are the major drivers influencing the adoption of sustainable construction practice. Therefore, in terms of disclosing of sustainability practices and performing life-cycle analysis, the respondents were of the view that the client could drive it. However, there were positive indications that construction contracting firms could develop strategies in disclosing their sustainability practices and carrying out life-cycle analysis. Nonetheless, findings revealed that the firm had implemented some strategies of voluntarily disclosing their sustainability practices by registering their projects with the Considerate Constructors Scheme. Also, at the project level different mechanisms were adopted in engaging and educating the external stakeholders.

Another interesting finding from the interviews was that government laws and regulations are likely to influence the sustainability performance of construction firms. It was noted that the firm developed innovative practices at both organisational and project levels in complying with government regulations. An example of government regulations was the directive issued by the UK government that all companies listed in the London Stock Exchange to report their carbon footprint in their annual reports (Dadhich et al., 2015). Although, comparing sustainability practice of manufacturing sector and the AEC sector might not be helpful, but lessons and knowledge could be gained from other sectors (Tennant & Fernie, 2014). Construction-contracting firms in disclosing their sustainability practices are enabled to communicate their performance, develop a reputation for responsible behaviour and to gain a competitive advantage (Glass, 2012). Such competitive advantage could be gained through effective and continuous utilisation of organisational resources which will make it difficult for

competitors to understand and imitate the strategies (Barney, 1991; Hart, 1995; Ruivo et al., 2015).

In general, therefore, it is evident that large construction-contracting firms sustainability policies align with their workers' values and external factors. Also, the case study showed that the firm developed a mechanism for opening their practices to public scrutiny by registering with the Considerate Constructors' Scheme. However, construction firms need to do more in disclosing their sustainability practices (RobecoSAM, 2019). It is therefore plausible from the results that disclosing of sustainability performance by firms as shown in Figure 44, will be dependent on the type of client, nature of the firm, the role of the firm in the design process, profit, and government laws and regulations.

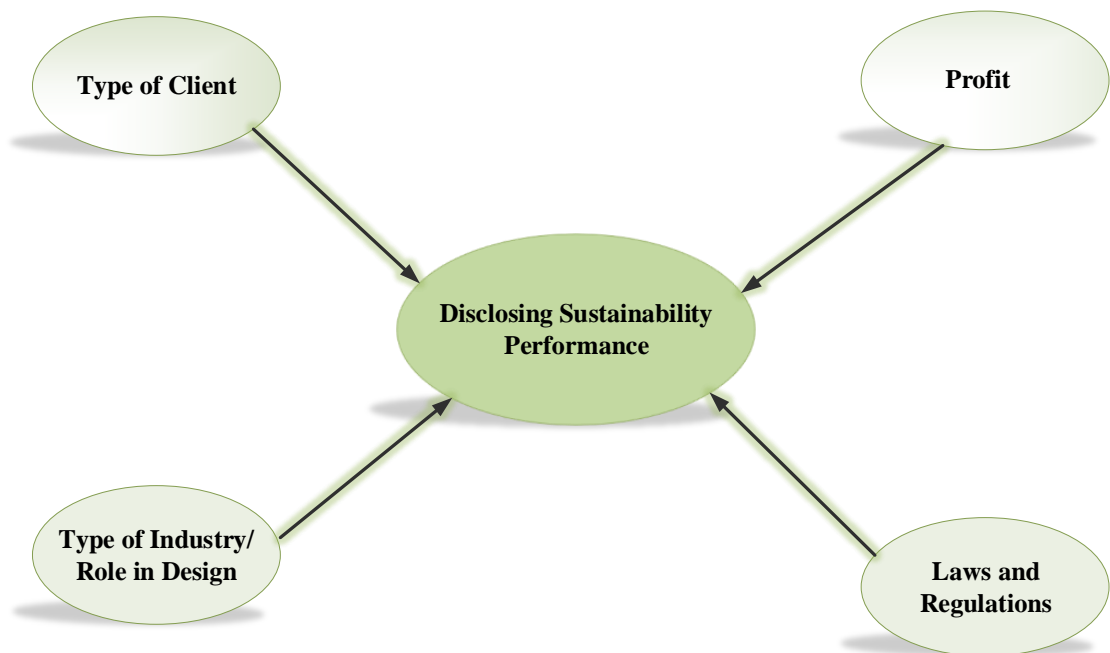


Figure 44: Drivers to Disclosing Sustainability Performance

This section discussed the findings with regards to the development of strategies, which shows the level of compliance in the implementation of an organisation's sustainability policies in promoting procurement practice. It shows that the policies align with the various organisational resources. Therefore, how the firms utilise these organisational

resources is discussed in the subsequent sections. The next section discusses how the human capital resources are utilised in promoting sustainable procurement.

7.2 Sustainable Construction Practice and Implementation within the Firm

The firms' human resources are key in driving and implementing sustainable procurement practice (Terouhid & Ries, 2016). Therefore, to understand how large construction-contracting firms utilised their human resources, the level of collaboration is discussed. The level of collaboration on how information is shared and communicated within the various units and amongst teams. The level of collaboration is discussed in three parts. The first part discussed how collaboration is carried out within staff in the firm, and the second part discussed how the workers in the firm address government and the external stakeholders' requirements. The third part discussed how the firm addresses the client's requirements and demands.

7.2.1 Collaboration within the firm

The findings from both the survey and interviews found out that large construction-contracting firms invest in their human capital resources. The results of the importance-performance analysis (IPA) showed that large construction-contracting firms invest well in developing their core capabilities. Apart from item C1 (improving communication system through information technology) that requires improvement, all other areas are “keep up the good work” or “low priority”. The IPA results agree with the case studies carried out at both the organisational and project level. The interviews revealed how important the firm placed in the training and recruitment of experienced staff. Also, it was noted that the company staff are conversant with the sustainability policies and management procedures of the organisation, for instance, with issues of unethical practices. The finding of the study complement earlier studies on the level of understanding of practitioners with regards to sustainable construction practice (Adetunji et al., 2003; Akotia et al., 2016; Chang, Zuo, et al., 2016; Higham et al., 2016; Opoku & Ahmed, 2013). This study was able to demonstrate that large construction-contracting

firms have developed strategies for educating and training their workers in the adoption and implementation of sustainable procurement. This finding agrees with the works of Loosemore (2017), and To et al. (2015), that states that firms that pay attention to sustainability practice are expected to improve their image and attract talented persons. Equally, the firm will enjoy employee loyalty and gain a competitive advantage while improving its relationship with the society (Lim & Loosemore, 2017; To et al., 2015).

Furthermore, Terouhid and Ries (2016) explained that workers capabilities are critical resources that play a vital role in the attainment of sustainability goals in construction firms. A possible explanation of the performance level of large construction-contracting firms might be due to their social complexity. The social complexity relates to the interpersonal relationship among managers in the firm, the firm's culture, the reputation of the firm among suppliers, and the customers of the firm (Barney, 1991). Such core capabilities are the product of long organisational learning and cannot be easily imitated, therefore constitutes a source of competitive advantage to the firm (Barton, 1995).

Furthermore, with regards to the human resource factors that are of low priority to the firms, the unique historical condition of the firms might be attributed to such a score. Barney (1991) argued that the unique historical circumstances of the firm enabled them in developing different strategies, and it is an important determinant for their long term performance. Therefore, employee reward system (C2), employee empowerment (C3), and inter-firm collaboration (C6) have been found in the interviews to be a norm in the company operations. Also, the findings revealed that the company had developed a long-term relationship with their supply chains. Factors of low priority represent no threats to the organisation; nevertheless, the manager could think about the option of transferring resources from these elements to those requiring urgent action (Ormanovic et al., 2017). Even though, the results on inter-firm collaboration must be interpreted with caution, because inter-firm collaboration in the AEC sector has been observed to be characterised

with structural dominance and power regime (Adetunji et al., 2008). Such structural dominance influences the behaviour of the supply chains because of the regularity of work that they will be expecting from the main contracting firm.

However, the results of this study further indicate that collaboration amongst the teams in the organisation (S10) are a possible waste of resources. The case study revealed that communication and sharing of information at both the organisational and project levels was quite challenging in the company. In other words, exchanging information from the head office to the site team, and exchanging information within the various units in the company was challenging. These challenges could likely be one of the reasons attributed for the low sustainability performance of the AEC sector (Linesight, 2018b; McKinsey Global Institute, 2017; Russell et al., 2018; World Economic Forum, 2016b). Effective planning and delivering sustainable projects require a high level of teamwork and effective communication (Demaid & Quintas, 2006; Fellows, 2006).

Additionally, it is therefore likely that the low level of information exchange also contributes to the low performance in undertaking post-project evaluation and review. However, post-project evaluation and review fall under supplemental capabilities that support the core capabilities in driving an organisation's competitive advantage. Therefore, the disclosure of a firm's sustainability performance will require the exchange and sharing of information amongst the team within the organisation. The findings from the interviews revealed that the disclosing of sustainability performance at the planning and completion stage of a project could be an advantage to the firm. However, as it was stated in section 8.1 above that disclosing of sustainability performance by the firm was voluntarily carried out, and the considerate constructor's scheme assesses only project performance, which could be limited. Hence, for a firm to derive a competitive advantage Elkington (1997) suggested that the need to move from the old paradigm of a closed system to a new paradigm of being open.

To further discuss and understand how construction-contracting firm utilizes its human capital resources, the next section discusses how the workers address government and external stakeholders' requirements.

7.2.2 Implementing Government and External Stakeholders Requirements

In addressing the government and external stakeholders' requirements, the case study results found out that the firm developed different strategies and mechanisms. Such strategies were seen in addressing environmental requirements like noise, air pollution, waste management and engaging and educating the external stakeholders. The survey results confirmed the case study findings by showing the importance-performance of complying with sustainability legislation, and stakeholder's engagement as excellent. Further findings from the case study revealed that the company's sustainability policies are developed to align with government and external stakeholder's requirements. These findings agree with earlier studies that understanding the statutory laws and regulations could be drivers in promoting sustainable procurement in the AEC sector (Bohari et al., 2016; Chang, Soebarto, et al., 2016; Yusof et al., 2016). Also, the level of relationship between the project team and the external stakeholders to a project determines its success (Liang et al., 2017). However, the company workers are conversant with the government regulations and the need for educating their external stakeholders' in a project.

Nevertheless, there seems to be a limitation about the level at which the firm educates its external stakeholders and in demonstrating how they comply with government regulations and laws. As mentioned earlier, and as supported by the literature, the disclosing of sustainability requirements by the construction firm is carried out voluntarily. The low level of disclosing sustainability performance by firms could likely be the reason why the effectiveness and impacts of the regulations in most of the European states in driving sustainability are found to be inadequate (Meacham, 2016;

Rosenow et al., 2016; Visscher et al., 2016). Therefore, for any significant contribution to be made by the AEC sector in driving sustainability, there is the need for the sector to adopt a holistic approach that will demonstrate their sustainability practice (Fellows, 2006).

Another important finding from the study was that in complying with government and external stakeholders' requirements, the firm was found to adopt innovative strategies. One of such strategies was collaborating with the Construction Industry Federation (CIF) in the training of their workers on issues of sustainability. Similarly, the importance-performance analysis results showed that there is a need for improvement by firms in collaborating with international bodies. Other areas that are likely to enhance the sustainability performance of the firms were rated as low priority. It is important to note that developing strategies by firms for collaboration with various bodies lead to enabling capabilities. Enabling capabilities are those that are important to a company as a minimum basis for competition in the industry but, by themselves convey no competitive advantage (Barton, 1995). Complying with sustainability legislation and stakeholder's engagement are supplemental capabilities. These capabilities (supplemental), are those that add value to core capabilities but not enough in themselves to distinguish a company competitively (Barton, 1995). Therefore, it is possible to hypothesise that government regulations and laws and collaborating with external stakeholders by construction firms are likely to motivate construction firms in disclosing their sustainability performance. This is because for a firm to derive a competitive advantage, there is the need to move from the old paradigm of a closed system to a new paradigm of being open (Elkington, 1997; Myers, 2005).

Additionally, another possible reason that might be attributed to the score on the enabling capabilities could be due to the role of the various respondents that participated in the study. In chapter five, 33% of the respondents are directors, while 67% are at the

managerial level, which is operational based. The discrepancy in the response rate might probably lead to some biases. Also, decisions with regards to external collaborations and other enabling capabilities might be at the corporate level with little participation from the managerial cadre. This is because driving sustainability from the findings in the study emanates from the top to down.

Similarly, the findings were supported by Opoku et al. (2015) and Kannan (2021) that organisational leadership impacts the implementation of sustainability practices in an organisation by providing the necessary training, policies and awareness. Similarly, developing a high level of interaction with workers and providing the right leadership improves the sustainability performance of construction firms (Kannan, 2021; Korkmaz & Singh, 2011). Therefore, top management in construction firms need to develop strategies that could enable them to communicate their sustainability plans and strategies. This is necessary because it will be of no importance if a firm's adoption of sustainability practices at the corporate level is not entirely infused into the entire organisation and its process (Schulz & Flanigan, 2016). These strategies could be driven through organisational learning by undertaking a post-project review and post-occupancy evaluation (Opoku & Fortune, 2011). Anbari et al. (2008), noted that post-project reviews are a vehicle for continual learning and improvement in organisations.

The last aspect of understanding the utilisation of organisational human resources is the implementation of the client's requirements. The discussion focuses on how the contactor's team collaborate with the client and his/her team.

7.2.3 Collaborating and Implementing Client's Requirements

Addressing project and client requirements has been found, from the results of the survey, to be of high importance along with the level of performance of the firm. Project

and client's requirements are categorised under supplemental capabilities in the Principal Component Analysis (PCA) result. What this explains is that understanding and implementing project and client's requirements enhances the competitive advantage of a firm. This is because supplemental capabilities add value to core capabilities even though it can be imitated by rival firms (Barton, 1995). Therefore, there is the need for construction firms to be innovative and collaborate closely with their clients in the delivering of sustainable projects (Adetunji et al., 2003; Bohari et al., 2016; Boyd & Schweber, 2012; Chang, Zuo, et al., 2016; Dodge Data & Analytics, 2016). One interesting finding from the interviews was that in collaborating with their clients, the construction firm categorized their clients according to their needs and expectations. Although the survey findings revealed that the level of clarity concerning the client requirements on sustainability varies.

Nevertheless, the case study found that the construction firm developed various strategies in addressing and collaborating with their clients. Understanding the nature and type of client is one of the major drivers that aid firms in meeting their requirements and demands (Boyd & Chinyio, 2008; Newcombe, 2003). Some of the strategies that were found include suggesting alternative materials, proposing alternative construction methods and the early engagement of their supply chains. Besides, the case study further revealed that despite the client requirements as drivers for sustainable procurement, the project team are mindful of their company management procedure. So, they ensured that due diligence is carried out on recommended supply chains by the client. Also, depending on the procurement method, the contracting firm suggests alternative design and construction solutions. It is indicative from the findings of the case study that the construction firm studied exerted some level of influence in the design and construction process. A possible explanation for such an influence might be probably due to their long years in the construction business that have enabled them to gain experience, and a very

good image and relationship with the construction clients. Barney (1991) explained that early entrants or the unique historical condition of a firm are an important determinant to the long term performance of a firm. A second reason could be due to the firm's financial turnover because firms with higher financial turnover are willing to invest in more innovative practices (Adetunji et al., 2003; Boyd & Schweber, 2012; Chang, Zuo, et al., 2016; Upstill-Goddard et al., 2016). Such practices enhance their corporate image and provide an opportunity for gaining a competitive advantage (Barney, 1991; Hart, 1995). The last possible reason might be due to the level of involvement and roles of practitioners during the planning and execution of the project. Akotia et al. (2017) explained that the role of practitioners in a sustainable project is defined by the project requirements, type of project organisations, type of contract and procurement method. Therefore, collaborating and implementing client's requirements as shown in figure 45, could likely be dependent on the type of client, years of business of the firm, financial turnover, and level of involvement in the design and construction process.

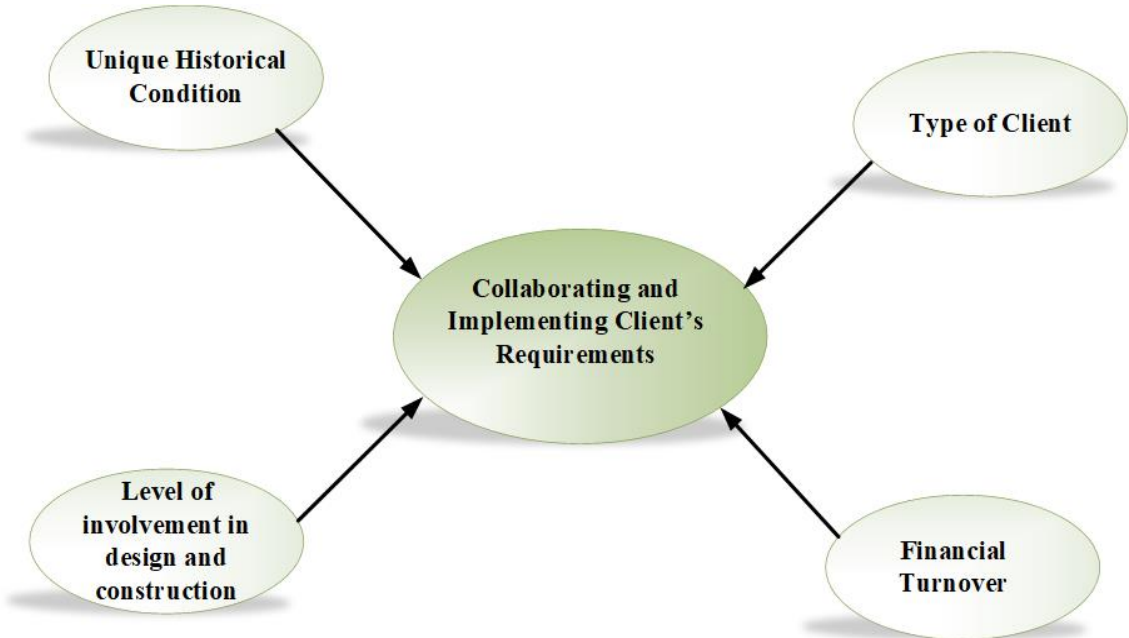


Figure 45: Collaborating and Implementing Client's Requirements

Although it is often difficult to unfold some of the strategies adopted by large firms in gaining a competitive advantage, however, there are often lessons that could be learned (Barney, 1991; Hart, 1995). Such lessons on how large contracting firms utilise their organisational resources could be beneficial to other firms because their performance and practices are often regarded as the benchmark of the learning model for other firms (Chang, Zuo, et al., 2016).

Overall, this section addresses the research question one and four and unveils how large construction firms utilise organisational human resources. Furthermore, the findings and discussions suggest that the utilisation of human capital resources in an organisation as shown in Figure 46, is dependent on collaboration and sharing of information within the team members and different units in a firm. Secondly, it is also dependent on the workers understanding of the statutory government laws and regulations. Lastly, workers understanding in implementing and addressing the client requirements are essential in the success of delivering a sustainable project.

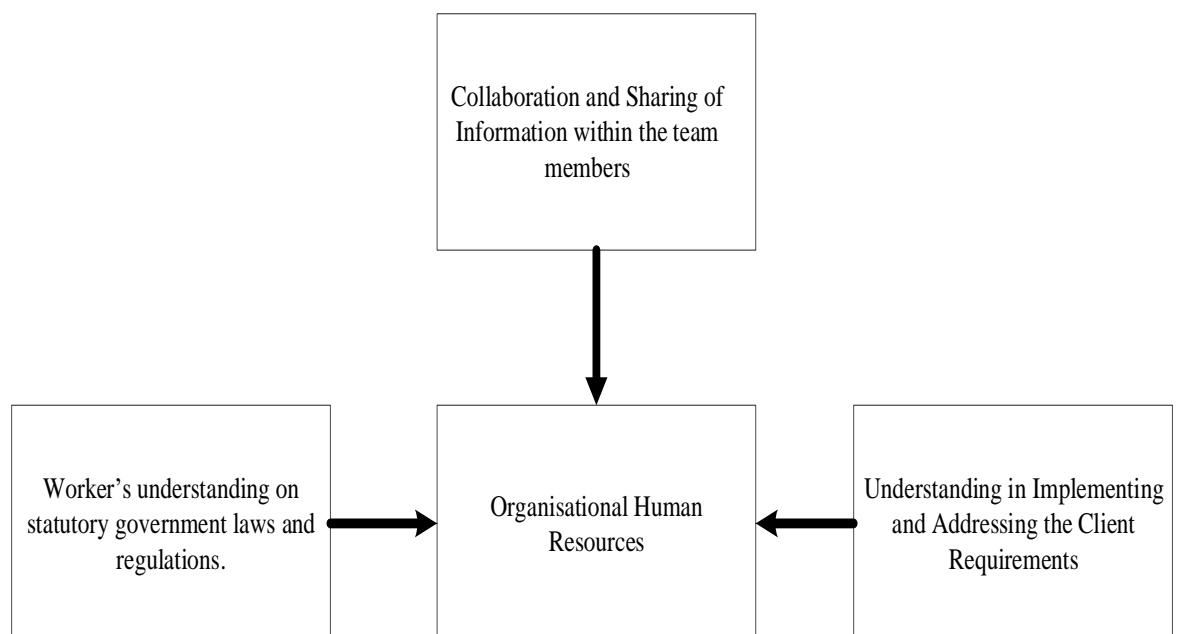


Figure 46: Utilisation of Organisational Human Resources

This section discussed and addressed research question one and four, the next section discusses findings that will address research question three. Research question three seeks to understand how the main contracting firm influences their supply chains in the adoption of sustainable construction practice.

7.3 Supply Chain Management Practice

This section addresses the second research question and further discusses research question four on government impact in adopting and implementing sustainable procurement. As discussed in the literature, main contracting firms depend on their supply chains in the delivery of their projects (London, 2008; Oyegoke et al., 2010). Such dependency has made the main contractor take responsibility for the behaviour of their supply chains (Lin & Tseng, 2016; Sancha, Gimenez, et al., 2016; Wu & Barnes, 2016). The supply chain organisations, as part of the main contractor's resources, is considered in this study as the organisational capital resources. How the main contractors relate with their supply chains in adopting and implementing sustainable construction is critically discussed. To have an in-depth understanding of addressing the research question, the discussion is divided into three sub-sections. The first section sets the foundation by discussing sustainable supply chain management. The second section discusses how a long-term relationship influences the adoption of sustainable procurement. The last part discusses supply chain improvement mechanism and how it helps in promoting sustainable construction practice in a project.

7.3.1 Sustainable Supply Chain Management Practice

In driving sustainable procurement practice, the results from the survey showed that sustainability criteria are of importance in the selection of supply chains by the main contracting firms. Such selection, as revealed during the interviews, was based on the supply chains meeting the firm's sustainability criteria and requirements. However, a contrary view was noted that the selection of a supply chain is normally reactive to the existing legislation and laws; therefore, the selection will be more on performance and price based. Engagement based on price and performance was experienced in Project A, where the sub-contractors revealed that even though they were engaged early, the focus

was more on cost than buildability. Therefore, there could be two possible explanations for this result with regards to the selection criteria. First, it could be assumed that sustainability is self-driven by sub-contractors based on their size and nature of work undertaking, as reported in the findings in Chapters six and seven. Therefore, the main contracting firm will be more concerned about cost and performance. This assertion is consistent with earlier findings that sustainability in an organisation is mostly self-driven than the imposition of laws or regulations (Rietbergen et al., 2015; Russell et al., 2018; Upstill-Goddard et al., 2015). At the same time, the second assumption could be that the sustainability criteria in the selection requirements of supply chains in an organisation have less influence in the overall scoring system. This assumption is similar to the study by Rietbergen et al. (2015), and Upstill-Goddard et al. (2015), with regards to the implementation of sustainability practice. Therefore, it is possible to assume that organisation's intention in developing a sustainability strategy might be at odds with retaining its competitive advantage in the pursuit of profit (Glover et al., 2014). This is because driving sustainability provides a rare opportunity to create value or profit at the short-term (Adetunji et al., 2008).

Another interesting finding from the case study was that collaboration with supply chains is primarily determined by the type of procurement method, type and nature of the project, and the client's influence. The results from the survey showed that supply chains are engaged in different phases when planning for a project. The findings on the client's influence agree with the result of Briscoe et al. (2004), that construction clients are key drivers in achieving integration in the supply chain. The influence of the client was seen in the procurement of materials and certain trade sub-contractors in the two completed projects studied. Furthermore, with regards to the method of procurement, the findings agree with earlier studies, that in the delivery of a sustainable project, the procurement method adopted enhances team integration and effectiveness in communication (Berry

& McCarthy, 2011; Mollaoglu-Korkmaz et al., 2013; Naoum & Egbu, 2016; Woo et al., 2016). Although Koolwijk et al. (2018), argued that collaboration is developed amongst team irrespective of the procurement method due to the long-term relationship established. However, this study found that long-term relationship has little impact on project performance and that collaboration is driven by close engagement, leadership, and structural dominance. The close engagement and collaboration experienced in Project B enabled the main contractor's team to realise that, due to the large nature of the project, the supply chains do not have the financial capacity to supply all the materials required. Also, with regards to structural dominance, this agrees with the work of Adetunji et al. (2008) that, inter-firm collaboration in the supply chain network in driving sustainability, is characterised by structural dominance and power regime. Also, close engagement within the team enables the firm to exert some influence over the supply chain network (Vurro et al., 2009). Hence it could be conceivably hypothesised that project performance is related to the level of collaboration. Collaboration in a supply chain management relationship is built on trust (Koolwijk et al., 2018). Hence, Farmer (2017), suggest that the adoption of a more collaborative working, greater use of non-adversarial procurement and contracting processes, and harnessing performance-related incentives to align interests are key in promoting the performance of the AEC sector.

To further discuss how long-term relationship influences the supply chains in the adoption of sustainability, the next section, 8.3.2 provides a critical analysis and discussion.

7.3.2 Long-Term Relationship

Developing long-term strategies and relationship was found to drive the construction firms studied in the implementation and adoption of sustainability practice, as shown in Table 19 in chapter five. In developing a long-term relationship with its supply chains,

findings from the case study revealed that the company recognises that their success is dependent on their supply chains. Therefore, different strategies were developed to enhance collaboration with their supply chains. However, as noted earlier, that long-term relationship does not guarantee good project performance, but it is evident that it enables the supply chains to understand and align their practices to the main contractor's organisation's policies. Supply chains aligning their practices with the main contractor's sustainability policies and procedures has been found to influence the competitiveness of both the main contractor and that of the supply chains (Chardine-Baumann & Botta-Genoulaz, 2014; Pagell & Wu, 2009). Such competitiveness can be realised through close collaboration, because a well crafted sustainable supply chain management (SSCM), creates value to the construction organisation (Adetunji et al., 2008). In the creation of value, the findings from the case study revealed that in the delivery of projects, most of the supply chains engaged had long years of business relationship with the main contractor's organisation. These findings support the earlier work of Walker et al. (2008), that, the focus of procurement practice has changed from the short-term cost minimisation to long term value creation and delivery. Also, that value creation through procurement is evolutionary and requires long-term collaboration (Walker et al., 2008).

In addition, the survey and interview findings showed that long term relationship is based on equitable relationship and power relationship/structural dominance. Equitable relationship and power relationship/structural dominance, as noted by Adetunji et al. (2008) are the two school of thoughts in the academic literature for the implementation of supply chain management. The findings in Section 5.3 showed that all the factors identified had a relative important index (RII) above 0.7, with the highest RII having a score of 0.93 (Trust). Trust in a supply chain relationship has been found to enhance collaboration (Koolwijk et al., 2018). From the case study carried out, it was observed that the level of collaboration determined the level of trust and commitment in the

delivery of the project. It was noted that in Project B, close collaboration yielded a positive outcome and achieved the desired project objectives. However, collaboration in Project A was more transactional than relational. Also, from the case study it was noted that innovative solutions and practices were developed as a result of close collaboration. The findings with regards to collaboration support earlier studies that governance mechanisms (transactional or relational), collaborative relationships (mandated or collaborative approach), and innovations (improving performance) are drivers in the adoption of sustainability practice amongst supply chains (Govindan et al., 2016; Lin & Tseng, 2016).

Therefore, the results of this study indicate that equitable relationship enhances a long-term relationship. These findings were further proven by the results of the survey that shows a high relative importance index of all the factors related to the equitable relationship. These factors are level of commitment, a common goal and mutual support, effective communication, win-win situation, continuous innovation, sharing of information. Additionally, the findings are consistent with the work of Russell et al. (2018) that promoting shared values aligned with transparency and monitoring is more effective in attaining sustainability goals in the supply chain. However, as stated earlier, that structural dominance determines the level of collaboration. One of the reasons found was that large construction firms are very mindful of their image, and are willing to invest in improving their corporate identity and gaining a competitive advantage (Adetunji et al., 2003; Boyd & Schweber, 2012; Chang, Zuo, et al., 2016; Upstill-Goddard et al., 2016). The RII importance index results in section 5.3, showed that high knowledge of construction process, high purchasing power, the regularity of workload, and internal and external alignment (through coordinated teams and cross-functional integration) were important factors in determining long-term relationship.

The structural dominance and power relationship between the main contractor and their supply chains were found from the case study to focus more on unethical practices, purchasing power, the regularity of work, and opportunities for new entrants. It was observed that the structural dominance position occupied by the main contracting firm enabled them to use their purchasing power and regularity of workload advantage. This enabled them to develop pro-active strategies with regards to their sustainability operations, like unethical practices, and opportunity for new entrants. For instance, it was noted that supply chains are careful not to indulge in any unethical practices like colluding with other supply chains organisation during tendering. The findings showed that because of their long working relationship with the main contractor's firm, they would not want to jeopardise such a relationship. Also, it was observed in Project A, despite the level of dissatisfaction by the sub-contractors, they see such an experience as a learning process rather than a total loss. This is also, a result of the long working relationship with the main contracting firm and are always assured of future projects. Lastly, in becoming more competitive in the industry, the main-contracting firm creates opportunities for new entrants by engaging them in their project, as observed in Project B.

There are two likely explanations with regards to developing a long-term relationship between the supply chains and the main contractor. First, it is possible that supply chains in developing their social capital would want to work with a reputable tier one company. This assumption is consistent with that of Noorizadeh et al., (2018), who explained that supply chains will always want to behave appropriately to ensure regular engagement by the main contractor's firm. Such opportunities, they explained enabled supply chains to develop their social capital and company image. Secondly, it could be assumed that the structural dominance position occupied by the main contracting firm enabled them to use their purchasing power and regularity of workload advantage. For instance, creating an

opportunity for new entrants might give the main contractor the opportunity of widening his alternatives to promote innovation and commitment. Adopting such strategies is possible in a situation where the dependent suppliers pose no threat to the flow of value appropriation and are forced to pass a value to the dominant player (Adetunji et al., 2008; Stannack, 1996).

It is possible to submit that the structural dominance position of the main contracting firm, influences their level of importance and performance placed on the strategies identified in section 5.2.3. The results of the Importance-Performance Analysis showed surety, bonds, and insurance policies, and Industrialised Building Systems (IBS)/Prefabricated building units as low priority. While the partnering with suppliers was scored “Keep UP the good work”, however inter-firm collaboration under core capabilities was scored as low priority. These results might be due to the level of integration which Oyegoke et al. (2010) referred to as social integration. However, the case study at the project level has demonstrated the benefit of inter-firm collaboration. Therefore, competitive advantage can only be sustained in a situation where the capabilities creating the advantage are supported by resources that are not easily duplicated by competitors (Barney, 1991; Hart, 1995). Finally, better sustainability performance could be gained in a collaborative approach (Adenso-Díaz et al., 2008; Brockhaus et al., 2013). So, to further understand how main contracting firms support their supply chains in improving their performance is discussed in the next section.

7.3.3 Supply Chains Improvement Mechanism

In promoting the sustainability performance of their supply chains, large construction firms develop various mechanism and strategies (Abidin & Ingirige, 2018; Meehan & Bryde, 2015; Noorizadeh et al., 2018). From the results of the survey, supplier’s assessment and instigating competition amongst supply chains were scored as the most

often used strategies. While, training of supply chains, providing incentives, and helping in organisational restructuring were ranked third, fourth and fifth. These findings are somewhat surprising, given the fact that the case study revealed a different result. The case study at both the organisational and project level found out that supporting supply chains has become a norm in the company. This was demonstrated through the different approaches adopted in improving the performance of the sub-contractors. This discrepancy could be attributed to the differences in the implementation of sustainability practices by firms as found in the results in section 5.2.1, that relates to compliance with the implementation of an organisation's sustainability policies. The second probable explanation for the discrepancies could be due to the sampling size of the survey, where out of the sixty-two respondents only twenty-one (33%) are at the directors' level, while forty-one (67%) are at the managerial level. The third likely explanation for the low score in organisational restructuring/ investing resources in a supply chain organisation could be due to the shift from the traditional contractor's contractual role. This shift has seen the main contractor from active participation in construction activities to a management role that has made them dependent on the various supply chains (London, 2008; Oyegoke et al., 2014). Therefore, the results from the survey, need to be interpreted with caution, because most of the strategies like training emanate most of the time from the corporate level down to the operational level (Kamann, 2007; Opoku et al., 2015).

However, some interesting findings were revealed in the case study, that improved earlier studies on the lack of clarity on how construction firms implement the various strategies in driving sustainable procurement (Li et al., 2014; Lönngren et al., 2010). The findings revealed that both formal and informal method is used in providing feedback on supply chain assessment. But the informal approach tends to be more effective than the formal. It was evident from the case study that close collaboration with supply chains enabled effective feedback to be provided and training needs identified, which improved the

overall project and supply chains performance. These findings align with the work of Sancha et al. (2016) that assessing supplier practices contributes to improving the main contractor's social performance, while collaborating with them, enhances the suppliers' social performance.

Furthermore, it was revealed that the informal approach was adopted in the training of both supply chains and the company staff, which provided a positive impact and enabled the trust to be built amongst the team members. Such an approach of informal learning enables the collective act of exploration, discovery, and analysis which improve the project objectives and enhances innovation (Hojem et al., 2014). It also enables the incorporation of elements of trust and identifying the benefits of the contracts by the various actors (Sparrevik et al., 2018). Additionally, the findings support earlier studies that poor collaboration leads to lack of trust and denies the parties of the benefits to be gained during the delivery of the project (De Melo & Da Alves, 2010; Upstill-Goddard et al., 2016). With regards to the disposition of the supply chains in embracing new practices and training, the findings revealed that some of the sub-contractors were reactive while some were open. The study found out that the disposition of sub-contractors in accepting innovative practice is primarily determine by the size and availability resources.

Lastly, another interesting finding from the case study was on incentives provided to supply chains for good performance. It was revealed that different strategies like providing recognition awards, an opportunity for future engagement, moving to a higher tier, and ensuring early payments were found to be some of the strategies adopted by the firm. Such strategies, as observed by Krause et al. (2000), increase the level of commitment and level of performance of supply chains. On the other hand, the supply chains apart from the incentives provided, they see it as an opportunity and privilege to work with a tier-one contractor on a flagship project. This opportunity enables them to

improve their social capital and public image while driving a competitive advantage (Noorizadeh et al., 2018; Sancha, Gimenez, et al., 2016). However, despite the incentives and other strategies adopted by the main contracting firm, it was noted that external factors like government regulations and policies like the sectorial employment order (SEO) were threats to the industry. Therefore, close collaboration with supply chains was noted to have averted the impact of the risk on Project B on the availability of labour.

In comparison, it had a negative effect on Project A that led to delay and extra cost on the project. At the organisational level, it was acknowledged that the shortage and availability of supply chains most especially trade sub-contractors is a risk to the company, therefore, the ensure supply chains are treated with respect and are paid early. These results corroborate with the work of Upstill-Goddard et al. (2016) that strong communication channels and commitment to training programmes increase the capacity for implementation of sustainability practice.

In summary, this section revealed that sustainability criteria influence the selection of supply chains and that early engagement and close collaboration with supply chains yields a positive project outcome. Collaboration was found to be influenced by the type of procurement method, type and nature of the project, and client's influence. On the other hand, a long-term relationship was found to have less impact on the project performance, but rather close collaboration, leadership, and structural dominance were found to influence project performance and long-term relationship. The study revealed that different mechanism was used in the assessment and improvement of supply chains. The formal and informal approach was found to be utilised in training and providing feedback to supply chains. The informal approach was found to be quite effective and enhances collaboration. Lastly, different incentives were provided to high performing supply chain organisations. Although participating in the project was found to be more rewarding to the supply chains.

The last organisational resources to be discussed is the organisation's physical capital resources. Digital technology tools and resources are considered in this study as physical capital resources. The next section discusses the findings on the utilisation of digital tools in driving sustainable procurement.

7.4 Utilisation of Digital Technologies

The possession of digital technology tools and resources are considered as part of the organisation's physical asset. How these tools and resources are utilised by main contracting- construction firms in driving sustainable procurement is discussed in this section. The section addresses the research question three and four. The discussion of the findings is divided into two sections, that addresses the current level of adoption of digital technology tools and resources, and the potential area of growth in utilising digital technologies.

7.4.1 The Current Level of Adoption and Utilisation of Digital Technology

The literature review has provided some of the benefits to be gained in the utilisation of digital technology resources in driving sustainable procurement. However, how construction-contracting firms utilise their digital technology tools to driving sustainable procurement is not well understood. The current study found out that digital technology has positively impacted the procurement process of construction-contracting firms in Ireland. Also, its application varies in different areas in the construction process. Findings from the case study confirmed the results of the survey. However, the level of impact in the adoption and utilisation of digital technology seems to vary amongst the firms, because about 34% of the respondents indicated fairly significant and not significant. Such level of differences might be a result of the different level of implementing sustainability practice in firms as discussed earlier in section 8.1 (Boyd & Schweber, 2012; Zuo et al., 2012).

Nevertheless, from the case study at both the organisational and project levels, some of the benefits of utilising digital technology tools and resources were found. Also, it was found out that the adoption and utilisation of digital technology have changed the way the company operates. These findings agree with the Roland Berger consulting report

that the adoption of digital technology is changing the way organisations operate (Roland Berger, 2016). Although it is indicative that the utilisation and possession of digital technology tools and resources added value to the firm's operation, it does not constitute a source of competitive advantage (Barney, 1991; Mata et al., 1995). Such strategies do not constitute a competitive advantage, because it can be simultaneously implemented by other firms and possessing such tools and technology does not place the rival company at a disadvantage in acquiring them. Therefore, competitive advantage is gained when a rival firm cannot easily duplicate the strategies developed by a firm, and the competing firms face significant disadvantages in acquiring the resources necessary to implement the strategy that provides the advantage (Barney, 1991; Mata et al., 1995). The results of the importance-performance analysis in section 5.2.3 showed the need for improvement in information communication technology. The need for improvement in information communication technology (C1) is likely to be related to the poor collaboration amongst the various teams (S10) in the various construction firms. The case study revealed that sharing and communicating of information is quite challenging amongst the different units and teams. So, in deriving value, construction-contracting firms will have to compete and respond to industry-level challenges, exploit relationship capabilities, and understand and respond to customers' needs (Kähkönen & Lintukangas, 2012).

On the question of the level of utilising digital technology in promoting sustainable procurement, the results on Section 5.4.2, showed that all the six activities are mostly carried out only often and sometimes. The result is not surprising, because earlier results and the case study showed that utilisation of digital technology focuses more on planning and site operations, compared to utilising it for disclosing sustainability performance. Also, the survey results from the activities that could promote sustainable procurement like life-cycle costing has a low RII score. The underutilisation of digital technologies as reported by the Mckinsey group that compared to other economic sectors, the AEC sector

is the least digitized (Agarwal et al., 2018). Nonetheless, Mckinsey group noted that the adoption of digital technologies could be beneficial to the AEC sector through an increase in profit and performance (Agarwal et al., 2018). Also, the managerial and technological abilities of a firm are related to the firms' sustainability performance (Li et al., 2013). Therefore, the managerial capabilities of a firm to utilise their digital technologies in promoting sustainable procurement by strategizing how to disclose their sustainability performance can drive the firm's competitive advantage. In developing such a strategy, Barney (1991), suggested that a particular mix of physical capital, human capital, and organisational resources will be required to implement.

Therefore, as mentioned in the literature, that for effective utilisation of digital technology in promoting sustainable procurement, the availability of information and data is vital (Ahmadian et al., 2017; Häkkinen et al., 2015). With the complex set-up of the construction industry, and as earlier explained that the sector is socially integrated, where the main contracting firms rely on their supply chains in the delivery of their projects (London, 2008; Oyegoke et al., 2010). This set-up will require close collaboration of firms in sharing and exchanging of data. The findings from the case study revealed that some supply chains are weak in sharing or providing data. Nevertheless, as it was observed in Project B, close collaboration yielded trust and project performance. Koolwijk et al.(2018), explained that collaboration in a supply chain management relationship is built on trust. On the disposition and level of adoption of digital technologies by supply chains, the results in Section 5.4.1 revealed that 49% Very high/ high, while 48% average, and 3% low. This result may be explained by the fact that the type and size of the supply chain organisation determine their level of adoption of digital technologies as it was noted in the interviews. The findings from the interviews showed that some of the bigger supply chains are already advanced in the

utilisation of digital technologies. Also, it was noted that the nature and size of the project was also a determinant for the adoption of digital technology tools by supply chains.

Therefore, to ensure that their supply chains adopt the use of digital technology tools, it was made a requirement at the pre-appointment. Also, the main-contracting firm took time to educate their supply chains on the need to procure and utilise digital tools. This strategy agrees with earlier studies that main contracting firms have the responsibility of effectively communicating and supporting their supply chains in the adoption of new technologies (London, 2008; Meehan & Bryde, 2011; Upstill-Goddard et al., 2016). However, it was noted from one of the case studies, that not all information shared on the 4P platform to sub-contractors is very important and relevant to them. So, to effectively utilise digital technology tools and resources, the firm needs to develop their managerial capability through an effective process of organising and managing the digital tools in the firm (Mata et al., 1995; Powell & Dent-Micallef, 1997).

There is a potential benefit that can be derived from the AEC sector through the adoption of digital technology (Saieg et al., 2018). Besides, the collaborative working of the industry will be enabled by future generations' acceptance of digital technology (Farmer, 2017). Therefore, to further unveil the potential areas in the utilisation of digital technologies in promoting sustainable procurement, the next section discusses findings on the potential and future area of growth.

7.4.2 Potential and Future Area of Growth

The ability of a firm to disclose their sustainability performance and practice to their clients and stakeholders improves their public image and enhances their competitive advantage (Kibert, 2007; Myers, 2005). From the earlier results discussed in this study, it is evident that there are prospects for improvement in the utilisation of digital technology in promoting sustainable procurement. The relative importance index (RII)

results in Chapter five (Table 31, Section 5.4.2), showed a very high score in all the areas on the level of importance in utilising digital technology in promoting sustainable procurement. Such level of importance was confirmed in the case study, where the respondents believed that disclosing sustainability performance of a project at the planning and completion stage will provide the client with the necessary information about the building. Also, such a strategy will enable the construction firm to disclose to the public and stakeholders about their company sustainability performance. However, the demand and adoption of sustainability in a project are mostly driven by the client (Dewick & Miozzo, 2002; Dodge Data & Analytics, 2016; Du Plessis, 2002). However, the main contracting firm could take advantage of their social complexity or their long history in influencing the client's decisions.

Furthermore, findings from the case study, revealed that developing such a strategy would require additional financial and human resources. Nevertheless, the potential benefits were identified to be enormous. As discussed earlier, the vital resources that will drive such innovation are the managerial capability of the firm. The strategy will be driven by an effective process of organising and managing the digital tools in the firm, which leads to a competitive advantage (Mata et al., 1995; Powell & Dent-Micallef, 1997). The managerial capability will also aid in the adoption of digital technologies by the organisation's supply chains (Papadonikolaki, 2016; Papadonikolaki et al., 2015).

In summary, the findings in this section have shown that there is a significant benefit in the adoption of digital technologies by construction-contracting firms. However, most of the application focuses on planning and site operations with less focus on promoting sustainable procurement by disclosing the firm's sustainability performance. Nevertheless, the adoption of digital and utilisation of digital technologies have impacted on the company operations. Further findings revealed that there are potential benefits in utilising digital technologies to disclosing the firm's sustainability performance.

Overall, the findings in this chapter have important implications for theory, practice, and policy. The implications of this study are presented in the next section.

7.5 Implications and limitation of the findings

This study was set to understand how construction-contracting firms embed sustainability in their procurement process. Findings from the literature showed that sustainability performance in the AEC sector is still low (Russell et al., 2018; World Economic Forum, 2018). Some of the reasons attributed to the low performance are low level of understanding of practitioners (Adetunji et al., 2003; Akotia et al., 2016; Opoku & Ahmed, 2013; Tan et al., 2011); and lack of interest by firms due to benefits to be enjoyed not clearly understood (Mulligan et al., 2014; Ruparathna & Hewage, 2015a; Upstill-Goddard et al., 2016). However, it was noted that the size of the firm (annual financial turn over), client demands, and government laws and regulations are some of the major drivers for constructions firms to adopt and implement sustainability practice (Adetunji et al., 2003; Bohari et al., 2016; Boyd & Schweber, 2012; Chang, Zuo, et al., 2016).

Therefore, to understand and proposed a framework that will guide the adoption and implementation of sustainable procurement practice, a case study was carried out on the top fifty construction-contracting firms in Ireland. The study using the Resource-Based View theory of competitive advantage examined and analysed the utilisation of the various organisational resources of the firm in driving sustainable procurement practice. The study revealed some interesting findings that will aid in the development of a framework. Additionally, the findings provide an important implication for theory, practice, and policymakers.

The procurement process as one of the ways construction-contracting firms relate with their supply chains (Belfit et al., 2011), and assigned responsibilities to the project teams

enable the introduction of sustainability practice into the process. In assigning responsibilities and defining relationships, the underpinning theory enabled inferences of best explanations to be drawn from the procurement practices of the large construction-contracting firm. The study unveiled how the various organisational resources of the firm were utilised in driving value.

Secondly, the implication of the findings in terms of practice may help to understand and improve collaboration within the firm and with supply chains. It was indicative that for firms to improve and disclose their sustainability performance, there is a need for effective communication and sharing of information. Such a strategy can be realised with the effective utilisation of the digital technology resources that will enable the sharing of real-time data and information. Nevertheless, it was found that the digital technologies tools and resources are valuable to the firm studied, but not adequate for sustained competitive advantage. Therefore, the firm could only experience a competitive parity because such strategies in using digital technology are simultaneously implemented by other construction-contracting firms (Mata et al., 1995). Developing strategies will enhance the availability of rich data and provide the opportunity for firms to disclose their sustainability performance to the public and their clients.

Lastly, the implication of the findings to policymakers, showed that for the Government of Ireland to realise their Project 2040 and the SDGs 2030 targets, they would be required to collaborate closely with the AEC sector. Such collaboration will see the AEC sector disclosing their sustainability performance to the public and external stakeholders. However, the findings from the study revealed that disclosing of sustainability performance is voluntarily carried out by construction firms in Ireland. Therefore, it makes the disclosing of sustainability performance limited. Such collaboration will guide policymakers to align their policies to the need of the construction sector and develop a template for disclosing their sustainability performance. Such collaboration with the

AEC sector is necessary because it will be unhelpful to compare sustainability practice of the construction industry with that of the manufacturing sector (Tennant & Fernie, 2014).

Finally, this study was able to unveil the internal organisation practice of large construction-contracting firms in Ireland. However, it is limited in some certain areas.

- First, the study is limited in investigating how such social complexity of the firm leads to gaining a competitive advantage.
- Secondly, the study is limited to how construction firms disclose their sustainability performance to the public and how they go about collaborating with external bodies.
- Thirdly, findings with regards to exploring power relations and structural dominance in the supply chain network are limited.
- The fourth limitation of the study is on helping in organisational re-structuring/ investing resources in supply chain organisation.
- Finally, this study is limited in unveiling the economics and cost implication of developing strategies and ways of diffusing the adoption of digital technology across the organisation. However, other several perspectives could provide good insights into understanding the potentials of utilising digital technologies. Therefore, further study using transaction cost economics theory (Williamson, 1975), and diffusion of innovation theory (Rogers, 2010) could contribute to the limitations of this study.

7.6 Chapter Summary

The chapter triangulates the findings of both the quantitative and qualitative aspect of the study. From the findings, it was understood that large construction-contracting firms design their sustainability policies to align with both internal and external factors. The collaboration was found to be key in driving their sustainable procurement agenda. Companies have developed several strategies and capabilities; this was confirmed by both the survey and case study results. Furthermore, it was revealed that collaboration was carried out both formally and informally. The informal approach to collaboration was found to be more effective in driving sustainable procurement practice. However, it was found that there is a need for firms to develop strategies in improving their collaboration amongst the various teams in the company and improving their communication system through information communication technology. With regards to improving supply chains, it was found that firms are always mindful about their image and reputation. Therefore, they always engage in supply chains that will be committed and have a high knowledge of construction. Also, trust was found to be essential in building a long-term relationship with the supply chains. In developing supply chains performance, large construction-contracting firms use several mechanisms.

Besides, with regards to the use and adoption of digital technologies, the research found out that the adoption and application of digital technology at both the organisation and project level has created value to firms. Although, it was found that there is still an opportunity for firms to explore the potentials of digital technologies which could help them develop strategies that will enable them to demonstrate their sustainability performance and practice. On the other hand, the findings from the study suggest some practical and theoretical applications. Implication with regards to practice showed that construction firms would have to develop strategies of disclosing their sustainability performance. Similarly, policymakers will have to collaborate closely with the AEC

sector to develop strategies of disclosing sustainability performance. Lastly, some of the limitations of the findings were noted.

CHAPTER 8 FRAMEWORK DEVELOPMENT

8.0 Introduction

This Chapter addresses objective 5 of the study, which is to develop a framework for the implementation of sustainable procurement practice. The framework is developed from the findings in the literature and fieldwork carried out during the study, which is reported in chapters 2,4,5 and 6. The Integrated Definition for Function (IDEF0) process is used in developing the framework that will guide practitioners in developing a strategy in adopting and implementing sustainable procurement. The framework considered the actors, the constrains, and tools/resources that will be required in driving sustainable procurement. IDEF0 technique are used to model and analyse complex systems, study function and interrelation of system components, model system life cycles, as well as model enterprise operations (Aguilar-Saven, 2004; Department of Commerce, 1993). The IGOE (Inputs, Guides, Outputs, and Enablers) diagram (Harmon, 2009), is used to summarise the IDEF0 framework. The Chapter is divided into four sections. The first part is a reflection on the conceptual framework, while the second part gives a general background and explanation of the IDEF0 techniques and processes. The third part is on the application of IDEF0 in the implementation processes of sustainable procurement. The last part provides the limitations and summary of the Framework in IGOE diagram form.

8.1 Reflection on the Conceptual Framework

In understanding how top Irish construction-contracting firms embed sustainability in their procurement process, it was necessary to understand how firms utilise their resources. This is because firms will invest in innovations only when the benefits to be gained is understood. Also, knowledge gained from large construction firms have been proven to be a learning model for the wider industry (Chang, Zuo, et al., 2016).

Therefore, in driving competitive advantage, firms develop strategies that are developed into capabilities (Barton, 1995; Butler & Pyke, 2003). From the literature review, and the researcher's experience and knowledge of the construction sector, it was found that the firm's sustainability policies guide the utilisation of the various resources (Eilers et al., 2016; Meehan & Bryde, 2011; Opoku et al., 2015; Qi et al., 2010; Rickaby & Glass, 2017). The workers utilise these policies in managing their supply chains in the delivery of projects (Eilers et al., 2016). Also, digital technology tools are valuable in all the phases of the project and the firms' operations (Papadonikolaki, 2016; Papadonikolaki et al., 2015)..

In providing the route for the study, interviews, documents, and questionnaire surveys were developed to collect data that provided an understanding of how sustainable procurement practice is adopted and implemented by large firms in Ireland. The research seeks to provide an inference of best explanation from an abductive approach. The theoretical relationships are formed based on the research findings, philosophies, and existing theories (Havenga et al., 2014). The conceptual framework gave a foundation for the development of the final framework. Furthermore, as noted in Chapter 2, section 2.7 on the limitations of the existing frameworks, the proposed framework was developed based on such limitations. It was noted that the existing frameworks are generic, which could only provide a guide but are limited in terms of geography and peculiarity of organisations and nature of projects. Also, another limitation noted was that the existing frameworks tend to be developed assuming that the adoption or implementation of sustainable procurement is a linear process. However, mainstreaming sustainability in the AEC sector is not the uniform linear process as it is made to be seen but varies with each firm's dominant organisational culture and history (Boyd & Schweber, 2012). Therefore, the proposed framework is developed considering the geographical location, the organisation culture and history. This is necessary because the

implementation and adoption of sustainable construction vary according to regions and organisations (Du Plessis, 2002; Montalbán-Domingo et al., 2018; Van der Heijden & van Bueren, 2013). Although, the component of the existing frameworks provided a guide in developing the new framework. For example, the component of BS 8903 as shown in figure 18 (fundamentals, procurement process, and enablers), was critically examined and analysed, enabling an innovative framework to be developed based on the factors identified earlier (geography, the organisation culture and history).

There are different techniques for developing a framework in an organisation's or business processes (Aguilar-Saven, 2004; Hindle, 2010). The choice or purpose of using a business process framework/model is divided into four (Aguilar-Saven, 2004). These are:

1. Descriptive framework/models for learning.
2. Descriptive and analytical framework/models for decision support to process development and design.
3. Enactable or analytical framework/models for decision support during the process execution, and control; and
4. Enactment support framework/models for information technology.

Reflecting on the central research question of the study, the descriptive and analytical for decision support to process development and design fits the research question. Using the descriptive and analytical framework is advantageous because it identifies and describes the key actors, tasks, and organisational setting (Aguilar-Saven, 2004; Hindle, 2010).

Therefore in the selection of the appropriate technique to be applied in the study, Aguilar-Saven (2004) proposed about seven different techniques. These are Soft System Methodology (SSM)-Rich Pictures, IDEF0, IDEF3, Role Interaction diagram, Data Flow

Diagrams (DFD)-Yourdon, Role Activity diagram, and flow chart. The IDEF0 technique was found suitable to be used in developing the framework of the study. This is because IDEF0 can be used in developing structural graphical representations of processes or complex systems as enterprises (Dorador & Young, 2000). Furthermore, it has a wider application in the research community because of its flexibility and clarity for displaying activities and information flows between them (Dorador & Young, 2000). Using the IDEF0 methodology has been beneficial in developing strategic plans and operational and strategic management (Waissi et al., 2015). In addition, compared to other techniques, the IDEF0 methodology is easy to learn, powerful, easy to modify, standardized, and have precise rules (Department of Commerce, 1993; Harmon, 2009; Sarkis & Lin, 1994; Waissi et al., 2015).

These benefits of using IDEF0, aligned with this study because the complex nature of construction process can be easily represented and understood graphically. The framework developed using IDEF0 is novel and innovative because it provided graphical representation for improving organisation's sustainable procurement processes. Furthermore, the framework developed through a comprehensive case study of the top fifty construction-contracting firms in the Republic of Ireland helped fill the literature gap in understanding sustainable procurement practice. For example, the framework provided a deeper understanding of the structure and a supply chain perspective in implementing sustainability practice (Brockhaus et al., 2013). Additionally, it demonstrates how organisational policies align with supply chain goals, which was not clearly understood in previous studies (Iles & Ryall, 2016; Walker & Brammer, 2009).

The details of how the IDEF0 was used in this study are presented in the subsequent sections.

8.2 The IDEF0 Framework Technique and Processes

The acronym IDEF has different interpretations. Some authors refer to it as Integrated Definition for Function Modelling (Aguilar-Saven, 2004; Department of Commerce, 1993). Others refer to it as Integration computer-aided manufacturing (ICAM) Definition language (Ghazy et al., 2008; Sarkis & Liles, 1995; Sarkis & Lin, 1994). The IDEF0 functional technique was derived from a well-established graphical language known as the structured analysis and design technique (SADT). The language was used for systems design and analysis for the US Air Force Integrated Computer-Aided Manufacturing (ICAM) (Colquhoun et al., 1993; IDEF; Kim & Jang, 2002; Sarkis & Liles, 1995). There are a different number of tools and techniques within the IDEF family which have been assigned numbers from IDEF0,1, 1x,3,4 and 5. The IDEF function modelling method is designed to represent the decisions, actions, and activities of an organisation or system in a structured graphical form. It provides users with a powerful means of analysis and development for an organisation process (Kim & Jang, 2002).

Furthermore, the method establishes the scope of analysis either of functional analysis or future analyses from another system's perspective. In another way, the IDEF0 diagrams can exist as either generic "as is" or "as should be" (Dorador & Young, 2000). The "as is" archetype allows evaluation of the present situation of the system and the "as should be" helps to define the strategies to follow to improve the system by describing the information flow necessary to support each activity. Therefore, in this study, the framework is developed towards the latter, which is the "as should be" which is concerned with an improvement process.

In developing a framework using IDEF0, two primary components are used. These are:

1. Functions (represented on a diagram by boxes).
2. Data and objects that interrelate those functions (represented by arrows).

These components are shown and explained in Figure 47 below.

- a. Function (coloured green) are the activities, actions, processes, and operations. The function transforms the inputs into the outputs. The boxes are distinguished by an active verb phrase inside the box.
- b. Control (coloured red): the arrow represents the flow that guides, regulates or constraint a function.
- c. Input (coloured blue): are data, information, material, or element that are needed to perform a function.
- d. Output (coloured light green): it shows the data that is produced out of the function.
- e. Mechanism (coloured black): refers to the person, device, asset, resource which performs the function.

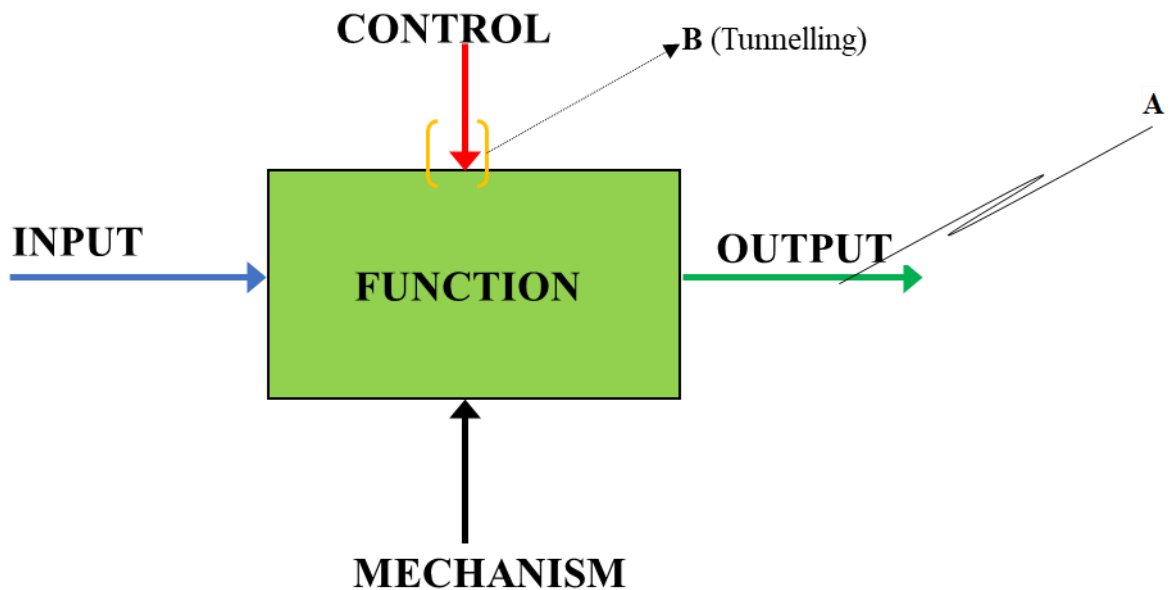


Figure 47: IDEF0 Diagram

Furthermore, in using the IDEF0 diagram, squiggle lines (figure 47-A) show that a particular name applies to a particular arrow. Also, parentheses around either the head or tail of an arrow depict a tunnel (Figure 47-B). A parenthesis around the head of an arrow

entering a function box indicates that the inputs, control, output or mechanism (ICOM) associated with that arrow will not be seen on other functions.

An IDEF0 diagram is made up of several integrated diagrams in a hierarchical form that displays an increasing level of detail describing functions and their interfaces within a context of a system (Dorador & Young, 2000; Ghazy et al., 2008). Providing these levels of details is referred to as decomposition, as shown in Figure 48. The decomposition can be to whatever level of detail appropriate for the purpose at hand (Ghazy et al., 2008). The first diagram which is labelled as A-0 is referred to as the context diagram which is decomposed to A0 level. The A0 level is further decomposed to other lower levels, as shown in Figure 48. It will be important to note that any activity or object could be input, control, mechanism, or output during the process of developing the framework. The IDEF0 structure is composed of three types of information: graphical diagrams, text, and glossary.

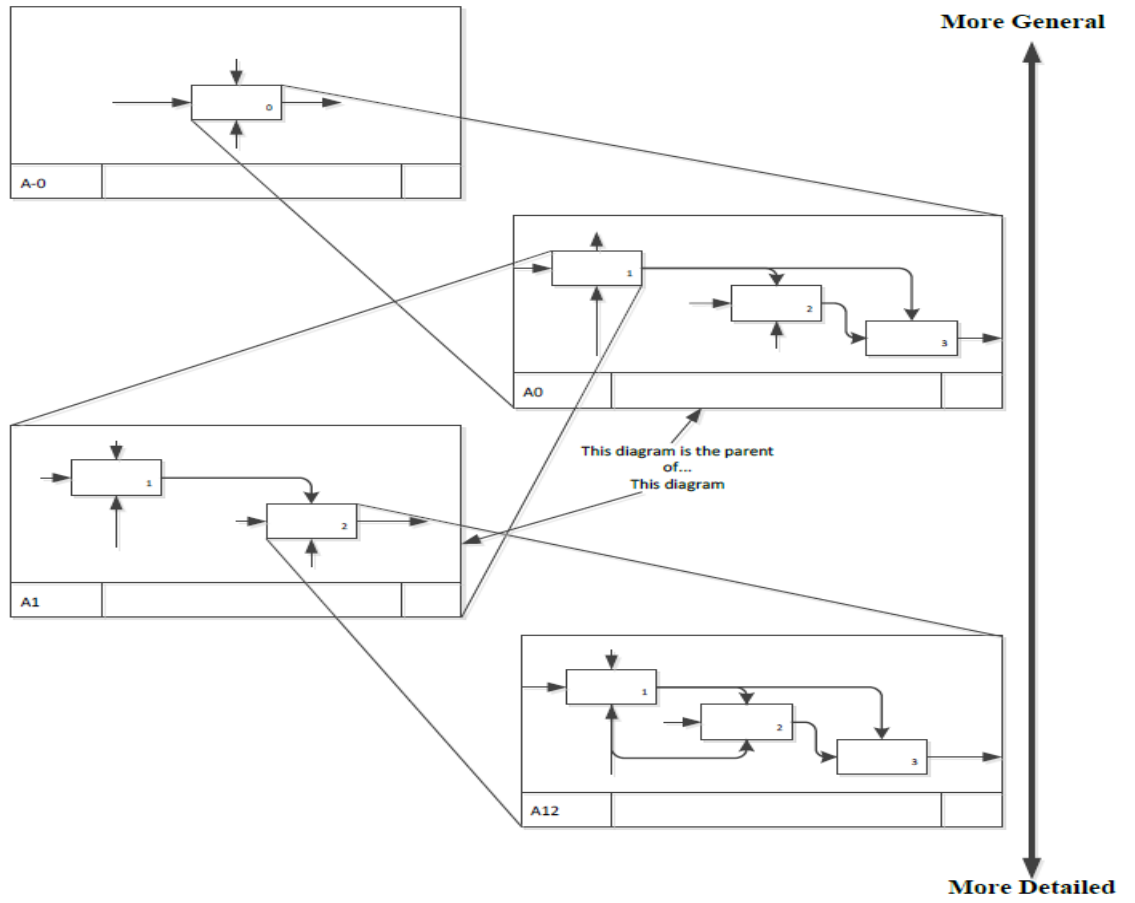


Figure 48: Decomposition and Hierarchy of an IDEF0 Model adapted from (Colquhoun et al., 1993)

8.3 Application of IDEF0 in the Study

This section presents the IDEF0 framework developed for improving the implementation of sustainable procurement in construction-contracting firms. The section is divided into three parts. The first part provides the features of the framework, while the second part briefly discusses the actors, and the last part presents and discusses the framework developed.

8.3.1 Features of the Framework

The framework is developed in four different stages as shown in figure 49. Starting from the context diagram (A-0), which presents the overall summary of implementing sustainable procurement. The A-0 diagram was decomposed into four different levels (A0-develop organisational resources and policy). The A0 diagram is also decomposed to another four different levels. A1 (develop policies and strategies), A2 (develop human development strategy), A3 (develop supply chain management strategy), and A4 (develop digital technology strategy). Levels A1, A3, and A4 were developed into four sub-levels, while A2 was developed into three sub-levels. The node index is developed and presented in table 35, while the IGOE diagram is presented in figure 56. The IDEFO methodology is well suited for an organisation's strategic plan development and operational and strategic management (Waissi et al., 2015). Therefore, depending on the organisation's resources, the proposed framework can be implemented sequentially or concurrently.

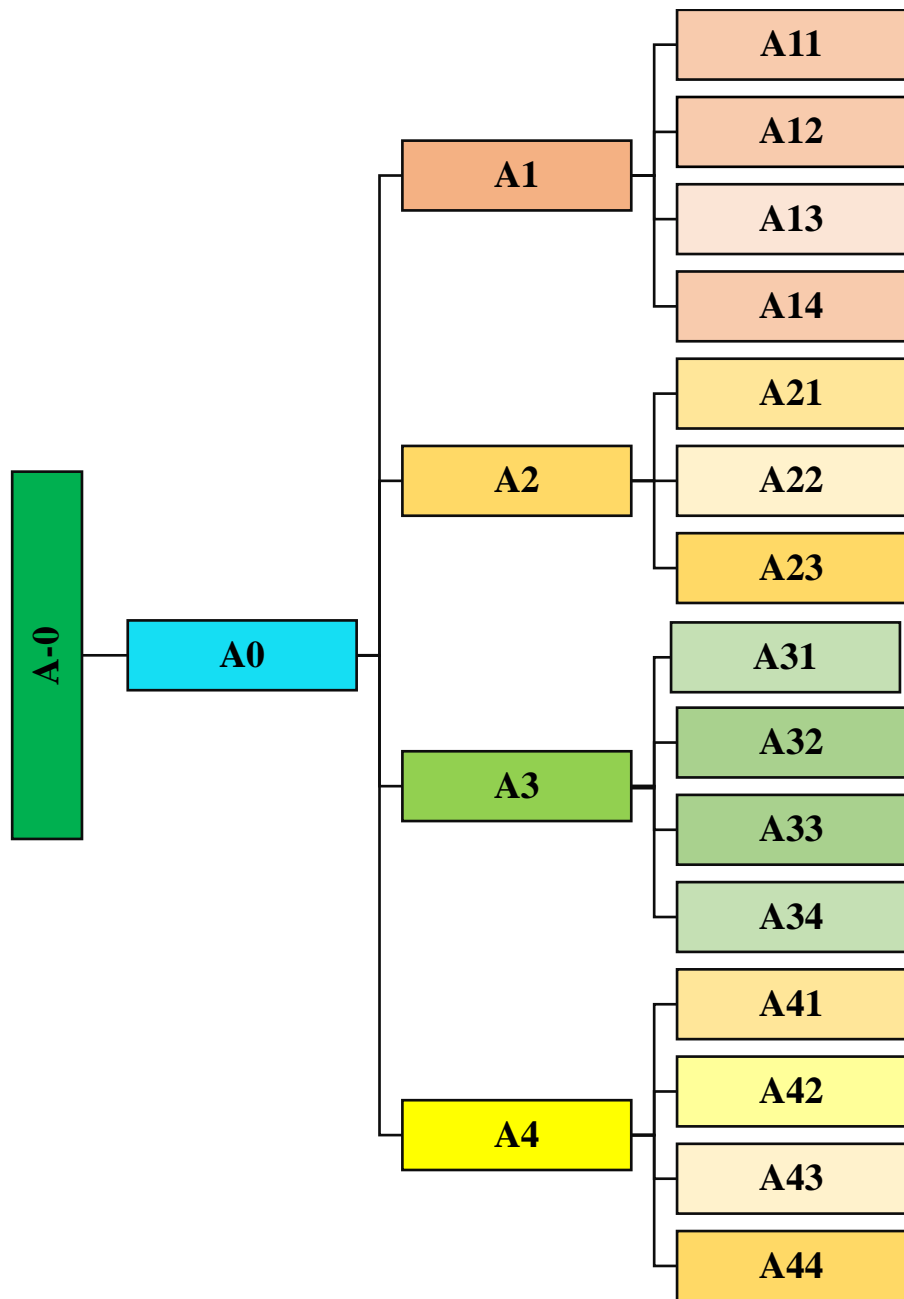


Figure 49: A Summary of the IDEF0 Process

8.3.2 Actors in the framework

The actors in the framework (represented as mechanism as shown in figure 47) are the people that are directly engaged in policy formulation and procurement activities. From the study, (see sections 5.2, 6.2 and 6.3) it was found that the following persons or units are key in driving sustainable procurement.

- i. **Managing Director:** The managing director reports to the board of the company. Together with the board, they are saddled with the responsibility for the development, coordination, and monitoring of the company sustainability policies. The Managing Director is also responsible for the implementation of the environmental management system, monitoring on-site performance, assigning the site responsibilities and resources, and assisting in incident investigation and reporting on corrective action to the company.
- ii. **Directors:** The directors head different units or functions in a company. Each of the directors is responsible for implementing and monitoring the policy in his or her area of business. This is by briefing all managers and supervisors on their responsibilities and support by regular updating.
- iii. **Managers:** The managers are the group of persons that are entrusted with a leadership role, and responsible for overseeing a department, project, or group of employees. They are based at the operational level, and the management of the company relies on their leadership and ability to operationalise the management structure and implement the organisational goals and policies. In the construction firm, some of the managers responsible

for driving sustainable procurement are contracts manager, commercial manager, procurement manager, and sustainability manager.

- iv. The Procurement Unit: The unit is responsible for managing the strategic relationship with supply chains, and for streamlining the procurement process whilst keeping control of overspending. They also assist project teams in delivering projects on time and under budget.
- v. The Pre-Construction Unit: are responsible for job-winning, bidding, and estimating of projects. Their responsibilities include contract and risk reviews, reviews of insurance and bond requirements, reviewing subcontract quotation, value engineering reviews with the wider team, qualification, and clarifications for the tender submission.

8.3.3 Sustainable Procurement Framework (SPF)

As it was explained in section 8.3.1 that the IDEF0 diagram was developed in four stages, to further enhance clarity and show how the framework was developed from the research findings and literature, Table 34 present a mapping process of the tools and techniques that informed the development of the proposed framework.

Table 34: Mapping Process for Sustainable Procurement Framework

OBJECT	FACTORS	EVIDENCE		
		LITERATURE	FINDINGS FROM QUESTIONNAIRE SURVEY	FINDINGS FROM INTERVIEWS AND DOCUMENTS
CONTROL	<ul style="list-style-type: none"> • Government Laws and Regulations • Organisational Sustainability Policies • Procurement Route • Company Management Procedures • External Stakeholders Requirements • Client’s Requirements • Company Sustainability policies 	<p>Qi et al. (2010), Coulson (2014), Naoum & Egbu (2015), Bohari et al. (2016), Yusof et al. (2016), Opoku et al. (2015), Qi et al. (2010), Meehan and Bryde (2011), Eilers et al. (2016), Terouhid and Ries (2016), Kannan (2021), Zuo et al. (2012),</p>	<p>Sections 4.2.1,4.2.2. and 4.2.3.</p>	<p>Sections 5.2.1, 5.2.2, 6.2.1 and 6.3.1</p>
INPUT	<ul style="list-style-type: none"> • Client’s Requirements and Needs • Project and Sustainability Requirements • Design Requirements and Specifications • Post Project Evaluation Reports • Feedback from site • Design Information • Product Information • Trade Union Laws • Supply assessment report • Life Cycle Analysis 	<p>Opoku et al. (2015), Sfakianaki (2015), Wu et al. (2017), Yusof et al. (2016), Adetunji et al. (2003) Boyd and Schweber, (2012), Chang et al., (2016b), Chang et al. (2017), Upstill-Goddard et al. (2016), Kumar & Rahman (2016), Rugarathna & Hewage (2015).</p>	<p>Sections 4.2.1,4.2.2. 4.2.3,4.3, and 4.4.</p>	<p>Sections 5.2,5.3, 6.2 and 6.3</p>

OBJECT	FACTORS	EVIDENCE		
		LITERATURE	FINDINGS FROM QUESTIONNAIRE SURVEY	FINDINGS FROM INTERVIEWS AND DOCUMENTS
OUTPUT	<ul style="list-style-type: none"> • Competitive Advantage • Trust • Better Performance • Improved Company’s Image • Attract Best Talents • Sustainability Policies • Long-Term Relationship • Higher Performance and Commitment • Better Collaboration • Improved awareness • Disclosure Strategy • Responsible Sourcing Strategy • Organisational learning • Snagging monitoring • Waste Reduction 	<p>Lim and Loosemore (2017), To <i>et al</i> (2015), Upstill-Goddard et al (2016), Berry & McCarthy (2011), Brooks et al. (2020), Eilers et al., (2016), Rickaby & Glass, (2017), Terouhid & Ries (2016), (Dadhich et al., 2015; Kibert, 2007; Pero et al., 2017; Sancha, Gimenez, et al., 2016; Sancha, Wong, et al., 2016), Ahmadian et al., (2017), Farmer, (2017) Häkkinen et al., (2015), Naoum & Egbu, (2016).</p>	<p>Sections 4.2.1, 4.2.2, 4.2.3, 4.3, and 4.4</p>	<p>Sections 5.2, 5.3, 5.4, 6.2, and 6.3.</p>

OBJECT	FACTORS	EVIDENCE		
		LITERATURE	FINDINGS FROM QUESTIONNAIRE SURVEY	FINDINGS FROM INTERVIEWS AND DOCUMENTS
MECHANISM	<ul style="list-style-type: none"> • Main Contractor’s Team • The Procurement Unit • The Pre-Construction Unit • Digital Technology tools and Resources • Supply Chains 	Opoku et al. (2015), Qi et al. (2010), Meehan and Bryde (2011), Eilers et al. (2016), Terouhid and Ries (2016), Kannan (2021)	Sections 4.1, 4.2.3, 4.3, and 4.4.	Sections 5.2, 5.3, 5.4, 6.2, and 6.3

8.3.3.1 Implementing Sustainable Procurement (A-0)

The first stage of the IDEF0 diagram is the context diagram, as shown in figure 50. The diagram provides an overall picture of the essence of the framework. The function which is implementing sustainable procurement could be achieved by the main contractor's team, supply chains, and digital technology tools and resources. The role of each member of the team (both main contracting firm and supply chain team) for the successful delivery of the projects was evident in the two case studies which shows the importance of close collaboration (sections 6.1 and 6.2). Also, the utilisation of digital technologies was beneficial in both the procurement process and delivery phase of the projects (sections 4.2.3, 4.4.2, 5.4, 6.2.3 and 6.3.3). However, they will need to be guided or controlled by the laws and regulations in the society, their organisation's sustainability policies, and the method of procurement. From, the questionnaire survey, and findings from interviews it was evident that government laws and regulations have a significant impact on the behaviour of the construction companies (sections 4.2.3, 5.2.2, 6.2.1.2, and 6.3.1.2) Additionally, findings from the interviews showed that the organisation's sustainability policies and management procedure influences and guide the activities of team members. The various policies enabled the firm in understanding their client's, design team, and project requirements. Some of the information that was found to be relevant in achieving the client's and project objectives are the client's requirements and needs, project and sustainability requirement (sections 4.2.3, 5.2.1, 6.2 and 6.3). Other information required are the design requirements and specifications. Once all this information and constraints are properly addressed, the firm is expected to gain a competitive advantage, better performance improved their image, and attract the best talents. These outputs are supported by various academic studies. For example the studies by Lim and Loosemore (2017) and To *et al* (2015) showed that firms that pay attention to sustainability practices are expected to improve their image, attract best

talents, improve their performance, and gain a competitive advantage. The node index of the framework processes is presented in Table 35, showing the description and activities in the IDEF0 diagram.

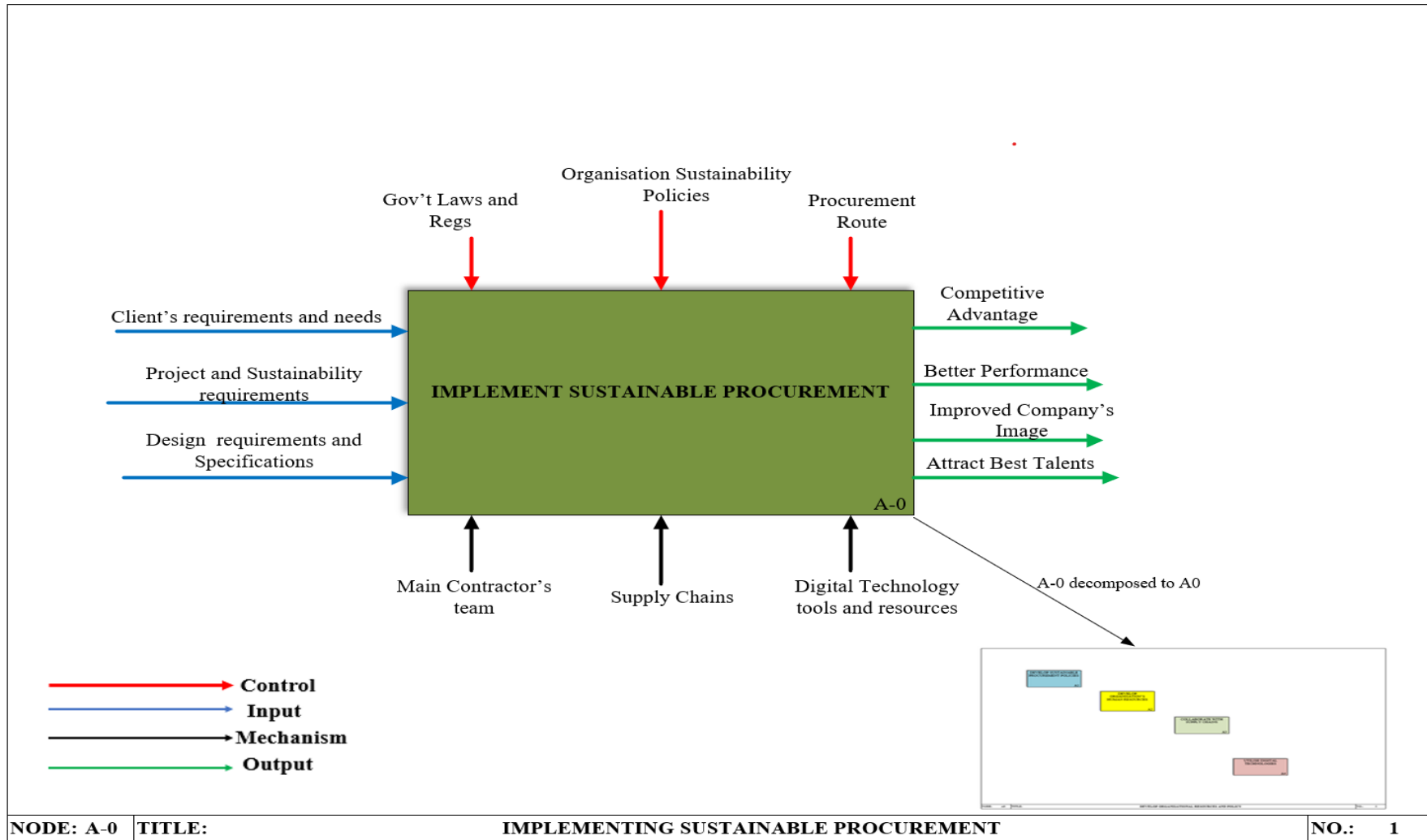


Figure 50: Context Diagram-Implementing Sustainable Procurement

Table 35: Node Index for Sustainable Procurement Process

DIAGRAM REFERENCE	DESCRIPTION AND ACTIVITIES INCLUDED	
A0	Develop Organisational Resources and Policy	
A1	Develop Sustainable Procurement Policy	
	A11	Develop Strategies on Addressing External Factors
	A12	Develop Strategies on Human Resources Development
	A13	Develop Strategies on Responsible Sourcing and Supply Chain Management
	A14	Develop Strategies on Utilisation of Digital Technologies
A2	Develop the Organisation's Human Resources	
	A21	Develop Workers Understanding on Company Management Procedures
	A22	Implement Strategy on Disclosing Sustainability Performance
	A23	Develop and Empower Workers with Requisite Skills and Knowledge
A3	Collaborate with Supply Chains	
	A31	Engage Supply Chains Early
	A32	Develop Long-Term Relationship with Supply Chains
	A33	Develop Supply Chain Assessment Mechanism
	A34	Develop a Mechanism for Training
A4	Utilise Digital Technologies	
	A41	Develop a Digital Central Database
	A42	Develop Database for Procurement, Bidding and Planning
	A43	Develop Database for Project and Site Operations
	A44	Develop Strategy for Disclosing Sustainability Performance

8.3.3.2 Develop Organisational Resources and Policy (A0)

The A-0 diagram was decomposed to provide more details on the A0 diagram. The A0 diagram is developed into four different sub-processes, as shown in figure 51. The four levels show the different strategies that a construction-contracting firm will require to develop into capabilities. The different levels are A1: develop sustainable procurement policies, A2: develop the organisation's human resources, A3: collaborate with supply chains, and A4: utilise digital technologies.

The various functions yield different output, and some of the outputs are used as either inputs or control for another function. These functions are found in the literature and evidence in the questionnaire survey and the case study. From the literature, most construction firms have developed various strategies and policies that will enable them to implement their sustainable procurement practice (Berry & McCarthy, 2011; Brooks et al., 2020; Eilers et al., 2016; Rickaby & Glass, 2017; Terouhid & Ries, 2016). The case study found that such policies and strategies in the firm were developed (training, digital technology, responsible sourcing, and supply chains policies) that guide their planning and project delivery (sections 4.2.3, 5.2, 6.2.1.1 and 6.3.1.1). For instance, function A2, the respondents believed that developing the organisation's human resources, yielded higher sustainability performance and commitment, better collaboration, and improved public image. From the interviews and questionnaire survey, it was found that firms invest significant resources in their staff to yield better sustainability performance (sections 4.2.3, 5.2, 6.2.1.1 and 6.3.1.1). Such findings agree with earlier studies in the literature that aligning organisational policies with workers values promote high sustainability performance (Eilers et al., 2016; Rickaby & Glass, 2017; Terouhid & Ries, 2016). Also, regarding function A3, collaborate with supply chains, findings from the case study (A and B) (sections 6.2.2 and 6.3.2) showed that supply chains are critical organisational resources. Collaborating with them influenced

the project's performance and enhanced trust and long-term relationships. Supply chain collaboration and development have been significant drivers in promoting sustainable procurement practice (Dadhich et al., 2015; Kibert, 2007; Pero et al., 2017; Sancha, Gimenez, et al., 2016; Sancha, Wong, et al., 2016). Function A4, which is utilising digital technologies, was found in the study to be an area that will require improvement. The findings discovered that digital technology tools and resources are primarily used in the organisation's operations and less on areas that promote sustainability practices (sections 4.2.3,4.4,5.4, 6.2.3, and 6.3.3). However, several studies and the findings from the study have shown that utilising digital technology tools and resources can promote sustainable construction practice. Such practices were noted in disclosing sustainability performance, life cycle analysis, and enhancing collaboration (Ahmadian et al., 2017; Farmer, 2017; Häkkinen et al., 2015; Naoum & Egbu, 2016).

The functions in each of the sub-processes will be required to be executed by either the management staff, or company staff, or the various managers, or the various units. The A0 diagram is further decomposed to four different sub-processes which is discussed in the next sections.

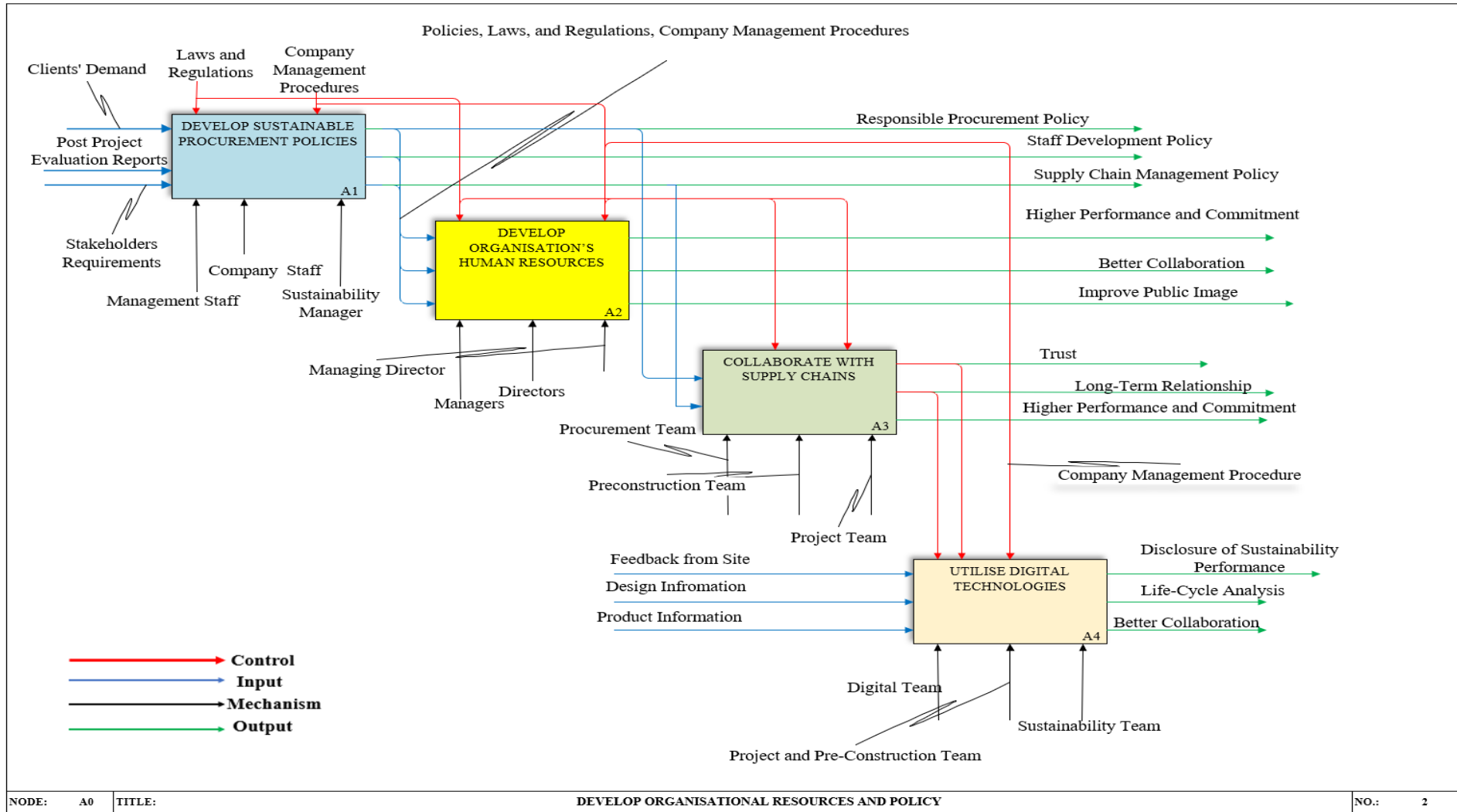


Figure 51: Develop Organisational Resources and Policy/A0

8.3.3.2.1 Develop Policies and Strategies (A1)

This function is decomposed from the A1 function under node A0, which is developing sustainable procurement policies. It is decomposed into four different sub-processes namely as shown in figure 52: A11: develop strategies on addressing external factors, A12: develop strategies on human development, A13: develop strategies on responsible sourcing and supply chain management, and lastly A14: develop strategies on the utilisation of digital technologies. As discussed earlier, leading construction-contracting firms have developed various policies and strategies to drive sustainability (Berry & McCarthy, 2011; Brooks et al., 2020; Eilers et al., 2016; Rickaby & Glass, 2017; Terouhid & Ries, 2016). Also, from the case study on the various sustainability policies developed by the firm, it is evident that the policies direct the attainment of the organisation's sustainability goals (sections 5.2, 5.3, and 5.4). The case study revealed that external factors like government laws and regulations influence the organisation's sustainability policies development (sections 5.2.2, 6.2.1.2, and 6.3.1.2). Also, previous studies have shown that government laws and regulations are likely drivers in promoting sustainable construction practice (Bohari et al., 2016; Coulson, 2014; Naoum & Egbu, 2016; Qi et al., 2010; Yusof et al., 2016). Implementing an effective and successful sustainable procurement practice requires close collaboration of all the team members (Fellows, 2006; Korkmaz & Singh, 2011; Woo et al., 2016). To motivate the various team members, Rickaby and Glass (2017) argued that individuals' values are critical to achieving sustainability goals in a project or an organisation. Therefore, they suggested aligning organisational values/policies with personal values, which is strongly important and associated with project success. Furthermore, from the research findings, construction firms invest quite a lot of resources in developing their human capital (sections 4.2.3, 5.2.1, 6.2.1, and 6.3.1). Developing successful human development

strategies was found to lead to a successful project outcome from the case studies (section 6.3).

Another strategy that will need to be developed is responsible sourcing and supply chain management. The position of the supply chains in the AEC sector has made the main contractors dependent on their services in the delivery of projects. This has made the supply chains valuable organisational resources (London, 2008; Oyegoke et al., 2010). Therefore, supply chain collaboration and development are vital requirements in driving sustainable procurement (Dadhich et al., 2015; Sancha, Gimenez, et al., 2016; Sancha, Wong, et al., 2016). Project B (section 6.3.2) demonstrates the importance of the role of the supply chain members, where the supply chains provided their expertise in terms of responsible sourcing and design improvement.

Regarding the utilisation of digital technologies, its potential in driving sustainable procurement was evident both in the literature and empirical findings. The research findings showed that using digital technology tools and resources could improve collaboration and integration in the implementation of sustainable procurement (sections 4.4.2, 5.4,6.2.3, and 6.3.3). These findings agree with earlier studies on the importance of utilising digital technology tools and resources (Agarwal et al., 2018; Naoum & Egbu, 2016; Roland Berger, 2016; World Economic Forum, 2016b).

The various actors identified earlier are required in the transformation of the various data and resources to develop the various strategies. Therefore, as shown in figure 52, the following outputs, sustainability strategies, improved awareness, better performance, and training strategies are likely to be achieved. Further output expected are competitive advantage, supplier's development strategies, easy access to data and information, enhance collaboration, and disclosure strategy.

The next sub-process that was decomposed was function A2 in node A0. Function A2, which is on develop human development strategies, is discussed in the next section.

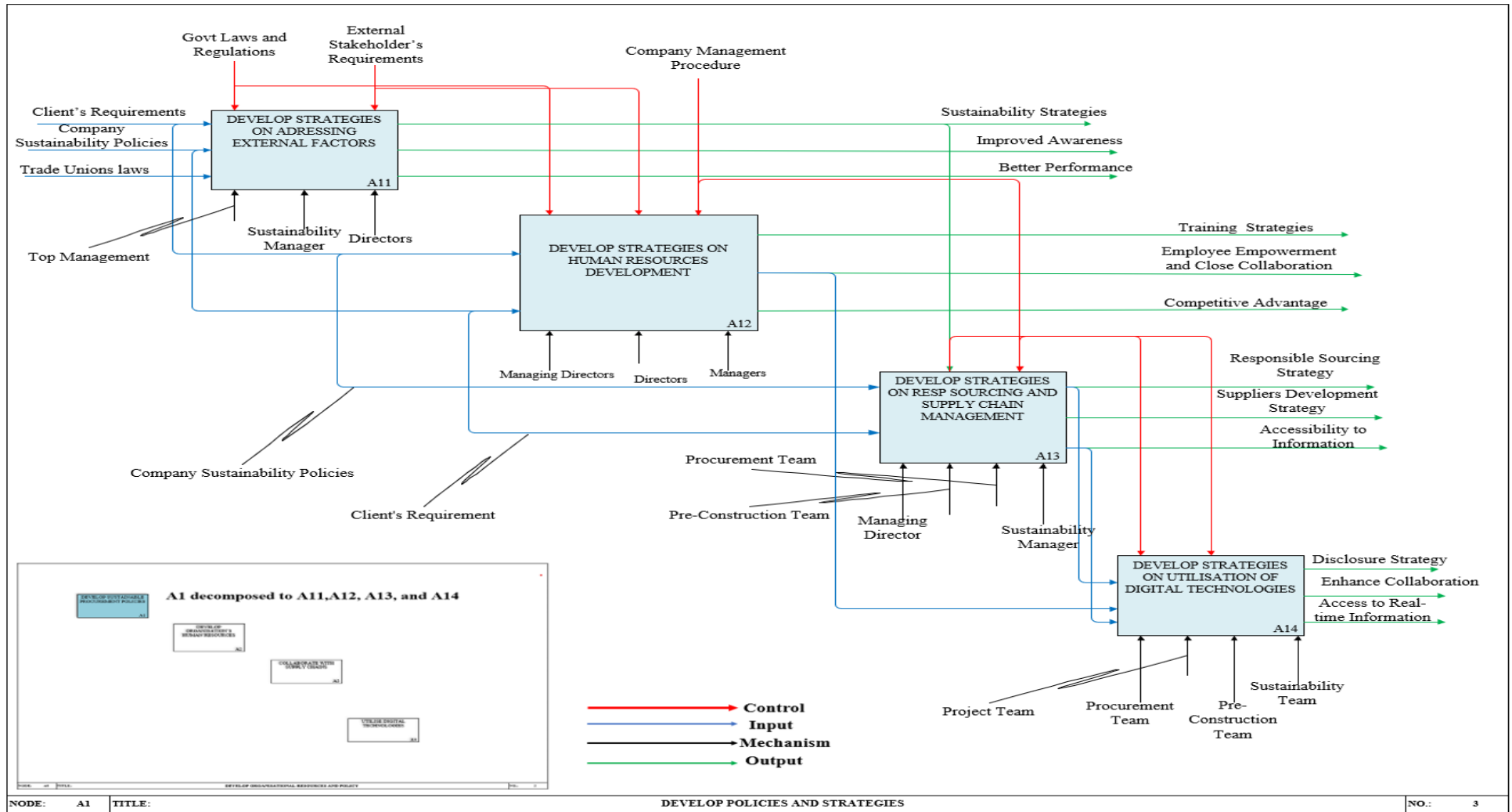


Figure 52: Develop Policies and Strategies

8.3.3.2.2 Develop Human Development Strategies (A2)

This function is on the development of human resources in an organisation. From the findings and literature, it is evident that human resources are the core capabilities of an organisation that enable them to gain a competitive advantage (Opoku & Fortune, 2011; Schulz & Flanigan, 2016). The functions are divided into three sub-processes, as shown in figure 53. These sub-processes are A21: develop workers understanding of management procedures, A22: implement a strategy on disclosing sustainability performance, and A23: develop and empower workers with requisite skills and knowledge. Developing workers' understanding of management procedures (A21) was influential in the case study at the organisation and project levels (section 5.2). Schulz and Flanigan (2016) noted that the successful adoption of sustainability practices could only be effective if the leadership in an organisation develop workers understanding. One way of developing workers understanding is through organisational learning (Anbari et al., 2008; De Giacomo et al., 2018; Meehan & Bryde, 2015; Opoku & Fortune, 2011). Anbari et al. (2008) further noted that organisational learning is a vehicle for continual learning and improvement in organisations.

Regarding implementing a strategy on disclosing sustainability performance (A22), findings from the study revealed that currently, disclosure of sustainability performance by firms is carried out voluntarily (section 5.4, 6.2.3, and 6.3.3). Also, collaboration within the various units of the organisation studied needed to be improved (section 5.4, 6.2.3, and 6.3.3). Developing and implementing a strategy to disclose the firm sustainability performance could likely improve collaboration in terms of sharing information and data and encourage the development of life-cycle analysis of a building (section 4.2.3, 5.4, 6.2.3, and 6.3.3).. Elkington (1997) noted that for firms to remain competitive, they will have to develop strategies to disclose their sustainability performance. Such disclosure could be either voluntarily, or involuntarily, or mandatory

(Elkington, 1997). Disclosing their sustainability performance enables companies to communicate their performance, develop a reputation for responsible behaviour and gain a competitive advantage (Glass, 2012; Myers, 2005).

The last function under node A2 is to develop and empower workers with requisite skills and knowledge (A23). Meehan and Bryde (2015) argued that for effective delivery of sustainable construction projects, corporate organisations should transfer knowledge and the requisite skills to individuals and their supply chains. Transferring knowledge and developing the requisite skills is vital in driving sustainable procurement (De Giacomo et al., 2018). Furthermore, the level of expertise of practitioners in sustainable procurement is an essential factor in aiding the delivery of a successful sustainable project (Mahamadu et al., 2015; Mahamadu et al., 2018). Such strategies were evident in both the questionnaire survey and case study (sections 4.2.3, 6.2, and 6.3). The case study at both the organisational and project levels revealed that requisite skills are developed through formal and informal training (section 5.2, 5.3, 6.2, and 6.3). Formal training was through mandatory continual professional development, while informal was on the job training, where responsibilities and tasks are assigned to every team member. Developing workers skills and knowledge through an informal approach has been found to enhance productivity, learning, innovation and collaboration (Hojem et al., 2014). Barton (1995) noted that such core capabilities are the product of long organisational learning and cannot be easily imitated, therefore constitutes a source of competitive advantage to the firm. The output to be gained is employee commitment, knowledge development, organisational learning and training, high performance, and workers satisfaction. The next process developed is supply chain management (A3).

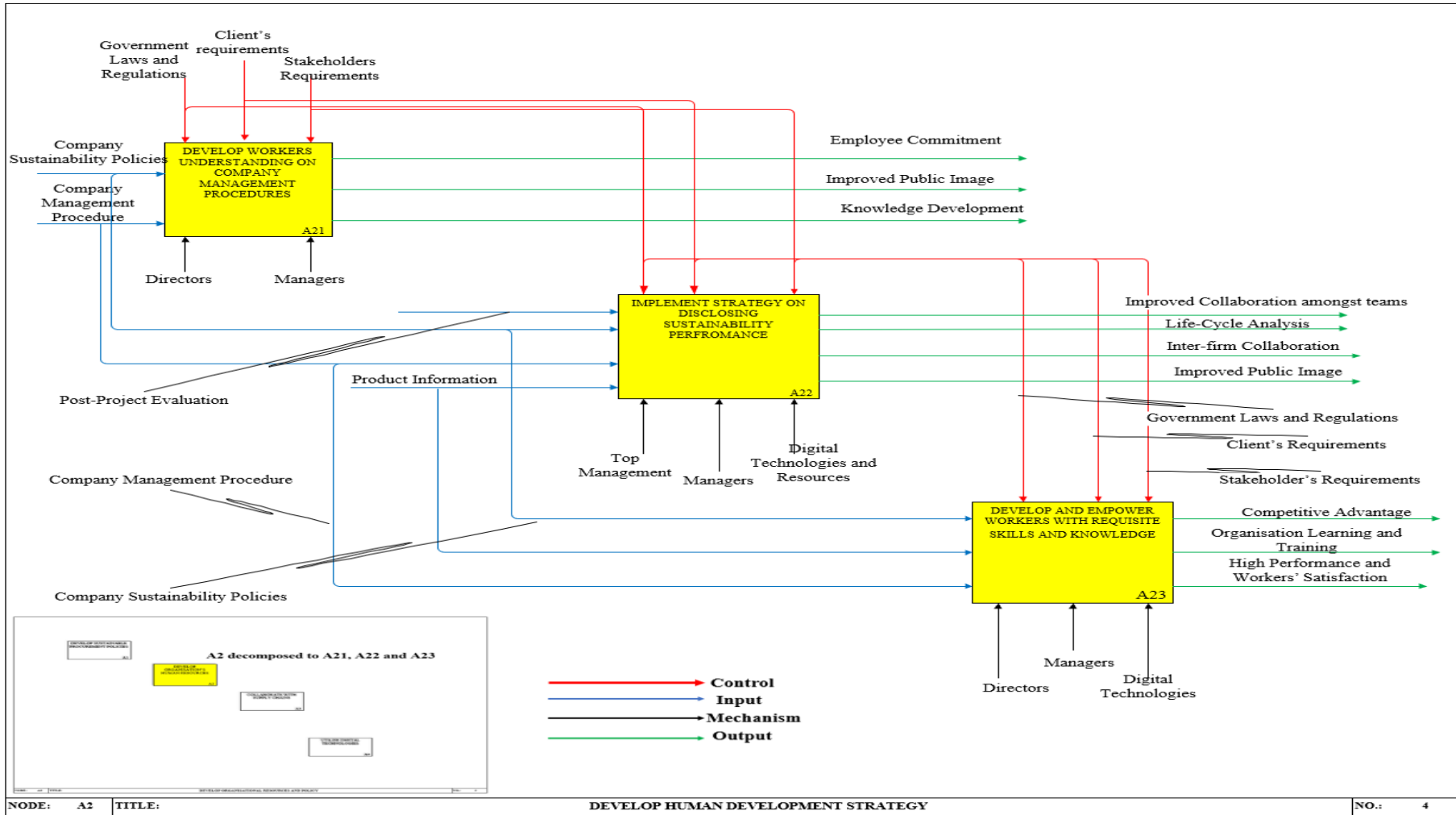


Figure 53: Develop Human Development Strategies

8.3.3.2.3 Develop Supply Chain Management Strategy (A3)

The supply chains are valuable organisational resources, and close collaboration with them yield a positive outcome. The A3 node is decomposed into four sub-processes, as shown in figure 54. The functions are A31: engage supply chains early, A32: develop a long-term relationship with supply chains, A33: develop supply chain assessment mechanism, and A34: develop a mechanism for training. The findings from the study show that early engagement with supply chains during a project enhances collaboration, high performance and facilitates decisions on materials and construction methods (sections 5.3,6.2.2, and 6.3.2). Response from the main contractor's team and the supply chains demonstrates the benefit of early engagement in design improvement and responsible sourcing. Collaborating with supply chains improves the project performance (Dadhich et al., 2015; Sancha, Gimenez, et al., 2016; Sancha, Wong, et al., 2016).

The second function, A32, developing a long-term relationship with supply chains, was one of the firms' strategies (section 4.2.3, 4.3, 5.3,6.2.2, and 6.3.2). This long-term relationship enables the supply chains to align with the main contractor's company procedures and processes. Developing long-term relationships has been observed to enhance trust, collaboration and reduce adversarial relationships (Farmer, 2017; Zander et al., 2016). Poor collaboration leads to a lack of trust and denies the parties the benefits gained during the project's delivery (De Melo & Da Alves, 2010; Upstill-Goddard et al., 2016).

The third function A33: develop a supply chain assessment mechanism. Supplier's assessment mechanism positively impacts achieving organisational sustainability targets (Gosling et al., 2015; Krause et al., 2000; Kumar & Rahman, 2016). Findings from the interviews and questionnaire survey revealed that supplier's assessment is the most used mechanism in improving the performance of supply chains (section 4.2.3, 4.3, 5.3.2,6.2.2, and 6.3.2).. Further findings from the case study revealed that regular supply chain

assessment enables the contractor's organisation to identify the needs of their supply chains and provide the necessary training and support.

The last function on node A3 is developing mechanism for training (A34). For effective delivery of sustainable construction projects, procurement consortia should transfer knowledge and the requisite skills to their supply chains (De Giacomo et al., 2018; Meehan & Bryde, 2015; Opoku et al., 2015). Such training provided to the various supply chains was found during the case study to have improved the performance of the supply chain organisation by creating growth opportunities (sections 6.2.2 and 6.3.2). Also, the training provided created an opportunity for collaboration amongst the various teams. One of the ways that training was provided to supply chains were through demonstration exercise on the use of various computer applications and software.

The last strategy proposed is on utilising digital technology resources.

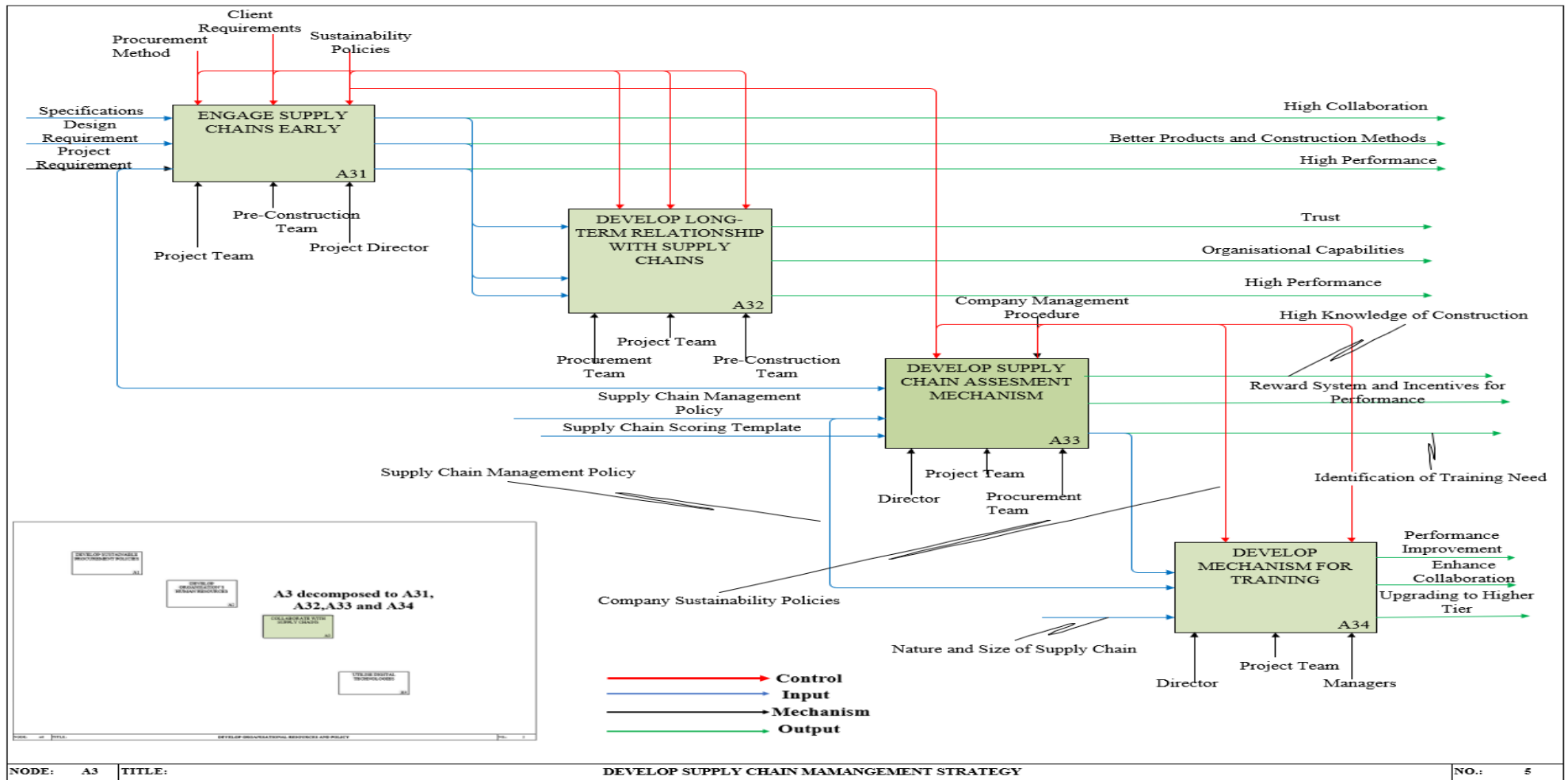


Figure 54: Develop Supply Management Strategy

8.3.3.2.4 Develop Digital Technology Strategy (A4)

The last function decomposed is node A4, develop a digital technology strategy. The adoption and utilisation of digital technologies have been proven to have the potential of yielding high sustainability performance (Papadonikolaki, 2016; Papadonikolaki et al., 2015). However, findings from the questionnaire survey showed the need for improving communication through information technology (section 4.2.3). The questionnaire findings were supported by the interviews carried out (section 5.4, 6.2.3, and 6.3.3). The case study revealed that disseminating and sharing information amongst the various units in the organisation was challenging (section 5.2.1, 6.2.1 and 6.3.1). Sharing information is vital in driving sustainable procurement practice (Ahmadian et al., 2017). Therefore, for an organisation to effectively implement their sustainability practice, there is a need to develop an effective digital technology strategy (Agarwal et al., 2018; Farmer, 2017; Roland Berger, 2016).

As noted during the case study, developing and implementing digital technology strategies will enable easy access of information to all team members (sections 5.4, 6.2.3, and 6.3.3). As explained by the respondents, such availability of information will enable the organisation to develop innovative strategies like carrying life cycle analysis, disclosing their sustainability performance, and developing competitive bids.

Figure 55 presents the processes in developing digital technology strategy. The sub-processes are divided into four different levels. A41: develop digital central database, A42: develop a database for procurement, bidding, and planning, A43: develop a database for project and site operations, and A44: develop a strategy for disclosing sustainability performance. The various teams and managerial capabilities are required to feed information to the databases to be utilised by human resources. Some of the benefits of developing and implementing the various strategies are added value, accessibility to

information, and waste reduction. Others are time savings, snag monitoring, better planning and delivery, improved public image, environmental impact disclosure, and competitive advantage. A tunnel (parenthesis) is introduced on the control arrows of function A41. The tunnel indicates that functions A42, A43, and A44 will require the same control. Therefore, their control arrows will not be seen, or they will be blank on their functions.

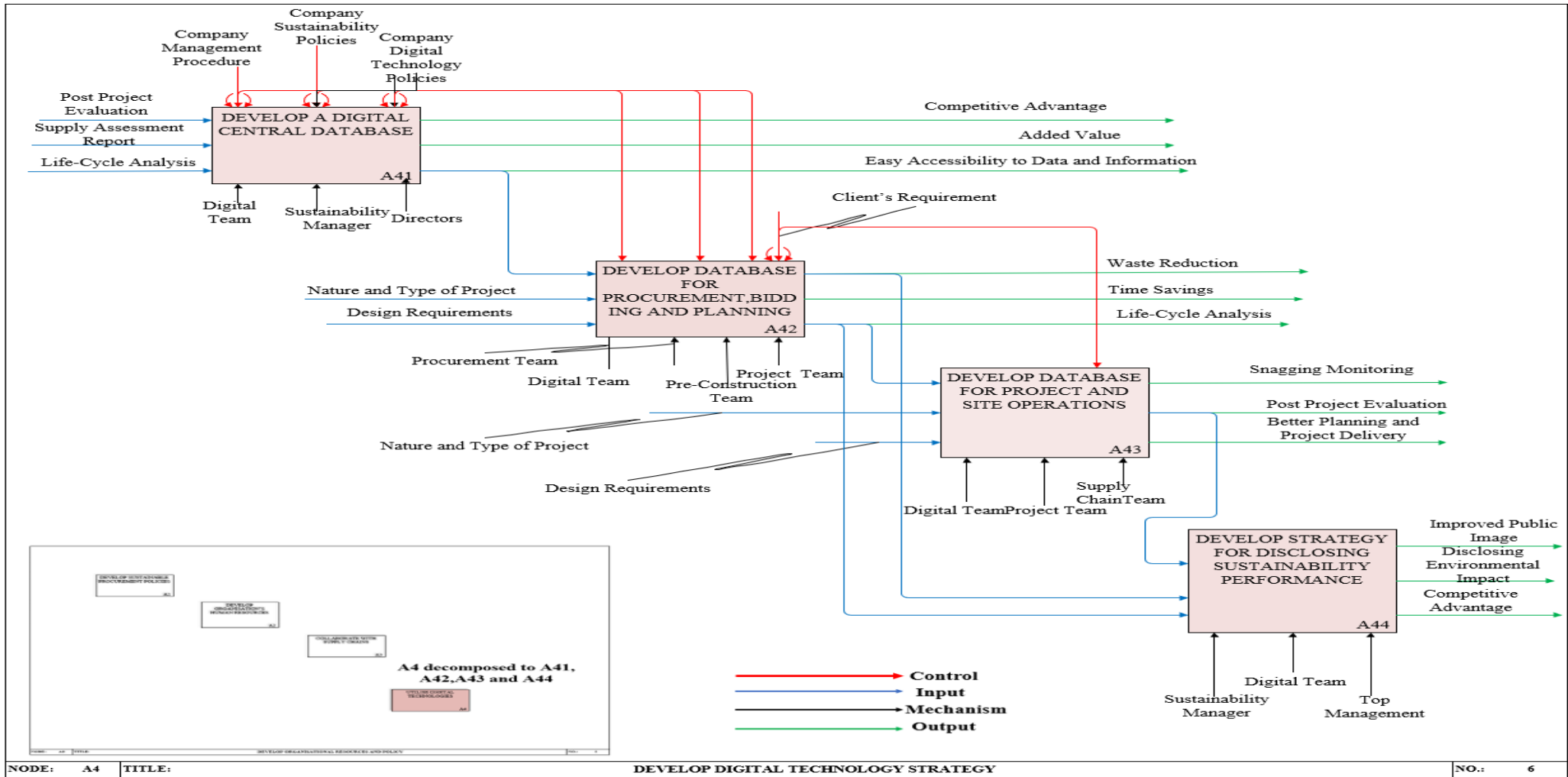


Figure 55: Develop Digital Technology Strategy

8.4 The IGOE Diagram

Roger Burlton and consultants developed an extension to the IDEF0 model (Harmon, 2009). The acronym IGOE stands for Inputs, Guides, Outputs, and Enablers. The main difference with the terminologies of IDEF0 is the mechanism that is replaced with the term, Enabler. The IGOE model provides users with a good way to analyse the problems they face when they try to improve a given business process (Harmon, 2009). Harmon (2009), further explains that the IGOE is sometimes documented formally. However, they are often created on the whiteboard to allow the team of business managers and employees to participate in the discussion and analysis that goes into creating the IGOE. In this study, just as it was shown in the context diagram in figure 51, figure 57 shows a summary of the framework in an IGOE diagram that shows that various actors and objects required to implement sustainable procurement.

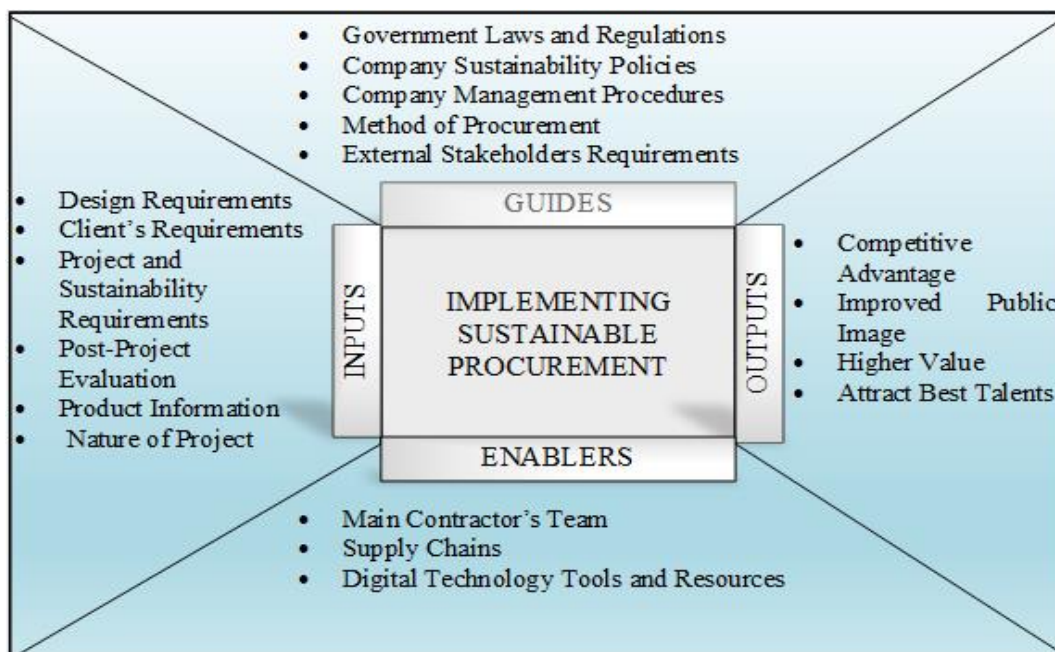


Figure 56: IGOE diagram for Implementing Sustainable Procurement

In general, the framework has successfully demonstrated the processes of implementing and adopting sustainable procurement by construction-contracting firms. However, some

challenges and limitations are noted in this type of framework. First, the IDEF0 technique process is very difficult to understand but becomes clearer and better understood after an explanation is made (Presley & Liles, 1995). Secondly, the framework is developed based on the findings of large construction-contracting firms that have resources to adopt and implement innovative practices. Therefore, it is limited in addressing the practices of small and medium construction firms, but it could be a model for developing a long-term strategic plan for them. Furthermore, because the study is a cross-sectional study, that is limited in terms of time and resources, the framework developed is yet to be tested. However, it has the potential to be used in other construction-contracting firms both within and outside the Republic of Ireland. It has the potential to guide practitioners and policymakers in adopting and implementing sustainable procurement. The framework is new and original that will benefit firms in developing strategies in improving their sustainable procurement performance and practice.

The next phase is the validation of the framework, which is discussed in the next Chapter.

CHAPTER 9

VALIDATION OF FRAMEWORK

9.1 Introduction

This chapter is on the validation of the proposed framework presented in chapter 9, and it also addresses objective 5 of the study. The chapter provides the background to the validation process and the method of validation. Also, in this chapter, the background of the participants, the response of the participants, and the results of the evaluation questionnaire is reported. Finally, a summary of the chapter is provided.

9.2 Background to the Validation Approach

The validation process is the final process involved in the research process. The validation process is aimed at determining the correctness of a framework/model and also to check whether the developed framework/model meet the actual requirement of the users, or it is fit for purpose (Inglis, 2008; Kavishe & Chileshe, 2019). Different classifications and methods proposed for validating a framework/model exist. Yang *et al.*(2011), and Roschke (1994) explained that the validation process could be carried out either in a qualitative or quantitative approach. They explained that the qualitative validation approach offers opinion-based data in the form of words and ideas as opposed to numbers. At the same time, quantitative validation approach utilises research designs that include numerical or statistical and objective data that can be used to test relationships among variables.

On the other hand, Inglis (2008), argued that validation of framework could be done in three ways. The first is by reference to the appropriate literature, however, relying on the most frequently cited literature may result in some articles being overlooked. The second possible approach to validating a framework is against the knowledge of experts in the field. Inglis (2008) observed that drawing on the tacit knowledge of an expert that has

been acquired over a lifetime is valuable in validating a framework. The third approach to validation is by combining the first two approaches. When using this approach, a search through the literature on the possible candidates for inclusion is proposed and submitted to a panel of expert for review (Inglis, 2008).

To validate the proposed framework developed, many factors were considered in the selection of the validation method. First, the time frame and available resources for the study were considered, and the aim of the study, which is to provide an inference of best explanation rather than generalising the findings. Therefore the qualitative approach suggested by Yang *et al.*(2011), and Roschke (1994) was found to be more appropriate. Also, the second approach suggested by Inglis (2008), which was an expert opinion, was found appropriate. In deciding the approach of engaging experts in a study, different approaches are used, but the two main approaches are the one-one interview and the focus group panel (Breen, 2006; Denscombe, 2014).

The focus group panel consists of small groups of people who are brought together by a researcher to explore attitudes, perceptions, feelings, and ideas about a specific topic (Denscombe, 2014). It is an expensive and time-consuming approach (Breen, 2006; Denscombe, 2014), but it seems to be most appropriate. Therefore, an invitation was sent out via email to a selected panellist (see appendix B), but due to the pandemic (COVID-19), it is challenging to meet physically or online as a group for the focus group discussion. The inability of the focus group to hold is seen as a likely limitation on the validation of the framework. However, the one-to-one interview approach was found appropriate to validate the framework.

9.3 Method of Validation

In this study, a five-staged process was adopted in the validation process. The first approach was to identify and select potential participants that will be involved in the

interview. In choosing participants for validation O'Leary (1991), suggested the following category of people:

- i. The same expert from whom knowledge/information was gathered during the study;
- ii. Different expert than from whom the knowledge was gathered;
- iii. End-users;
- iv. Knowledgeable Practitioner;
- v. Sponsor of the project;
- vi. Independent validator.

The first and second approach (i-ii) in the selection of validators was adopted. An invitation via email to participate in the validation process was sent to the various experts. The experts were persons that are directly involved in the procurement process of the company and occupy at least a managerial position. A total of fifteen invitations (n=15) were sent to the experts in the firm that the case study was carried and other firms that participated in the survey. Six (n=6) out of the fifteen experts showed interest and agreed to participate in the validation process. All the six participants that showed interest was from the company of the case study presented in Chapter Six. This number was found adequate because as mentioned in Chapter Four, in a qualitative study it is not the number of cases that matters, "it is what you do with them that counts" (Flick, 2007; Sim et al., 2018).

The second stage of the process was to agree on a time and date. An invitation was sent for a meeting via the Microsoft Teams and a summary report of the findings, and the proposed framework was sent to each of the participants at least one week before the date of the interview. This was to enable them to study and familiarise themselves with the report before the date of the interview. The interview is the third stage of the process, and

they were conducted through Microsoft Teams. The researcher did a presentation to each participant carrying them through the findings and the proposed framework. After the presentation and general discussion, the participants were asked questions relating to robustness, usefulness/benefits, and challenges of using the framework (see Appendix B). All the interviews lasted between 1hr-1hr:30 minutes. After the interview, a short online questionnaire survey was sent to the participants to complete to further give an insight into the framework (see Appendix B). The online evaluation survey is the fourth stage of the validation process. The questionnaire was designed using a series of questions on five-point Likert scales to provide their opinion on the framework comprehensiveness, user-friendliness, logic and flow and its value-adding potential. Also, additional comments (open) were sought from the participants.

The fifth and final stage of the validation process was to analyse and report the findings of the expert's opinion. These findings are presented in the next section.

9.4 Background of Participants

The background of the participants presented in Table 36 shows their role and years of experience in the construction industry. All the participants have substantial working experience in the construction sector.

Table 36: Participants Information

Participants	Role	Years of Experience
A	Supply Chain Manager	15 Years
B	Commercial Manager	24 Years
C	Commercial Manager	Over 20 Years
D	Purchasing Manager	20 Years
E	Sustainability Manager	15 Years
F	Commercial Manager	28 years

9.5 Response of Participants on the Framework

The response and feedback from participants are discussed, considering four different areas. These areas are:

- i. The overall benefits of the framework for the implementation of sustainable procurement practice;
- ii. Suggestions on improvement for the framework;
- iii. The likely obstacles or barriers in using the framework;
- iv. The comprehensiveness, user-friendliness, logic and flow and its value-adding potential.

With regards to the first question on the benefits of the framework, the participants shared different views and opinions. They noted that the framework would enhance collaboration amongst the different units in the company and project teams. Such collaboration, they noted, will lead to a reduction in time and transaction cost, and it will also enhance a good relationship and build trust with supply chains. Such a reduction in time and transaction cost will increase the company's competitiveness in winning more jobs. Also, they noted that with the current practice in the organisation where information is in different places, the framework would aid in centralising all data required to promote sustainable procurement practice. Another benefit noted by the participants is that the framework will provide a checklist in ensuring organisational procedures and practices are adhered to. Finally, they noted the small and medium-size construction firms could benefit from the framework by using it as a guide for long-term planning.

On suggestions for potential areas of improvement on the framework, the participants suggested potential improvements in three different areas. First, it was suggested that there is a need for the sustainability manager to be involved in all the activities to enable

full compliance and implementation of the framework. Secondly, because of the nature and set-up of the construction industry, it was suggested that the opportunity for new entrants should have been included in the framework. Such opportunity a respondent explained will guide against exploitation and abuse of processes. Finally, the last suggestion made was with regards to the legal issues and relationship with supply chains. One of the participants noted that there is a need to review the existing legal agreement with their supply chains because the company has only limited information about their supply chains. Such an agreement will ensure the company has all the necessary information about the production processes, location of the factory, responsible sourcing mechanism, and ethical practices.

The third and last area discussed during the validation interview was on the likely obstacle and barriers in using the framework. The feedback received suggested that both internal and external factors are likely to be a barrier in using the framework. The internal barriers noted are resistance by workers in changing from old practice to new practice and the potential for the relationship built with supply chains, if not checked, resulting to abuse of procedures. The top management could overcome these challenges, they noted, through communicating and educating all workers on the implementation procedures. Also, another respondent observed that because of the large nature of the company that comprises of different regions, all the chief operating officers, and regional directors will have to be involved in developing the implementation strategy.

About external factors, the first one noted was the impact on BREXIT. The respondents noted that most of the big supply chains in Ireland are from the UK; therefore, the policy on BREXIT might likely have an impact on their business operations. Besides, they explained that because of the long-term relationship they have developed with their supply chains, where the supply chain has gained an understanding of company procedures and client's requirements, that this might be negatively be affected. In

addressing the risk that might affect the industry because of BREXIT, the respondent explained that the company is developing different strategies and discussing with their supply chains on proactive measures. Lastly, the respondents noted that because of the resources involved in the framework, it would be challenging for small and medium-sized companies to adopt.

9.6 Results of Evaluation Questionnaire

The final step in the evaluation of the framework was the consideration of the comprehensiveness, user-friendliness, logic and flow and value-adding potential of the framework. The important relative index (RII) was used to analyse the scores of the participants with regards to the above issues. The results, as shown in Table 37, showed the highest RII to be 0.87 and the lowest to be 0.67. With regards to the comprehensiveness of the framework, which is related to items 6 and 8, the results showed RII of 0.8 and 0.87. The ranking was 1st and 2nd, and these results agree with the opinion of the participants during the interviews, where they acknowledged the comprehensiveness of the framework. The second factor considered was the user-friendliness of the framework; this is related to items 2 and 9 on the table. The RII was 0.73 ranking 6th and 0.67 ranking 10th. The low ranking of the user-friendliness was not surprising, because some of the participants expressed difficulties in understanding the IDEF0 diagram when the report was first sent to them. However, after the explanation, it became clearer and better understood. This confirmed the finding of earlier studies about the user-friendliness of IDEF0 diagrams (Presley & Liles, 1995).

Additionally, with regards to the logic and flow of the framework which are related to items 3 and 7, the RII scores were 0.77 and 0.77, which was a tie which ranked 4th. Finally, with regards to the value-adding potential of the framework which is related to items 1,4, 5, and 10 the RII were 0.8 (2nd), 0.73 (6th), 0.70 (8th) and 0.70 (8th). It was noted

that items 5 and 10 are tied which are ranked 8th. Overall, the RII returned a very impressive score. Although the sample size is limited, as previously noted in qualitative study sample size is not as important because it is not the number of cases that matters, "it is what you do with them that counts" (Flick, 2007; Sim et al., 2018).

Table 37: Evaluation Questionnaire

Item	Factors	To a very high extent	To a high extent	To some extent	To a Limited Extent	To no Extent at all	Total respondents (N)	Weighted total	RII	Rank
1	How useful would you rate the overall framework for implementing sustainable procurement in the construction industry?		6				6	24	0.800	2
2	How easy would it be to follow the IDEF0 process in the framework (clarity of the framework)?		4	2			6	22	0.733	6
3	To what extent can following the framework help in implementing an effective, sustainable procurement?	1	3	2			6	23	0.767	4
4	How effectively can the framework facilitate the overall success of construction projects?		4	2			6	22	0.733	6
5	How effectively does the framework focus on sustainable procurement issues relevant to the construction firms?		3	3			6	21	0.700	8
6	How would you rate the applicability of the framework in driving sustainable procurement?	1	4	1			6	24	0.800	2
7	How would you rate the logical structure of the framework?	1	3	2			6	23	0.767	4
8	How would you rate the comprehensiveness of the framework?	2	4				6	26	0.867	1
9	How would you consider the user-friendliness of the framework?		2	4			6	20	0.667	10
10	How would consider the value-adding of the framework		3	3			6	21	0.700	8

9.7 Summary of the Chapter

This chapter provides a report on how the validation process was carried out. Six expert's opinions were drawn in testing the framework comprehensiveness, user-friendliness, logic and flow and its value-adding potential. The benefits, areas of improvement and likely obstacles in the use of the framework were identified. The relative importance index scores were generally good with the highest as 0.87 and the lowest 0.67. The findings found that the framework was quite comprehensive, had good logical flow and had strong value-adding potential. With regards to user's friendliness, the clarity of the framework was better appreciated after the participants were taken through the diagrams in an online interview.

The last chapter provides a conclusion and recommendation for further study.

CHAPTER 10

CONCLUSION AND RECOMMENDATION

10.0 Introduction

The chapter presents the conclusion and recommendations from the study. The contribution to knowledge is explored along with the potential and actual impact of the research. Finally, areas for potential future research are explored along with an exploration of the study's limitations.

10.1 Conclusion

This research set out to understand how large construction-contracting firms in the Republic of Ireland embed sustainability in their procurement process. Answering the research question was aimed at developing a sustainable procurement framework. Research objectives were set to help in addressing the research question and aid in developing the framework. Five objectives were developed and addressed, they are:

1. To critically review literature on the current level of sustainable construction practices in the Irish construction industry and globally.
2. To evaluate the current level of adoption/performance of sustainable procurement amongst Irish construction contracting firms.
3. To determine how contracting firms in Ireland motivate their supply chains in embedding sustainable construction practice.
4. To assess the current levels of, and potential for the adoption of digital technologies by construction-contracting firms at the procurement phase of a project to help achieve sustainability goals.

5. To develop and validate a sustainable procurement framework that will guide firms in the implementation of sustainable procurement.

The research focuses on the top fifty construction-contracting firms listed by the Construction Industry Federation (CIF) in 2018. Learning from large construction-contracting firms is beneficial because their practice is often regarded as the benchmark of the learning model for other firms (Chang, Zuo, et al., 2016). Therefore, using the case study approach, a framework was developed to guide construction firms' sustainable procurement practice. Findings from the literature has shown that adopting and implementing sustainable construction is challenging, and most construction firms are slow in the adoption. The reason for the slowness had been attributed to the uncertainty of the benefits to be derived in committing to long-term investments. These resources are human capital resources (employees), organisational capital resources (supply chains), and physical capital resources (digital tools and technologies). Different data collection procedures and techniques were utilised and analysed that enabled the development and validation of a framework. Figure 57 below presents the findings of the study.

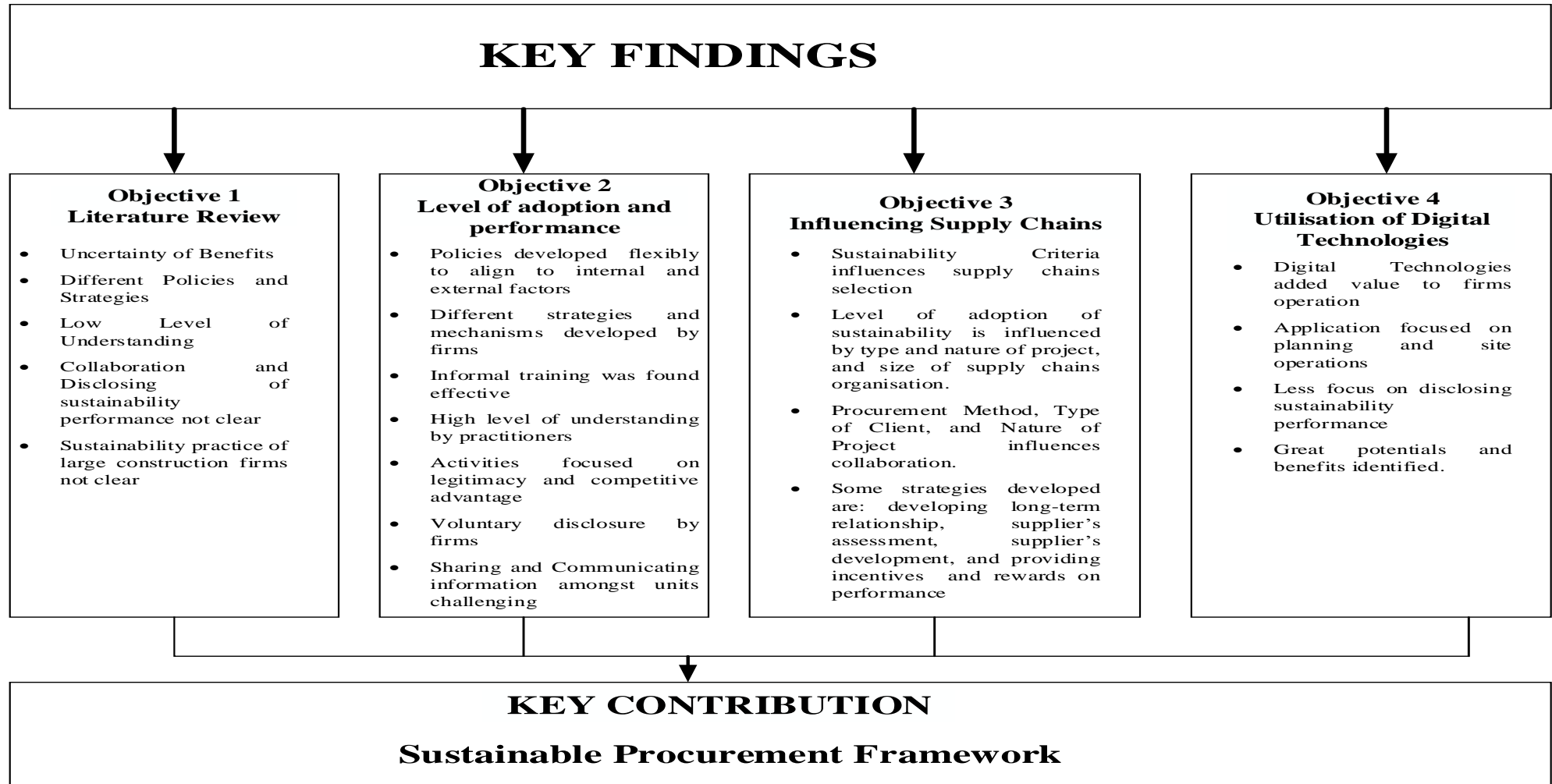


Figure 57: Summary of Key Findings

In achieving objective one findings from the literature review revealed that construction firms had developed various policies and strategies in driving sustainable construction practices. These strategies include stakeholder engagement, collaborating with clients, aligning policies with government laws and regulations and working closely with supply chains. Despite the efforts and commitments by firms, their sustainability performance was found to be low. Some of the reasons for this are the low level of understanding of most firms, complexity and set-up of the construction industry and, as stated earlier, a lack of interest. However, in an effort in improving their performance, it was found that most construction and other business enterprises have used their procurement mechanism in driving their sustainable construction practice. In driving sustainable construction, the procurement mechanism has been found to lead to innovation and enhanced collaboration amongst team members and their supply chains. The focus of procurement has also changed from short-term cost minimisation to long-term value creation and delivery.

However, there is no clear understanding or the evidence of how firms collaborate and disclose their sustainability performance (addressing objective 1). This research gap could be one reason that has created the assumption of the low performance of the AEC sector. Also, construction firms are expected to demonstrate to their clients and stakeholders their commitments in delivering sustainable products, while also educating them on how this can be achieved. Disclosing their sustainability performance and educating their clients will show firms' commitment and willingness to drive sustainability rather than seek legitimacy and competitive advantage. Therefore, there is the need to explore how firms, specifically large construction firms, implement sustainability in their procurement process. This is important because firms with high financial turnover have the resources and capacity to implement innovative strategies. So,

the study focused on how organisational resources are utilised to implement sustainable procurement from the organisational level to the project level.

In addressing objective two of the study on the performance of firms in the adoption and implementation of sustainable procurement, the findings revealed that firms developed different policies and strategies. The policies were developed from the top management and are reviewed regularly based on feedback from employees. It was also found that the policies align with government regulations, client's requirements, and workers value. With regards to the strategies developed, different mechanisms were found to be utilised. These mechanisms are collaborating with their staff, clients, supply chains, addressing government laws and regulations, and engaging external stakeholders. The formal and informal approach in training and communication was utilised with the informal approach very effective. However, it was found that the major drivers in the adoption of sustainability practice by firms were focused on activities that drive legitimacy and competitive advantage rather than activities that will enable firms to disclose their sustainability performance (addressing objective 2). It could be argued that the type of client, nature of the firm, the role of the firm in the design process, profit, and government laws and regulations are some of the factors that influences the firm's behaviour.

Furthermore, another interesting finding in addressing objective two was the high level of understanding regarding sustainability amongst the respondents and practitioners. Such a high level of understanding was found to be due to most large construction firms investing resources in developing their core capabilities. Such investment in their core capabilities was carried out through training, recruiting experienced staff and aligning sustainability policies with government and external stakeholders' requirements. Other strategies and innovation developed by firms were observed in the monitoring of waste, noise, water disposal, and collaborating with external bodies like the Construction

Industry Federation (CIF) in their staff training. It is inferred that the firm's capabilities are likely attributed to their social complexity and long years in business. Although these findings are not surprising compared with existing literatures, however, they have provided a better insight and understanding on how large firms utilise their human capital resources.

In addition, notwithstanding the strategies developed and large construction-contracting firms' performance, the study revealed that sustainability performance was carried out voluntarily. Such disclosure was also found to have some limitations because it focuses only on some key aspects of construction operations. Therefore, to enable construction firms to disclose their sustainability performance, the study explored how collaboration within the firm was carried out. The findings revealed that sharing and communicating information amongst the various units have been challenging at both the organisational and project level (addressing objective 2). Also, the results demonstrated that there is a "possible waste of resources" with regards to collaboration within the firm. Such waste of resources is likely linked with the unavailability of a central database accessible to the various units in the organisation. Another possible reason for the lack of disclosure was found to be the absence of post-project evaluation reviews. Such barriers were noted to hinder data availability to enable firms to disclose their sustainability performance. These findings further helped in filling the gap in academic literature by unveiling the level of understanding of practitioners at both personal and organisational level with regards to adoption and implementation of sustainable procurement.

Objective three also provided a very interesting finding. The findings revealed that the sustainability criterion influences supply chains' selection by main contracting firms. The type and nature of the project and the supply chain organisation's size have been observed to determine the level of adoption and sustainability practice implementation. It was also found that the level of collaboration with supply chains is primarily determined by the

procurement method, type of client and nature, and type of project. Similarly, firms developed several strategies in collaborating with their supply chains (addressing objective 3). These strategies include developing a long-term relationship, supplier's assessment, supplier's development, and providing incentives and rewards on performance.

Nevertheless, a significant contribution was found in this study that shows that long-term relationship has less impact on the project performance. Instead, close collaboration through early engagement of supply chains influences projects performance. Furthermore, close collaboration with supply chains leads to trust and knowledge development by sharing relevant data and information. These findings further contribute to academic literature by showing a practical example of managing supply chains in the construction industry.

The last organisational resource considered as physical capital resources (digital technologies tools). Understanding the utilisation of these organisational resources addresses objective four of the study. Findings from both survey and interviews revealed that the adoption and utilisation of digital technology had added value to the construction firm's operation. Nonetheless, most of the applications were focused on planning and site operations, with less focus on disclosing sustainability performance (addressing objective 4). However, potential benefits were identified, such as having a central database for sharing and disseminating data and information. Such a database will enable equal access to information to the various units and project teams and enable firms to disclose their sustainability performance. These findings are somewhat not very surprising because, from earlier findings both in the literature and the study, the claims made by construction firms regarding adopting and implementing sustainability practice are to claim legitimacy and competitive advantage. However, the study contributed by illustrating how firms

could utilise their digital technology resources to enhance their sustainability performance or only enjoy competitive parity.

Finally, the findings revealed that in complying to government laws and regulations, innovative strategies were developed. Such strategies include using level two BIM, electric cars, and protecting the natural habitat. One of the reasons for large firms in developing innovative practices is that they are mindful of their image and will always want to project their image positively. Nevertheless, some of the government policies, like the Sectoral Employment Order (SEO), were found to have negatively affected supply chains' operations.

Finally, having explored how large construction firms' organisational resources are utilised in driving sustainable procurement, a framework was developed and validated. Developing the framework addresses objective five of the study. The framework proposes areas for improvement in driving and adopting sustainable procurement and provides a guide to firms struggling to implement sustainable procurement and addresses the research gap of the lack of a mechanism in promoting sustainability practice. Findings from the validation of the framework indicated that the framework's implementation might be affected by both internal and external factors. Internal factors like changing organisational culture and people's psyche, while external factors like BREXIT and the firm's size are likely to be barriers. Overall, the framework was found to be comprehensive, user-friendly, logical and value-adding.

10.2 Contribution to Knowledge and Impact of Study

Notwithstanding the limitations identified in Section 11.2, the study offers valuable insights into understanding how organisational resources could be utilised to drive the adoption and implementation of sustainable procurement. Driving sustainable construction is primarily dependent on firms procuring sustainable goods and services. However, from the literature review, it was found that the AEC sector sustainability performance is low. Some of the reasons attributed to such a low level of performance were the poor reflection of organisations sustainability policies on their procurement practice. Second, the lack of an identified benefits by firms in the adoption and implementation of sustainability. This study contributed by unveiling the practice of the large construction-contracting firms in adopting and implementing sustainable procurement. Additionally, the study contributed to the existing gaps in the academic literature on the lack of a mechanism in understanding sustainability practice at a personal and organisational level.

Methodologically, the study demonstrated how the single case study approach could be utilised in understanding internal organisations strategies. Using such a methodological approach was able to identify that disclosing sustainability performance is mainly dependant on the availability of data. Such data is dependent on the level of collaboration amongst the various units in a firm and the level of trust and collaboration with their supply chains. Therefore, to guide practitioners and policymakers in adopting and implementing sustainable procurement, the study developed and validated a sustainable procurement framework. The framework is new and original that will benefit firms in developing strategies in improving their sustainability performance and practice.

Additionally, the framework could be beneficial to practice by guiding large and medium companies in developing long-term strategies in driving sustainable procurement practice. On the other hand, with regards to policymakers, the framework provides a guide for collaboration with the AEC sector in contributing towards the SDGs 2030 targets and the Ireland 2040 project. Some of the SDG goals that the AEC sector can help achieve are: goals six (clean water and sanitation), seven (affordable and clean energy), eight (decent work and economic growth), nine (industry innovation and infrastructure). Other goals are eleven (sustainable cities and communities), thirteen (climate action), fourteen (life below water), and goal fifteen (life on land). Finally, the framework can also contribute to developing policies and strategies that will address meeting the development of physical and public infrastructure in meeting Ireland 2040 targets.

10.3 Limitation of the Study

Due to the level and availability of time and resources in executing the research, some limitations were noted. The study's limitations include that the case study focused only on the procurement practice of one large construction-contracting firm, which makes generalisation and broader understanding limited. Similarly, the survey findings were based on purposive sampling, which could make generalisation not possible. Nevertheless, the single case study approach and the purposive sampling technique provided a deep insight into understanding how organisational resources are utilised to drive sustainable procurement in large construction contracting firms in Ireland. However, the study's essence is not to generalise the findings but rather to provide an inference of best explanation (abduction). It will be interesting to conduct similar research using a multiple-case study approach by comparing different construction-contracting firms' practices.

On the other hand, the framework developed was based on large construction-contracting firms' practices, and its application to SMEs may be limited. Nevertheless, the framework provided a learning model to the SME's to learn from the practices of large construction-contracting firms. Regarding structural dominance and power regime in the supply chain network, the study was able to unveil the relationship between supply chains and contracting firms. However, it was limited in developing a further understanding of how power and structural dominance influences sustainability practice. Furthermore, regarding supply chains relationship, the study was able to unveil the benefits derived by firms in helping supply chains improve their performance. Though, it was limited in understanding how vertical integration would promote the firm's sustainability practice and business operations.

Additionally, the study revealed the benefits and potentials of utilising and adopting digital technologies in driving sustainable procurement practice. However, the economics and cost implications of adopting and diffusing such technologies and strategies across the organisation are limited in the study. Finally, as noted earlier, the study is a cross-sectional study bound within a specific time and resources. Therefore, some limitations might be observed during the framework's validation, due to the small sample size used, and it was limited only to Ireland. But, the study validation was found to have a significant contribution to the study because as stated earlier, the study focuses on providing an inference of best explanation rather than generalising.

10.4 Recommendation for Implementation by Practitioners

Based on the study's findings, implementing and adopting the proposed framework in a construction organisation will require policies and strategies be formulated and implemented as shown in Figure 58. It is recommended that top management develop policies and strategies of implementation. Such policies and strategies should have the

input and contribution of both company staff and supply chains. This is necessary because the study's findings show that organisational restructuring will be required for constructions firms to disclose their sustainability performance truly. Also, it is recommended that an intensive audit and SWOT (strengths, weaknesses, opportunities, and threats) analysis of existing resources of an organisation be made to identify barriers and opportunities. Carrying out such analysis will enable organisations to develop short, medium- and long-term plans for adopting and implementing the framework. In addition, for the construction industry to effectively disclose and enhance their sustainability performance, it will be expected that both government agencies and international organisations like the European Union and United Nations collaborate with the industry. Such collaboration will enhance developing a template and strategies to guide the AEC sector in driving their sustainability practice.

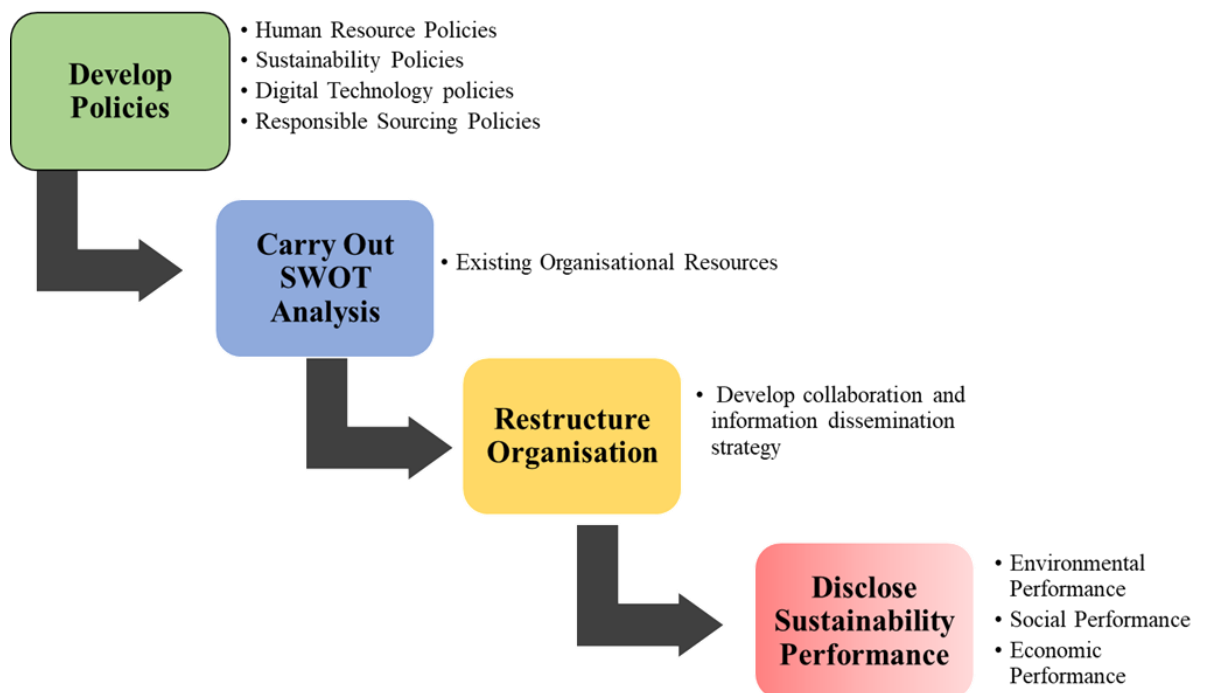


Figure 58: Recommendation for Implementation of Framework

10.5 Recommendation for further study

The findings revealed in this study provides the foundation for further research that will provide a broader understanding of sustainable procurement practice in the AEC sector. It would be beneficial to investigate how vertical integration by main contracting firms will drive sustainable construction practice and the impact on an organisation's operations. Likewise, further study will be required to understand the framework's implementation strategies by small and medium construction firms. Besides, exploring how structural dominance and power regime influences sustainable supply chain management will be interesting. These areas identified could be study using transaction cost economics theory (TCE) (Williamson, 1975), and diffusion of innovation theory (Rogers, 2010). Transaction Cost Economics theory could explore how the different types of cost (search and information, bargaining and decision, and policing and enforcement) could affect the operations of a firm in the adoption and implementation of sustainable procurement. Additionally, the TCE theory could explore how bounded rationality and opportunism could influence the relationship between main construction-contracting firms and their supply chains. On the other hand, adopting innovation or new practices does not happen simultaneously. Therefore, the diffusion of innovation theory could be used to study the various levels of adoption of sustainability internally (employees' level of understanding) and externally (supply chains level of adoption and understanding). Finally, the impact of BREXIT on the implementation and adoption of the framework needs to be further investigated and study need to be tested in the field.

REFERENCES

- Abalo, J., Varela, J., & Manzano, V. (2007). Importance values for Importance-Performance Analysis: A formula for spreading out values derived from preference rankings. *Journal of Business Research*, 60(2), 115-121.
- Abedi, M., Rawai, N. M., Fathi, M. S., & Mirasa, A. K. (2014). Cloud computing as a construction collaboration tool for precast supply chain management [Article]. *Jurnal Teknologi*, 70(7), 1-7. <https://doi.org/10.11113/jt.v70.3569>
- Abidin, N. A. Z., & Ingirige, B. (2018). Identification of the “Pathogenic” Effects of Disruptions to Supply Chain Resilience in Construction. *Procedia Engineering*, 212, 467-474. <https://doi.org/https://doi.org/10.1016/j.proeng.2018.01.060>
- Adams, C., Frost, G., & Webber, W. (2004). Triple Bottom Line: A Review of the Literature In Adrian, Henriques, & J. Richardson (Eds.), *The Triple Bottom Line: Does it All Add Up?* (pp. 17-25). Earthscan.
- Adenso-Díaz, B., Sarkis, J., & González, P. (2008). Environmental management system certification and its influence on corporate practices: Evidence from the automotive industry. *International Journal of Operations & Production Management*, 28(11), 1021-1041. <https://doi.org/10.1108/01443570810910179>
- Adetunji, I., Price, A., Fleming, P., & Kemp, P. (2003). Sustainability and the UK construction industry-a review. *Engineering Sustainability*, 156(4), 185-199. <https://doi.org/10.1680/ensu.156.4.185.36962>
- Adetunji, I. O., Price, A. D. F., & Fleming, P. R. (2008). Achieving sustainability in the construction supply chain.
- AECOM. (2018). *Sustaining Growth: AECOM Ireland Annual Review 2018*. C. Bank & A. Services. https://aecomtls.azurewebsites.net/annualreview/AECOM_REVIEW_2018.pdf

- Agarwal, R., Chandrasekaran, S., & Sridhar, M. (2018). The digital future of construction. <https://www.globalinfrastructureinitiative.com/article/digital-future-construction>
- Ageron, B., Gunasekaran, A., & Spalanzani, A. (2012). Sustainable supply management: An empirical study. *International Journal of Production Economics*, 140(1), 168-182.
- Aguilar-Saven, R. S. (2004). Business process modelling: Review and framework. *International Journal of production economics*, 90(2), 129-149.
- Ahmadian, A., Rashidi, T. H., Akbarnezhad, A., & Waller, S. T. (2017). BIM-enabled sustainability assessment of material supply decisions. *Engineering, Construction and Architectural Management*, 24(4), 668-695. <https://doi.org/10.1108/ECAM-12-2015-0193>
- Ahmadian F.F, A., Rashidi, T. H., Akbarnezhad, A., & Waller, S. T. (2017). BIM-enabled sustainability assessment of material supply decisions. *Engineering, Construction and Architectural Management*, 24(4), 668-695. <https://doi.org/10.1108/ECAM-12-2015-0193>
- Akanbi, L. A., Oyedele, L. O., Akinade, O. O., Ajayi, A. O., Davila Delgado, M., Bilal, M., & Bello, S. A. (2018). Salvaging building materials in a circular economy: A BIM-based whole-life performance estimator. *Resources, Conservation and Recycling*, 129, 175-186. <https://doi.org/https://doi.org/10.1016/j.resconrec.2017.10.026>
- Akintoye, A. (2000). Analysis of factors influencing project cost estimating practice. *Construction Management & Economics*, 18(1), 77-89.
- Akintoye, A., Goulding, J., & Zawdie, G. (2012). *Construction innovation and process improvement*. John Wiley & Sons.

- Akintoye, A., McIntosh, G., & Fitzgerald, E. (2000). A survey of supply chain collaboration and management in the UK construction industry. *European Journal of Purchasing & Supply Management*, 6(3), 159-168. [https://doi.org/https://doi.org/10.1016/S0969-7012\(00\)00012-5](https://doi.org/https://doi.org/10.1016/S0969-7012(00)00012-5)
- Akotia, J., & Fortune, C. (2012). Early stage evaluation of the socioeconomic benefits of built environment housing regeneration projects.
- Akotia, J., Opoku, A., Egbu, C., & Fortune, C. (2016). Exploring the knowledge 'base' of practitioners in the delivery of sustainable regeneration projects. *Construction Economics and Building*, 16(2), 14-26.
- Akotia, J., Opoku, A., & Hafiz, F. (2017). The Extent of Practitioners' Involvement in the Delivery of Sustainable Urban Regeneration Projects in UK. *European Journal of Sustainable Development*, 6(2), 147-164. <https://doi.org/http://dx.doi.org/10.14207/ejsd.2017.v6n2p147>
- Aktin, T., & Gergin, Z. (2016). Mathematical modelling of sustainable procurement strategies: three case studies. *Journal of Cleaner Production*, 113, 767-780.
- Al-Nassar, F., Ruparathna, R., Chhipi-Shrestha, G., Haider, H., Hewage, K., & Sadiq, R. (2016). Sustainability assessment framework for low rise commercial buildings: life cycle impact index-based approach [Article]. *Clean Technologies and Environmental Policy*, 18(8), 2579-2590. <https://doi.org/10.1007/s10098-016-1168-1>
- Alshaikh, F., Ramzan, F., Rawaf, S., & Majeed, A. (2014). Social Network Sites as a Mode to Collect Health Data: A Systematic Review. *J Med Internet Res*, 16(7), e171. <https://doi.org/10.2196/jmir.3050>
- Amaratunga, D., Baldry, D., Sarshar, M., & Newton, R. (2002). Quantitative and qualitative research in the built environment: application of "mixed" research approach. *Work study*, 51(1), 17-31.

- Amerise, I. L., & Tarsitano, A. (2015). Correction methods for ties in rank correlations. *Journal of Applied Statistics*, 42(12), 2584-2596. <https://doi.org/10.1080/02664763.2015.1043870>
- Anbari, F. T., Carayannis, E. G., & Voetsch, R. J. (2008). Post-project reviews as a key project management competence. *Technovation*, 28(10), 633-643.
- Ashby, A., Leat, M., & Hudson-Smith, M. (2012). Making connections: a review of supply chain management and sustainability literature. *Supply Chain Management: An International Journal*, 17(5), 497-516.
- Aslam, M., Gao, Z., & Smith, G. (2020). Exploring factors for implementing lean construction for rapid initial successes in construction. *Journal of Cleaner Production*, 277, 123295. <https://doi.org/https://doi.org/10.1016/j.jclepro.2020.123295>
- Bacon, M. (2012). *Pragmatism: An Introduction*. Polity Press.
- Baker, S. (2006). *Sustainable Development*. Routledge.
- Barbier, E. B. (1987). The Concept of Sustainable Economic Development. *Environmental Conservation*, 14(2), 101-110. <https://doi.org/10.1017/S0376892900011449>
- Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of management*, 17(1), 99-120.
- Barrett, P., & Sutrisna, M. (2009). Methodological strategies to gain insights into informality and emergence in construction project case studies. *Construction Management and Economics*, 27(10), 935-948.
- Barton, D. L. (1995). *Wellsprings of knowledge: Building and sustaining the sources of innovation*. Harvard Business School.
- Baxter, P., & Jack, S. (2008). Qualitative case study methodology: Study design and implementation for novice researchers. *The qualitative report*, 13(4), 544-559.

- Beck, P. (2005). Collaboration vs. Integration: Implications of a Knowledge-Based Future for the AEC Industry - Design Intelligence.
<https://www.di.net/articles/collaboration-vs-integration-implications-of-a-knowledge-based-future-for-the-aec-industry/>
- Belfit, R. J., Sexton, M., Schweber, L., & Handcock, B. (2011). Sustainable Procurement: Challenges for Construction Practice.
- Berardi, U. (2013). Clarifying the new interpretations of the concept of sustainable building. *Sustainable Cities and Society*, 8, 72-78.
<https://doi.org/https://doi.org/10.1016/j.scs.2013.01.008>
- Berry, C., & McCarthy, S. (2011). *Guide to sustainable procurement in construction*. CIRIA.
- Bildsten, L. (2011). Exploring the opportunities and barriers of using prefabricated house components. 19th Annual Conference of the International Group for Lean Construction 2011, IGLC 2011,
- Blaikie, N. (2010). *Designing Social Research* (2nd ed.). Polity Press.
- Bohari, A. A. M., Skitmore, M., Xia, B., & Zhang, X. (2016). Insights into the adoption of green construction in Malaysia: The drivers and challenges. *Environment-Behaviour Proceedings Journal*, 1(4), 45-53.
- Borghi, G., Pantini, S., & Rigamonti, L. (2018). Life cycle assessment of non-hazardous Construction and Demolition Waste (CDW) management in Lombardy Region (Italy). *Journal of Cleaner Production*, 184, 815-825.
<https://doi.org/https://doi.org/10.1016/j.jclepro.2018.02.287>
- Boyd, D., & Chinyio, E. (2008). *Understanding the construction client*. John Wiley & Sons.
- Boyd, P., & Schweber, L. (2012, 3 - 5 September). Variations in the mainstreaming of sustainability: A case study approach. Association of Researchers in Construction Management, ARCOM 2012 - Proceedings of the 28th Annual Conference, Edinburgh, UK.

- Brandon, P. S., & Lombardi, P. (2010). *Evaluating sustainable development in the built environment*. John Wiley & Sons.
- Bratt, C., Hallstedt, S., Robèrt, K. H., Broman, G., & Oldmark, J. (2013). Assessment of criteria development for public procurement from a strategic sustainability perspective. *Journal of Cleaner Production*, 52, 309-316.
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative research in psychology*, 3(2), 77-101.
- Breen, R. L. (2006). A Practical Guide to Focus-Group Research. *Journal of Geography in Higher Education*, 30(3), 463-475. <https://doi.org/10.1080/03098260600927575>
- Briscoe, G. H., Dainty, A. R. J., Millett, S. J., & Neale, R. H. (2004). Client-led strategies for construction supply chain improvement [Article]. *Construction Management and Economics*, 22(2), 193-201. <https://doi.org/10.1080/0144619042000201394>
- British Standard Institution (BSI). (2010). Principles and framework for procuring sustainably. In *BS 8903*. London: BSI Standards Publication.
- Brockhaus, S., Kersten, W., & Knemeyer, A. M. (2013). Where do we go from here? Progressing sustainability implementation efforts across supply chains. *Journal of Business Logistics*, 34(2), 167-182.
- Broft, R. (2017). Exploring the application of Lean principles to a construction supply chain. IGLC 2017 - Proceedings of the 25th Annual Conference of the International Group for Lean Construction,
- Bromiley, P., & Rau, D. (2016). Operations management and the resource based view: Another view. *Journal of Operations Management*, 41, 95-106.
- Brooks, T., Scott, L., Spillane, J. P., & Hayward, K. (2020). Irish construction cross border trade and Brexit: Practitioner perceptions on the periphery of Europe. *Construction Management and Economics*, 38(1), 71-90.

- Bryman, A. (2016). *Social research methods*. Oxford university press.
- Build Up. (2016). *European countries lead in global green building*. Retrieved 15/04 from
- Build Up. (2019). *Zero-Energy Buildings: does the definition influence their design and implementation?* . Retrieved 19th September from <https://www.buildup.eu/en/news/overview-zero-energy-buildings-does-definition-influence-their-design-and-implementation>
- Business and Sustainable Development Commission. (2017). *BETTER BUSINESS BETTER WORLD* (The report of the Business & Sustainable Development Commission, Issue. B. a. S. D. Commission. http://report.businesscommission.org/uploads/BetterBiz-BetterWorld_170215_012417.pdf
- Butler, T., & Pyke, A. (2003). Examining the influence of ERP systems on firm specific knowledge and core capabilities: A case study of SAP implementation and use. *ECIS 2003 Proceedings*, 2.
- Büyüközkan, G., Tüfekçi, G., & Uztürk, D. (2021). Evaluating Blockchain Requirements for Effective Digital Supply Chain Management. *International Journal of Production Economics*, 108309. <https://doi.org/https://doi.org/10.1016/j.ijpe.2021.108309>
- Caradonna, J. L. (2014). *Sustainability: A history*. Oxford University Press.
- Carter, C., Ketchen, D., & Kaufmann, L. (2021). CONFIGURATIONAL APPROACHES TO THEORY DEVELOPMENT IN SUPPLY CHAIN MANAGEMENT: LEVERAGING UNDEREXPLORED OPPORTUNITIES [<https://doi.org/10.1111/jscm.12275>]. *Journal of Supply Chain Management*, n/a(n/a). <https://doi.org/https://doi.org/10.1111/jscm.12275>
- Carter, C. R., & Rogers, D. S. (2008). A framework of sustainable supply chain management: moving toward new theory. *International journal of physical distribution & logistics management*, 38(5), 360-387.

- Carter, K., & Fortune, C. (2003). Procuring sustainable projects: A grounded approach.
- Carvalho, M. M., & Rabechini, R. (2017). Can project sustainability management impact project success? An empirical study applying a contingent approach. *International Journal of Project Management*, 35(6), 1120-1132. <https://doi.org/https://doi.org/10.1016/j.ijproman.2017.02.018>
- Central Statistics Office. (2018). *Production in Building and Construction Index Quarter 1 2018 - CSO - Central Statistics Office*. CSO. <https://www.cso.ie/en/releasesandpublications/er/pbci/productioninbuildingandconstructionindexquarter12018/>
- Chang, R.-d., Soebarto, V., Zhao, Z.-y., & Zillante, G. (2016). Facilitating the transition to sustainable construction: China's policies. *Journal of Cleaner Production*, 131, 534-544. <https://doi.org/https://doi.org/10.1016/j.jclepro.2016.04.147>
- Chang, R.-d., Zuo, J., Soebarto, V., Zhao, Z.-y., Zillante, G., & Gan, X.-l. (2016). Sustainability Transition of the Chinese Construction Industry: Practices and Behaviors of the Leading Construction Firms. *Journal of Management in Engineering*, 32(4), 05016009. [https://doi.org/10.1061/\(ASCE\)ME.1943-5479.0000439](https://doi.org/10.1061/(ASCE)ME.1943-5479.0000439)
- Chang, R.-d., Zuo, J., Soebarto, V., Zhao, Z.-y., Zillante, G., & Gan, X.-l. (2017). Discovering the Transition Pathways toward Sustainability for Construction Enterprises: Importance-Performance Analysis. *Journal of Construction Engineering and Management*, 04017013.
- Chang, R.-D., Zuo, J., Zhao, Z.-Y., Soebarto, V., Lu, Y., Zillante, G., & Gan, X.-L. (2017). Sustainability attitude and performance of construction enterprises: A China study. *Journal of Cleaner Production*. <https://doi.org/https://doi.org/10.1016/j.jclepro.2017.10.277>
- Chardine-Baumann, E., & Botta-Genoulaz, V. (2014). A framework for sustainable performance assessment of supply chain management practices. *Computers & Industrial Engineering*, 76, 138-147. <https://doi.org/https://doi.org/10.1016/j.cie.2014.07.029>

- Chartered Institute of Procurement & Supply. (2018). *What is procurement and supply?*
<https://www.cips.org/cips-for-individuals/what-is-procurement/>
- Cheah, C. Y. J., & Garvin, M. J. (2004). An open framework for corporate strategy in construction. *Engineering, Construction and Architectural Management*, 11(3), 176-188.
- Cheng, C.-C., Pouffary, S., Svenningsen, N., & Callaway, J. M. (2008). *The Kyoto Protocol, The clean development mechanism and the building and construction sector-A report for the UNEP Sustainable Buildings and Construction Initiative*.
<https://core.ac.uk/download/pdf/13709614.pdf>
- Chiarini, A., Opoku, A., & Vagnoni, E. (2017). Public healthcare practices and criteria for a sustainable procurement: A comparative study between UK and Italy [Article]. *Journal of Cleaner Production*, 162, 391-399.
<https://doi.org/10.1016/j.jclepro.2017.06.027>
- Chinyio, E., & Olomolaiye, P. (2009). *Construction stakeholder management*. John Wiley & Sons.
- Cole, R. J. (1999). Building environmental assessment methods: clarifying intentions. *Building Research & Information*, 27(4-5), 230-246.
<https://doi.org/10.1080/096132199369354>
- Colquhoun, G. J., Baines, R. W., & Crossley, R. (1993). A state of the art review of IDEFO. *International journal of computer integrated manufacturing*, 6(4), 252-264.
- Considerate Constructors Scheme. (2018). *History of the Considerate Constructors Scheme*. Considerate Constructors Scheme,. Retrieved 2nd February from
- Constructing Excellence. (2010). Integration and Collaborative Working. Retrieved 2010-02-10, from <http://constructingexcellence.org.uk/integration-and-collaborative-working/>
- Coolican, H. (2018). *Research methods and statistics in psychology*. Routledge.

- Coulson, J. (2014). *Sustainable use of wood in construction*. John Wiley & Sons.
- Cox, A. (2001). Understanding buyer and supplier power: a framework for procurement and supply competence. *Journal of Supply Chain Management*, 37(1), 8-15.
- Cox, A. (2007). Transactions, power and contested exchange: towards a theory of exchange in business relationships. *International Journal of Procurement Management*, 1(1-2), 38-59.
- Cox, A., & Ireland, P. (2002). Managing construction supply chains: the common sense approach. *Engineering, Construction and Architectural Management*, 9(5/6), 409-418.
- Craggs, D., Crilly, M., & Dawood, N. (2016, 11th - 13th December 2016,). *Reality Capture for BIM-Application, evaluation and integration within an architectural plan of works* ICONVR 2016-16th, International Conference on Construction Applications of Virtual Reality, Hong Kong. <http://nrl.northumbria.ac.uk/34039/1/Craggs%20et%20al%20-%20Reality%20Capture%20for%20BIM.pdf>
- Creswell, J. W. (2007). *Qualitative inquiry and Research design: Choosing among five approaches* (2nd ed.). Sage Publications Inc.
- Creswell, J. W. (2014). *Research design: qualitative, quantitative, and mixed methods approaches*. SAGE Publications.
- Crotty, M. (1998). *The Foundations of Social Research: Meaning and Perspective in the Research Process*. SAGE.
- Dadhich, P., Genovese, A., Kumar, N., & Acquaye, A. (2015). Developing sustainable supply chains in the UK construction industry: A case study. *International Journal of Production Economics*, 164, 271-284. <https://doi.org/https://doi.org/10.1016/j.ijpe.2014.12.012>

- Darko, A., & Chan, A. P. C. (2016). Critical analysis of green building research trend in construction journals. *Habitat International*, 57(Supplement C), 53-63. <https://doi.org/https://doi.org/10.1016/j.habitatint.2016.07.001>
- De Giacomo, M. R., Testa, F., Iraldo, F., & Formentini, M. (2018). Does Green Public Procurement lead to Life Cycle Costing (LCC) adoption? *Journal of Purchasing and Supply Management*. <https://doi.org/https://doi.org/10.1016/j.pursup.2018.05.001>
- De Melo, R. S. S., & Da Alves, T. C. L. (2010). Investigation of the supply chain of prefabricated wooden doors. Challenging Lean Construction Thinking: What Do We Think and What Do We Know? - 18th Annual Conference of the International Group for Lean Construction, IGLC 18,
- de Winter, J. C. F., Dodou, D., & Wieringa, P. A. (2009). Exploratory factor analysis with small sample sizes. *Multivariate behavioral research*, 44(2), 147-181.
- Demaid, A., & Quintas, P. (2006). Knowledge across cultures in the construction industry: sustainability, innovation and design. *Technovation*, 26(5), 603-610. <https://doi.org/http://dx.doi.org/10.1016/j.technovation.2005.06.003>
- Denscombe, M. (2002). Ground Rules for Good Research: A 10 Point Guide for Social Research.
- Denscombe, M. (2014). *The good research guide: for small-scale social research projects*. McGraw-Hill Education (UK).
- Department for Environment Food and Rural Affairs. (2013). *London 2012 Olympic and Paralympic Games The Legacy: Sustainable Procurement for Construction Projects- A Guide* Department for Environment Food Rural Affairs.
- Department of Commerce. (1993). *Draft Federal Information Processing Standards Publication 183: Announcing the Standard for INTEGRATION DEFINITION FOR FUNCTION MODELING (IDEF0)*. <https://nvlpubs.nist.gov/nistpubs/Legacy/FIPS/fipspub183.pdf>

- Department of Communications Climate Action and Environment. (2012). *Energy Performance of Buildings Directive (EPBD)*. [https://www.dccae.gov.ie/en-ie/energy/legislation/Pages/Energy-Performance-of-Buildings-Directive-\(EPBD\).aspx](https://www.dccae.gov.ie/en-ie/energy/legislation/Pages/Energy-Performance-of-Buildings-Directive-(EPBD).aspx)
- Dewick, P., & Miozzo, M. (2002). Sustainable technologies and the innovation–regulation paradox. *Futures*, *34*(9-10), 823-840.
- Doan, D. T., Ghaffarianhoseini, A., Naismith, N., Zhang, T., Ghaffarianhoseini, A., & Tookey, J. (2017). A critical comparison of green building rating systems. *Building and Environment*, *123*, 243-260. <https://doi.org/https://doi.org/10.1016/j.buildenv.2017.07.007>
- Dodge Data & Analytics. (2016). *World Green Building Trends 2016, Smart Market Report*. (Developing Markets Accelerate Global Green Growth, Issue. <http://fidic.org/sites/default/files/World%20Green%20Building%20Trends%202016%20SmartMarket%20Report%20FINAL.pdf>
- Dorador, J. M., & Young, R. I. M. (2000). Application of IDEF0, IDEF3 and UML methodologies in the creation of information models. *International Journal of Computer Integrated Manufacturing*, *13*(5), 430-445.
- Du Plessis, C. (2002). Agenda 21 for sustainable construction in developing countries. *CSIR Report BOU E*, 204.
- Dubois, A., & Gadde, L.-E. (2002). Systematic combining: an abductive approach to case research. *Journal of business research*, *55*(7), 553-560.
- Dyer Jr, W. G., & Wilkins, A. L. (1991). Better stories, not better constructs, to generate better theory: A rejoinder to Eisenhardt. *Academy of management review*, *16*(3), 613-619.
- Easterby-Smith, M., Thorpe, R., & Jackson, P. R. (2015). *Management and business research*. Sage.

- Edum-Fotwe, F. T., & Price, A. D. F. (2009). A social ontology for appraising sustainability of construction projects and developments. *International Journal of Project Management*, 27(4), 313-322. <https://doi.org/http://dx.doi.org/10.1016/j.ijproman.2008.04.003>
- Egan, J. (1998). Rethinking construction, construction task force report for department of the environment, transport and the regions. In: HMSO, London.
- Egemen, M., & Mohamed, A. N. (2006). Clients' needs, wants and expectations from contractors and approach to the concept of repetitive works in the Northern Cyprus construction market. *Building and Environment*, 41(5), 602-614.
- Eiadat, Y., Kelly, A., Roche, F., & Eyadat, H. (2008). Green and competitive? An empirical test of the mediating role of environmental innovation strategy. *Journal of World Business*, 43(2), 131-145.
- Eilers, H., Chong, W., Kim, J., Naganathan, H., & Glavinich, T. E. (2016). Impact of sustainability on business performance and strategy for commercial building contractors. *World Journal of Entrepreneurship, Management and Sustainable Development*, 12(4), 323-343. <https://doi.org/10.1108/wjemsd-07-2016-0032>
- Eisenhardt, K. M. (1989). Building theories from case study research. *Academy of management review*, 14(4), 532-550.
- Elkington, J. (1994). Towards the sustainable corporation: Win-win-win business strategies for sustainable development. *California management review*, 36(2), 90-100.
- Elkington, J. (1997). Cannibals with forks: The triple bottom line of twentieth century business. *Capstone: Oxford*.
- Elkington, J. (2004). Enter the triple bottom line. In A. Henriques & J. Richardson (Eds.), *The Triple Bottom Line: Does It All Add up?* (pp. 1-16). Routledge.

- Emuze, F., & Smallwood, J. J. (2014). Collaborative working in South African construction: Contractors' perspectives [Article]. *Journal of Engineering, Design and Technology*, 12(3), 294-306. <https://doi.org/10.1108/JEDT-08-2010-0057>
- Energy Efficiency Financial Institutions Group. (2017). *The Energy Efficiency De-risking Project*. <http://eefig.eu/index.php/about-the-project>
- Enshassi, A., Ayash, A., & Mohamed, S. (2018). Key barriers to the implementation of energy-management strategies in building construction projects. *International Journal of Building Pathology and Adaptation*, 36(1), 15-40. <https://doi.org/10.1108/IJBPA-09-2017-0043>
- Environmental Protection Agency. (2014). *Green Procurement— Guidance for the Public Sector*. <http://www.epa.ie/pubs/reports/other/corporate/olg/GreenPublicProcurementfinalwebv2.pdf>
- Eriksson, K., & Lindström, U. Å. (1997). Abduction—a way to deeper understanding of the world of caring. *Scandinavian journal of caring sciences*, 11(4), 195-198.
- Ethical Corporation. (2018). *The Responsible Business Trends Report*. http://1.ethicalcorp.com/LP=20703?utm_campaign=1679-16MAY18-Content-Autoresponder&utm_medium=email&utm_source=Eloqua&elqTrackId=395bf61d12d44ee7922a14535f85f948&elq=f7da2db6716a45ff9c90c2a7f4f33915&elqaid=36519&elqat=1&elqCampaignId=
- European Commission. (2020). *Internal Market, Industry, Entrepreneurship and SMEs*. Retrieved 08/10 from https://ec.europa.eu/growth/smes/sme-definition_en
- European Union. (2012). *Energy Performance of Building Regulations 2012* (S.I. No. 243 of 2012, Issue. <http://www.irishstatutebook.ie/eli/2012/si/243/made/en/pdf>
- Fang, D., Li, M., Fong, P. S. W., & Shen, L. (2004). Risks in Chinese construction market - Contractors' perspective [Review]. *Journal of Construction Engineering and Management*, 130(6), 853-861. [https://doi.org/10.1061/\(ASCE\)0733-9364\(2004\)130:6\(853\)](https://doi.org/10.1061/(ASCE)0733-9364(2004)130:6(853))

- Farmer, M. (2017). Collaborate or die. *Construction Journal*, 15-17.
- Farrell, P., Sherratt, F., & Richardson, A. (2016). *Writing Built Environment Dissertations and Projects: Practical Guidance and Examples*. John Wiley & Sons.
- Fellows, R. (2006). Sustainability: a matter of energy? *Property Management*, 24(2), 116-131. <https://doi.org/10.1108/02637470610658005>
- Fellows, R., & Liu, A. M. M. (2020). Borrowing theories: contextual and empirical considerations. *Construction Management and Economics*, 38(7), 581-588.
- Fellows, R. F., & Liu, A. M. M. (2008). *Research Methods for Construction*. In: Wiley-Blackwell.
- Fernie, S. (2005). Making sense of supply chain management in UK construction organisations: theory versus practice.
- Field, A. (2017). *Discovering statistics using IBM SPSS statistics: North American edition* (5th ed.). Sage.
- Flick, U. (2007). *Designing qualitative research* [doi:10.4135/9781849208826]. Sage Publications Ltd. <https://doi.org/10.4135/9781849208826>
- Francis, A., & Thomas, A. (2020). Exploring the relationship between lean construction and environmental sustainability: A review of existing literature to decipher broader dimensions. *Journal of Cleaner Production*, 252, 119913. <https://doi.org/https://doi.org/10.1016/j.jclepro.2019.119913>
- Frooman, J. (1999). Stakeholder influence strategies. *Academy of management review*, 24(2), 191-205.
- FSC. (2020). *Forest Stewardship Council*. Retrieved 28th September, from <https://fsc.org/en/chain-of-custody-certification>

- Gan, V. J. L., Cheng, J. C. P., Lo, I. M. C., & Chan, C. M. (2017). Developing a CO₂-e accounting method for quantification and analysis of embodied carbon in high-rise buildings. *Journal of Cleaner Production*, *141*, 825-836. <https://doi.org/https://doi.org/10.1016/j.jclepro.2016.09.126>
- Garcia, A. J., Mollaoglu-Korkmaz, S., & Miller, V. D. (2014, 2014). Progress loops in interorganizational project teams: An IPD case.
- Gerring, J. (2007). *Case study research: principles and practices* (052185928X).
- Ghazy, M. M., El-Kilany, K. S., & Fors, M. N. (2008, 2008). Structured System Analysis Methodology for Developing a Production Planning Model.
- Gill, J., & Johnson, P. (2002). *Research methods for managers*. Sage.
- Glass, J. (2012). The state of sustainability reporting in the construction sector. *Smart and Sustainable Built Environment*, *1*(1), 87-104. <https://doi.org/https://doi.org/10.1108/20466091211227070>
- Glass, J., & Simmonds, M. (2007). "Considerate construction": case studies of current practice. *Engineering, Construction and Architectural Management*, *14*(2), 131-149.
- Global Legal Insights. (2021). *Bribery and Corruption Laws and Regulations-Australia*. Retrieved 04/03/2021 from <https://www.globallegalinsights.com/practice-areas/bribery-and-corruption-laws-and-regulations/australia>
- Glover, J. L., Champion, D., Daniels, K. J., & Dainty, A. J. D. (2014). An Institutional Theory perspective on sustainable practices across the dairy supply chain. *International Journal of Production Economics*, *152*, 102-111. <https://doi.org/https://doi.org/10.1016/j.ijpe.2013.12.027>
- Goh, E., & Loosemore, M. (2017). The impacts of industrialization on construction subcontractors: a resource based view. *Construction management and economics*, *35*(5), 288-304.

- Gosling, J., Naim, M., Towill, D., Abouarghoub, W., & Moone, B. (2015). Supplier development initiatives and their impact on the consistency of project performance. *Construction Management and Economics*, 33(5-6), 390-403. <https://doi.org/10.1080/01446193.2015.1028956>
- Gough, S., & Scott, W. (2003). *Sustainable development and learning: Framing the issues*. Routledge.
- Government of Ireland. (2018a). *Project Ireland 2040*. <http://www.gov.ie/en/project-ireland-2040>
- Government of Ireland. (2018b). The Sustainable Development Goals National Implementation Plan 2018-2020. <https://www.dccae.gov.ie/documents/DCCAE-National-Implement-Plan.pdf>
- Government of Ireland. (2019a). *Climate Action Plan 2019*,. Retrieved 27th June from <https://assets.gov.ie/10206/d042e174c1654c6ca14f39242fb07d22.pdf>
- Government of Ireland. (2019b). *Press Release*. Retrieved 10/10/20 from <https://www.gov.ie/en/press-release/f633a8-government-takes-further-steps-to-promote-green-public-procurement/>
- Government of Ireland. (2019c). *Project Ireland 2040 (Build Construction Sector Performance and Prospects 2019 Issue*. <https://assets.gov.ie/6659/3312cd28edf04f4c83666ac76b534c45.pdf>
- Govindan, K., Seuring, S., Zhu, Q., & Azevedo, S. G. (2016). Accelerating the transition towards sustainability dynamics into supply chain relationship management and governance structures. *Journal of Cleaner Production*, 112, Part 3, 1813-1823. <https://doi.org/https://doi.org/10.1016/j.jclepro.2015.11.084>
- Grant, C., & Osanloo, A. (2014). Understanding, selecting, and integrating a theoretical framework in dissertation research: Creating the blueprint for your “house”. *Administrative Issues Journal*, 4(2), 4.
- Gray, D. E. (2013). *Doing research in the real world*. Sage.

- Grob, S., & Benn, S. (2014). Conceptualising the adoption of sustainable procurement: an institutional theory perspective. *Australasian Journal of Environmental Management*, 21(1), 11-21.
- Guba, E. G., & Lincoln, Y. S. (1994). Competing paradigms in qualitative research. *Handbook of qualitative research*, 2(163-194), 105.
- Gultekin, P., Mollaoglu-Korkmaz, S., Riley, D. R., & Leicht, R. M. (2013). Process indicators to track effectiveness of high-performance green building projects. *Journal of Construction Engineering and Management*, 139(12), A4013005.
- Hammersley, M. (1992). *What's Wrong with Ethnography?: Methodological Explorations*. Psychology Press.
- Hamza, N., & Greenwood, D. (2007, 3-5 September). The Impact of Procurement Methods on Delivering Environmentally Sensitive Buildings. 23rd Association of Researchers in Construction Management, Belfast, UK.
- Hardie, M. (2010). Influences on innovation in small Australian construction businesses [Article]. *Journal of Small Business and Enterprise Development*, 17(3), 387-402. <https://doi.org/10.1108/14626001011068699>
- Hardie, M., Allen, J., & Newell, G. (2013). Environmentally driven technical innovation by Australian construction SMEs [Article]. *Smart and Sustainable Built Environment*, 2(2), 179-191. <https://doi.org/10.1108/SASBE-01-2013-0003>
- Hardie, M., & Newell, G. (2011). Factors influencing technical innovation in construction SMEs: An Australian perspective [Review]. *Engineering, Construction and Architectural Management*, 18(6), 618-636. <https://doi.org/10.1108/09699981111180926>
- Harman, G. H. (1965). The inference to the best explanation. *The philosophical review*, 74(1), 88-95.

- Harmon, P. (2009). Deming, IT, and BPM IDEF0 Diagrams. Retrieved 27th July 2020, from <https://www.bptrends.com/publicationfiles/advisor20090428.pdf>
https://www.researchgate.net/publication/313894291_Deming_IT_and_BPM_IDEF0_Diagrams
- Hart, S. L. (1995). A natural-resource-based view of the firm. *Academy of management review*, 20(4), 986-1014.
- Harvey, J. B. (1974). The abilene paradox: The management of agreement. *Organizational Dynamics*, 3(1), 63-80.
[https://doi.org/https://doi.org/10.1016/0090-2616\(74\)90005-9](https://doi.org/https://doi.org/10.1016/0090-2616(74)90005-9)
- Haugbølle, K., Forman, M., & Gottlieb, S. C. (2012, 2012). Driving sustainable innovation through procurement of complex products and systems in construction.
- Havenga, Y., Poggenpoel, M., & Myburgh, C. (2014). Developing a model: An illustration. *Nursing Science Quarterly*, 27(2), 149-156.
- Helfat, C. E., & Peteraf, M. A. (2003). The dynamic resource-based view: Capability lifecycles. *Strategic management journal*, 24(10), 997-1010.
- Higham, A. P., Fortune, C., & Boothman, J. C. (2016). Sustainability and investment appraisal for housing regeneration projects [Article]. *Structural Survey*, 34(2), 150-167. <https://doi.org/10.1108/SS-09-2015-0044>
- Hill, R. C., & Bowen, P. A. (1997). Sustainable construction: principles and a framework for attainment. *Construction Management & Economics*, 15(3), 223-239.
- Hindle, K. (2010). Modelling Business Processes. In D. Paul, D. Yeates, & J. Cadle (Eds.), *Business Analysis*. BCS, The Chartered Institute. (2nd ed., pp. 127-148). British Informatics Society Limited.
- Hoejmose, S. U., & Adrien-Kirby, A. J. (2012). Socially and environmentally responsible procurement: A literature review and future research agenda of a managerial issue

in the 21st century. *Journal of Purchasing and Supply Management*, 18(4), 232-242.

Hoffman, A. J., & Henn, R. (2008). Overcoming the social and psychological barriers to green building. *Organization & Environment*, 21(4), 390-419.

Hojem, T. S. M., Sørensen, K. H., & Lagesen, V. A. (2014). Designing a 'green' building: expanding ambitions through social learning. *Building Research & Information*, 42(5), 591-601. <https://doi.org/10.1080/09613218.2014.905168>

Holt, G. D., & Goulding, J. S. (2014). Conceptualisation of ambiguous-mixed-methods within building and construction research. *Journal of Engineering, Design and Technology*, 12(2), 244-262. <https://doi.org/10.1108/JEDT-02-2013-0020>

Holt, G. D., & Goulding, J. S. (2017). PROD2UCT: an outcome-oriented dissertation study model for construction engineering students. *Journal of Engineering, Design and Technology*, 15(1), 104-117. <https://doi.org/10.1108/JEDT-10-2015-0068>

Hong, P., & Kwon, H.-B. (2012). Emerging issues of procurement management: a review and prospect. *International Journal of Procurement Management* 4, 5(4), 452-469.

Hoxley, M. (2008). Questionnaire design and factor analysis. In A. Knight & L. Ruddock. (Eds.), *Advance Research Methods in the Built Environment* . (pp. 122-134). Wiley-Blackwell.

Hughes, W., Hillebrandt, P. M., Greenwood, D., & Kwawu, W. (2006). *Procurement in the construction industry: the impact and cost of alternative market and supply processes*. Routledge.

Hwang, B.-G., & Tan, J. S. (2012). Green building project management: obstacles and solutions for sustainable development. *Sustainable Development*, 20(5), 335-349. <https://doi.org/10.1002/sd.492>

- Häkkinen, T., Kuittinen, M., Ruuska, A., & Jung, N. (2015). Reducing embodied carbon during the design process of buildings [Article]. *Journal of Building Engineering*, 4, 1-13. <https://doi.org/10.1016/j.jobe.2015.06.005>
- IDEF. *Integrated DEFinition Methods (IDEF)*. Retrieved 14th July 2020 from <https://www.idef.com/idef3-process-description-capture-method/>
- Iles, D., & Ryall, P. (2016). How Can The United Kingdom Construction Industry Implement Sustainable Procurement Strategies?. 32nd Annual ARCOM Conference, 5-7 September 2016, Association of Researchers in Construction Management, , Manchester, UK,.
- Inglis, A. (2008). Approaches to the validation of quality frameworks for e-learning. *Quality Assurance in Education*.
- International Organization for Standardization. (2017a). *ISO 20400 - Sustainable Procurement*. <https://www.iso.org/publication/PUB100410.html>
- International Organization for Standardization. (2017b). *Sustainable procurement -- Guidance (ISO 20400:2017)*. I. O. f. Standardization. http://gpp.golocal-ukraine.com/wp-content/uploads/ISO_20400_2017E-Character_PDF_document.pdf, <https://www.iso.org/standard/63026.html>
- IPCC. (2018). *Global Warming of 1.5°C*. <https://www.ipcc.ch/2018/10/08/summary-for-policymakers-of-ipcc-special-report-on-global-warming-of-1-5c-approved-by-governments/>
- Irish Building. (2017). *Considerate Constructors Scheme*,. Irish Building Magazine,. Retrieved 26th June from <https://www.irishbuildingmagazine.ie/2017/09/13/considerate-constructors-scheme-reaches-major-100000-milestone/>
- Irish Green Building Council (IGBC). (2018). CREATING AN ENERGY EFFICIENT MORTGAGE FOR EUROPE BUILDING ASSESSMENT BRIEFING: IRELAND. In *'Energy Efficient Mortgages Action Plan' initiative*.

- Irizarry, J., Karan, E. P., & Jalaei, F. (2013). Integrating BIM and GIS to improve the visual monitoring of construction supply chain management [Article]. *Automation in Construction*, 31, 241-254. <https://doi.org/10.1016/j.autcon.2012.12.005>
- Jackson, K. M., Pukys, S., Castro, A., Hermosura, L., Mendez, J., Vohra-Gupta, S., . . . Morales, G. (2018). Using the transformative paradigm to conduct a mixed methods needs assessment of a marginalized community: Methodological lessons and implications. *Evaluation and Program Planning*, 66, 111-119. <https://doi.org/https://doi.org/10.1016/j.evalprogplan.2017.09.010>
- Jelodar, M. B., Yiu, T. W., & Wilkinson, S. (2013, 2013). Stirring sustainable procurement by conceptualizing relationship quality in construction.
- Jeurissen, R. (2000). John Elkington, Cannibals with forks: The triple bottom line of 21st century business. *Journal of Business Ethics*, 23(2), 229-231.
- Johnson, R. B., & Onwuegbuzie, A. J. (2004). Mixed methods research: A research paradigm whose time has come. *Educational researcher*, 33(7), 14-26.
- Jones, K., Desai, A., Mulville, M., & Jones, A. (2015). Asset management using a hybrid backcasting/forecasting approach. *Facilities*, 33(11/12), 701-715. <https://doi.org/10.1108/F-11-2014-0090>
- Josephson, J. R., & Josephson, S. G. (1996). *Abductive inference: Computation, philosophy, technology*. Cambridge University Press.
- Kamann, D.-J. F. (2007). Organizational design in public procurement: A stakeholder approach. *Journal of Purchasing and Supply Management*, 13(2), 127-136. <https://doi.org/https://doi.org/10.1016/j.pursup.2007.05.002>
- Kannan, D. (2021). Sustainable procurement drivers for extended multi-tier context: A multi-theoretical perspective in the Danish supply chain. *Transportation Research Part E: Logistics and Transportation Review*, 146, 102092. <https://doi.org/https://doi.org/10.1016/j.tre.2020.102092>

- Karatas, A., Stoiko, A., & Menassa, C. C. (2016). Framework for selecting occupancy-focused energy interventions in buildings. *Building Research & Information*, 44(5-6), 535-551. <https://doi.org/10.1080/09613218.2016.1182330>
- Karim, K., Marosszeky, M., & Davis, S. (2006). Managing subcontractor supply chain for quality in construction. *Engineering, Construction and Architectural Management*, 13(1), 27-42. <https://doi.org/10.1108/09699980610646485>
- Kashyap, K., & Parida, S. D. (2017). Closing the Loop between Building Sustainability and Stakeholder Engagement: Case Study of an Australian University. *World Academy of Science, Engineering and Technology, International Journal of Civil, Environmental, Structural, Construction and Architectural Engineering*, 11(3), 262-269.
- Kats, G. (2003). *Green building costs and financial benefits*.
- Kaushik, V., & Walsh, C. A. (2019). Pragmatism as a Research Paradigm and Its Implications for Social Work Research. *Social Sciences*, 8(9), 255.
- Kavishe, N., & Chileshe, N. (2019). Development and validation of public–private partnerships framework for delivering housing projects in developing countries: a case of Tanzania. *International Journal of Construction Management*, 1-18.
- Kenichi, M., & Russell, D. (1994). Keiretsu: Inside the Hidden Japanese Conglomerates. In: McGraw-Hill, New York, NY.
- Kenley, R., Hampson, K. D., Bedggood, J., Harfield, T., & Sanchez, A. (2014). Sustainability non-price incentives and rewards: a collaborative procurement perspective.
- Kesidou, S. L., & Sorrell, S. (2018). Low-carbon innovation in non-domestic buildings: The importance of supply chain integration. *Energy Research & Social Science*. <https://doi.org/https://doi.org/10.1016/j.erss.2018.07.018>
- Ketokivi, M., & Choi, T. (2014). Renaissance of case research as a scientific method. *Journal of Operations Management*, 32(5), 232-240.

- Kibert, C. J. (2007). The next generation of sustainable construction. *Building Research & Information*, 35(6), 595-601. <https://doi.org/10.1080/09613210701467040>
- Kim, S.-H., & Jang, K.-J. (2002). Designing performance analysis and IDEF0 for enterprise modelling in BPR. *International Journal of production economics*, 76(2), 121-133.
- Kim, Y. W., Han, S. H., Yi, J. S., & Chang, S. W. (2016). Supply chain cost model for prefabricated building material based on time-driven activity-based costing [Article]. *Canadian Journal of Civil Engineering*, 43(4), 287-293. <https://doi.org/10.1139/cjce-2015-0010>
- Klewitz, J., & Hansen, E. G. (2014). Sustainability-oriented innovation of SMEs: a systematic review. *Journal of Cleaner Production*, 65, 57-75. <https://doi.org/http://dx.doi.org/10.1016/j.jclepro.2013.07.017>
- Knight, A., & Turnbull, N. (2009). Epistemology. In A. Knight & L. Ruddock (Eds.), *Advanced Research Methods in the Built Environment* (pp. 66-74). John Wiley & Sons,.
- Koolwijk, J. S. J., Van Oel, C. J., Wamelink, J. W. F., & Vrijhoef, R. (2018). Collaboration and Integration in Project-Based Supply Chains in the Construction Industry [Article]. *Journal of Management in Engineering*, 34(3), Article 04018001. [https://doi.org/10.1061/\(ASCE\)ME.1943-5479.0000592](https://doi.org/10.1061/(ASCE)ME.1943-5479.0000592)
- Korkmaz, S., & Singh, A. (2011). Impact of team characteristics in learning sustainable built environment practices. *Journal of professional issues in engineering education and practice*, 138(4), 289-295.
- Koskela, L. (1992). *Application of the new production philosophy to construction* (Vol. 72). Citeseer.
- Koskela, L. (2008). Is a theory of the built environment needed? *Building Research & Information*, 36(3), 211-215. <https://doi.org/10.1080/09613210801936530>

- Kralik, N., & Chrzan, J. (2020). *Sustainable Procurement for Infrastructure* [doi:10.1061/9780784483107]. The American Society of Civil Engineers. <https://doi.org/doi:10.1061/9780784483107>
- Krause, D. R., Scannell, T. V., & Calantone, R. J. (2000). A structural analysis of the effectiveness of buying firms' strategies to improve supplier performance. *Decision sciences*, *31*(1), 33-55.
- Krosnick, C. A., & Presser, S. (2010). Question and Questionnaire Design. In P. V. Marsden & J. D. Wright (Eds.), *Handbook of survey research* (pp. 263-313). Emerald Group Publishing.
- Kumar, D., & Rahman, Z. (2016). Buyer supplier relationship and supply chain sustainability: empirical study of Indian automobile industry. *Journal of Cleaner Production*, *131*, 836-848. <https://doi.org/https://doi.org/10.1016/j.jclepro.2016.04.007>
- Kuper, S. (2014). Thoreau, Leopold, and Carson: Challenging Capitalist Conceptions of the Natural Environment. *Consilience: The Journal of Sustainable Development*, *13*(1), 267-284.
- Kurdve, M., & Bellgran, M. (2021). Green lean operationalisation of the circular economy concept on production shop floor level. *Journal of Cleaner Production*, *278*, 123223. <https://doi.org/https://doi.org/10.1016/j.jclepro.2020.123223>
- Kvale, S. (2008). *Doing interviews*. Sage.
- Kähkönen, A.-K., & Lintukangas, K. (2012). The underlying potential of supply management in value creation. *Journal of Purchasing and Supply Management*, *18*(2), 68-75.
- Lam, P. T. I., Chan, E. H. W., Poon, C. S., Chau, C. K., & Chun, K. P. (2010). Factors affecting the implementation of green specifications in construction. *Journal of Environmental Management*, *91*(3), 654-661. <https://doi.org/http://dx.doi.org/10.1016/j.jenvman.2009.09.029>

- Laryea, S., & Hughes, W. (2011, 13-15 April). Negotiating access into firms: Obstacles and Strategies. 6th Nordic Conference on Construction Economics and Organisation – Shaping the Construction/Society Nexus, Copenhagen, Denmark.
- Latham, M. (1994). Constructing the team: final report by Sir Michael Latham. Joint Review of Procurement and Contractual Arrangements in the United Kingdom Construction Industry. In: HMSO, London.
- Lei, Z., Lowe, D. J., Kurul, E., & Keeping, M. (2005, 27-29 September). *Is Private Finance Initiative a Good Mechanism too Deliver Sustainable Construction?* The 2005 World Sustainable Building Conference, Tokyo, (SB05Tokyo).
- Leng, H. K. (2013). Methodological issues in using data from social networking sites. *Cyberpsychology, Behavior, and Social Networking*, 16(9), 686-689.
- Li, J., Chiang, Y. H., Choi, T. N. Y., & Man, K. F. (2013). Determinants of efficiency of contractors in Hong Kong and China: Panel data model analysis [Article]. *Journal of Construction Engineering and Management*, 139(9), 1211-1223. [https://doi.org/10.1061/\(ASCE\)CO.1943-7862.0000698](https://doi.org/10.1061/(ASCE)CO.1943-7862.0000698)
- Li, Y. Y., Chen, P.-H., Chew, D. A. S., & Teo, C. C. (2014). Exploration of critical resources and capabilities of design firms for delivering green building projects: Empirical studies in Singapore. *Habitat International*, 41, 229-235.
- Liang, X., Yu, T., & Guo, L. (2017). Understanding Stakeholders' Influence on Project Success with a New SNA Method: A Case Study of the Green Retrofit in China. *Sustainability*, 9(10), 1927.
- Lim, B. T. H., & Loosemore, M. (2017). How Socially Responsible is Construction Business in Australia and New Zealand? *Procedia Engineering*, 180, 531-540. <https://doi.org/https://doi.org/10.1016/j.proeng.2017.04.212>
- Lim, M. C. N., Ross, D., & Harper, S. (2015). Evaluation of Building Performance in Use-A Case Study of the Seager Distillery Development. *SDAR* Journal of Sustainable Design & Applied Research*, 3(1), 4.

- Lin, Y.-H., & Tseng, M.-L. (2016). Assessing the competitive priorities within sustainable supply chain management under uncertainty. *Journal of Cleaner Production*, 112, Part 3, 2133-2144. <https://doi.org/https://doi.org/10.1016/j.jclepro.2014.07.012>
- Linesight. (2018a). *Ireland Market Review*. <https://www.linesight.com/knowledge>
- Linesight. (2018b). *Is efficiency eluding the construction industry?* <https://www.linesight.com/insight/is-efficiency-eluding-the-construction-industry>
- Linesight. (2020). *Ireland Market Review 2020*
- Lingard, H., & Rowlinson, S. (2006). Sample size in factor analysis: why size matters. *Construction Management and Economics*, 24(11), 1107-1109. <https://doi.org/10.1080/01446190601001620>
- Lipton, P. (2004). *Inference to the best explanation*. Taylor & Francis.
- Liu, K. S., Shih, Y. L., Tzeng, C. T., & Chen, C. C. (2014). Research on energy-saving design transformation on the external shell of existing buildings - The example of Kaohsiung City Townhouses [Article]. *Journal of Environmental Protection and Ecology*, 15(3), 1303-1314.
- Liu, X., & Cui, Q. (2016). Assessing the impacts of preferential procurement on low-carbon building [Article]. *Journal of Cleaner Production*, 112, 863-871. <https://doi.org/10.1016/j.jclepro.2015.06.015>
- London, K. (2008). *Construction Supply Chain Economics*. Routledge.
- Love, P. E. D., Holt, G. D., & Li, H. (2002). Triangulation in construction management research. *Engineering, Construction and Architectural Management*, 9(4), 294-303. <https://doi.org/10.1108/eb021224>
- Love, P. E. D., Skitmore, M., & Earl, G. (1998). Selecting a suitable procurement method for a building project. *Construction Management & Economics*, 16(2), 221-233.

- Lu, Y., & Zhang, X. (2016). Corporate sustainability for architecture engineering and construction (AEC) organizations: Framework, transition and implication strategies. *Ecological Indicators*, *61*, 911-922. <https://doi.org/http://dx.doi.org/10.1016/j.ecolind.2015.10.046>
- Lönngren, H. M., Rosenkranz, C., & Kolbe, H. (2010). Aggregated construction supply chains: Success factors in implementation of strategic partnerships [Article]. *Supply Chain Management*, *15*(5), 404-411. <https://doi.org/10.1108/13598541011068297>
- MacCallum, R. C., Widaman, K. F., Zhang, S., & Hong, S. (1999). Sample size in factor analysis. *Psychological methods*, *4*(1), 84.
- Madhani, P. M. (2010). Resource based view (RBV) of competitive advantage: an overview. *RESOURCE BASED VIEW: CONCEPTS AND PRACTICES*, Pankaj Madhani, ed, 3-22.
- Mahamadu, A.-M., Mahdjoubi, L., Booth, C., & Fewings, P. (2015). Integrated delivery of quality, safety and environment through road sector procurement: The case of public sector agencies in Ghana. *Journal of Construction in Developing Countries*, *20*(1), 1-24.
- Mahamadu, A. M., Manu, P., Booth, C., Olomolaiye, P., Coker, A., Ibrahim, A., & Lamond, J. (2018). Infrastructure procurement skills gap amongst procurement personnel in Nigeria's public sector [Article]. *Journal of Engineering, Design and Technology*, *16*(1), 2-24. <https://doi.org/10.1108/JEDT-09-2017-0089>
- Marhani, M. A., Jaapar, A., & Bari, N. A. A. (2012). Lean Construction: Towards Enhancing Sustainable Construction in Malaysia. *Procedia - Social and Behavioral Sciences*, *68*, 87-98. <https://doi.org/https://doi.org/10.1016/j.sbspro.2012.12.209>
- Martilla, J. A., & James, J. C. (1977). Importance-Performance Analysis. *Journal of Marketing*, *41*(1), 77-79. <https://doi.org/10.1177/002224297704100112>

- Mata, F. J., Fuerst, W. L., & Barney, J. B. (1995). Information technology and sustained competitive advantage: A resource-based analysis. *MIS quarterly*, 487-505.
- May, T. (2001). *Social Research: Issues, Methods and Research* (3rd ed.). Open University Press.
- McAuley, B., Hore, A. V., & West, R. (2012). Use of Building Information Modelling in Responding to Low Carbon Construction Innovations: an Irish Perspective. Joint CIB W055, W065, W089, W118, TG76, TG78, TG81 & TG84 International Conference on Management of Construction: Research to Practice., Montreal.
- McKinsey Global Institute. (2017). *Reinventing construction through a productivity revolution*. <https://www.mckinsey.com/industries/capital-projects-and-infrastructure/our-insights/reinventing-construction-through-a-productivity-revolution>
- McMurray, A. J., Islam, M. M., Siwar, C., & Fien, J. (2014). Sustainable procurement in Malaysian organizations: Practices, barriers and opportunities. *Journal of Purchasing and Supply Management*, 20(3), 195-207. <https://doi.org/https://doi.org/10.1016/j.pursup.2014.02.005>
- Meacham, B. J. (2016). Sustainability and resiliency objectives in performance building regulations. *Building Research & Information*, 44(5-6), 474-489. <https://doi.org/10.1080/09613218.2016.1142330>
- Meehan, J., & Bryde, D. (2011). Sustainable procurement practice. *Business Strategy and the Environment*, 20(2), 94-106.
- Meehan, J., & Bryde, D. J. (2015). A field-level examination of the adoption of sustainable procurement in the social housing sector [Article]. *International Journal of Operations and Production Management*, 35(7), 982-1004. <https://doi.org/10.1108/IJOPM-07-2014-0359>
- Meehan, J., Menzies, L., & Michaelides, R. (2017). The long shadow of public policy; Barriers to a value-based approach in healthcare procurement. *Journal of Purchasing and Supply Management*, 23(4), 229-241.

Ministry of Justice. (2010). *The Bribery Act 2010*

Mirza, E., & Ehsan, N. (2017). Quantification of Project Execution Complexity and its Effect on Performance of Infrastructure Development Projects. *Engineering Management Journal*, 29(2), 108-123.
<https://doi.org/10.1080/10429247.2017.1309632>

Mitchell, A. (2018). A Review of Mixed Methods, Pragmatism and Abduction Techniques. *Electronic Journal of Business Research Methods*, 16(3).

Mollaoglu-Korkmaz, S., Swarup, L., & Riley, D. (2013). Delivering Sustainable, High-Performance Buildings: Influence of Project Delivery Methods on Integration and Project Outcomes. *Journal of Management in Engineering*, 29(1), 71-78.
[https://doi.org/10.1061/\(ASCE\)ME.1943-5479.0000114](https://doi.org/10.1061/(ASCE)ME.1943-5479.0000114)

Montalbán-Domingo, L., García-Segura, T., Sanz, M. A., & Pellicer, E. (2018). Social sustainability criteria in public-work procurement: An international perspective. *Journal of Cleaner Production*.
<https://doi.org/https://doi.org/10.1016/j.jclepro.2018.07.083>

Morgan, D. L. (2014). Pragmatism as a paradigm for social research. *Qualitative Inquiry*, 20(8), 1045-1053.

Mulligan, T. D., Mollaoglu-Korkmaz, S., Cotner, R., & Goldsberry, A. D. (2014). Public Policy and Impacts on Adoption of Sustainable Built Environments: Learning from the Construction Industry Playmakers. *Journal of Green Building*, 9(2), 182-202.

Mulville, M., Callaghan, N., & Isaac, D. (2016). The impact of the ambient environment and building configuration on occupant productivity in open-plan commercial offices. *Journal of Corporate Real Estate*.

Murray, M., Forbes, D., & Mason, S. (2011, 2011). Considerate constructors scheme: Glenfarg water treatment works.

- Myers, D. (2005). A review of construction companies' attitudes to sustainability. *Construction Management and Economics*, 23(8), 781-785.
- Nanyam, V. P. S. N., Sawhney, A., & Gupta, P. A. (2017). Evaluating Offsite Technologies for Affordable Housing. *Procedia Engineering*, 196, 135-143. <https://doi.org/https://doi.org/10.1016/j.proeng.2017.07.183>
- Naoum, S., & Egbu, C. (2015). Critical Review of Procurement Method Research in Construction Journals. *Procedia Economics and Finance*, 21, 6-13. [https://doi.org/http://dx.doi.org/10.1016/S2212-5671\(15\)00144-6](https://doi.org/http://dx.doi.org/10.1016/S2212-5671(15)00144-6)
- Naoum, S. G., & Egbu, C. (2016). Modern selection criteria for procurement methods in construction: A state-of-the-art literature review and a survey. *International Journal of Managing Projects in Business*, 9(2), 309-336. <https://doi.org/10.1108/ijmpb-09-2015-0094>
- Nathália de, P., David, A., & Silvio, M. (2017). Managing sustainability efforts in building design, construction, consulting, and facility management firms. *Engineering, Construction and Architectural Management*, 24(6), 1040-1050. <https://doi.org/10.1108/ECAM-07-2016-0165>
- Newcombe, R. (2003). From client to project stakeholders: a stakeholder mapping approach. *Construction management and economics*, 21(8), 841-848.
- Nienhüser, W. (2008). Resource dependence theory-How well does it explain behavior of organizations? *management revue*, 9-32.
- Noorizadeh, A., Rashidi, K., & Peltokorpi, A. (2018). Categorizing suppliers for development investments in construction: application of DEA and RFM concept. *Construction Management and Economics*, 1-20. <https://doi.org/10.1080/01446193.2017.1416151>
- O'Gorman, K. D., & MacIntosh, R. (2014). *Research methods for business and management*. Goodfellow Publishers Limited.

- O'Leary, D. E. (1991). Design, development and validation of expert systems: a survey of developers. In *Validation, verification and test of knowledge-based systems* (pp. 3-19).
- OECD. (2019). *Implementing the OECD Anti-Bribery Convention-Ireland*
- Ofek, S., Akron, S., & Portnov, B. A. (2018). Stimulating green construction by influencing the decision-making of main players. *Sustainable Cities and Society*, *40*, 165-173. <https://doi.org/10.1016/j.scs.2018.04.005>
- Ofori, G. (2000). Greening the construction supply chain in Singapore. *European Journal of Purchasing & Supply Management*, *6*(3), 195-206. [https://doi.org/10.1016/S0969-7012\(00\)00015-0](https://doi.org/10.1016/S0969-7012(00)00015-0)
- Oh, H. (2001). Revisiting importance–performance analysis. *Tourism management*, *22*(6), 617-627.
- Oladapo, A., Goulding, J. S., & Ogunbiyi, O. (2014). An empirical study of the impact of lean construction techniques on sustainable construction in the UK. *Construction Innovation*, *14*(1), 88-107. <https://doi.org/10.1108/CI-08-2012-0045>
- Olanipekun, A. O., Chan, A. P. C., Xia, B., & Adedokun, O. A. (2017). Applying the self-determination theory (SDT) to explain the levels of motivation for adopting green building. *International Journal of Construction Management*, 1-12. <https://doi.org/10.1080/15623599.2017.1285484>
- Onwuegbuzie, A. J., & Collins, K. M. T. (2007). A typology of mixed methods sampling designs in social science research. *Qualitative Report*, *12*(2), 281-316.
- Opoku, A. (2013). The Application of Whole Life Costing in the UK Construction Industry: Benefits and Barriers. *International Journal of Architecture, Engineering and Construction*, *2*(1), 35-42. <https://doi.org/10.7492/IJAEC.2013.004>

- Opoku, A., & Ahmed, V. (2013). Understanding sustainability: a view from intra-organizational leadership within UK construction organizations. *Int J Archit Eng Constr*, 2(2), 133-143.
- Opoku, A., Cruickshank, H., & Ahmed, V. (2015). Organizational leadership role in the delivery of sustainable construction projects in UK. *Built Environment Project and Asset Management*, 5(2), 154-169. <https://doi.org/10.1108/bepam-12-2013-0074>
- Opoku, A., & Fortune, C. (2011). Organizational learning and sustainability in the construction industry. *The Built & Human Environment Review*, 4(1), 98-107.
- Opoku, A., & Fortune, C. (2015). Current Practices Towards Achieving Sustainable Construction Project Delivery in the UK *The International Journal of Environmental, Cultural, Economic and Social Sustainability: Annual Review*, 10, 41-57.
- Oppenheim, A. N. (1992). *Questionnaire design, interviewing and attitude measurement*, New ed. Continuum.
- Ormanovic, S., Ciric, A., Talovic, M., Alic, H., Jeleskovic, E., & Causevic, D. (2017). Importance-performance analysis: different approaches. *Acta Kinesiologica*, 11, 58-66.
- Oyegoke, A. S., Akenroye, T. O., & Dickinson, M. (2014). Transformation in the organisation and management of traditional contracting system in the UK. *International Journal of Project Organisation and Management*, 6(4), 358-378.
- Oyegoke, A. S., McDermott, P., & Dickinson, M. (2010). The myth behind integration in the UK construction industry. *International Journal of Procurement Management*, 3(3), 247-264.
- Pagell, M., & Wu, Z. (2009). Building a more complete theory of sustainable supply chain management using case studies of 10 exemplars. *Journal of supply chain management*, 45(2), 37-56.

- Pallant, J. (2007). *SPSS Survival Manual: A Step by Step Guide to Data Analysis Using SPSS for Windows Version 15* (3rd ed.). Open University Press.
- Papadonikolaki, E. (2016). Alignment of Partnering with Construction IT: Exploration and Synthesis of network strategies to integrate BIM-enabled Supply Chains. In *A+BE Architecture and the Built Environment* (Vol. 20, pp. 1-328).
- Papadonikolaki, E. (2018). Loosely Coupled Systems of Innovation: Aligning BIM Adoption with Implementation in Dutch Construction. *Journal of Management in Engineering*, 34(6), 05018009. [https://doi.org/10.1061/\(ASCE\)ME.1943-5479.0000644](https://doi.org/10.1061/(ASCE)ME.1943-5479.0000644)
- Papadonikolaki, E., Vrijhoef, R., & Wamelink, H. (2015). Supply chain integration with BIM: a graph-based model [Article]. *Structural Survey*, 33(3), 257-277. <https://doi.org/10.1108/SS-01-2015-0001>
- Peers, I. (2006). *Statistical analysis for education and psychology researchers: Tools for researchers in education and psychology*. Routledge.
- Perera, O., Chowdhury, N., & Goswami, A. (2007). *State of play in sustainable public procurement* (International Institute for Sustainable Development: Winnipeg, Issue. https://www.iisd.org/pdf/2007/state_procurement.pdf
- Pero, M., Moretto, A., Bottani, E., & Bigliardi, B. (2017). Environmental collaboration for sustainability in the construction industry: An exploratory study in Italy. *Sustainability*, 9(1), 125.
- Polat, G., Turkoglu, H., & Gurgun, A. P. (2017). Identification of Material-related Risks in Green Buildings. *Procedia Engineering*, 196, 956-963. <https://doi.org/https://doi.org/10.1016/j.proeng.2017.08.036>
- Powell, T. C., & Dent-Micallef, A. (1997). Information technology as competitive advantage: The role of human, business, and technology resources. *Strategic management journal*, 18(5), 375-405.

- Powmya, A., Abidin, N. Z., & Azizi, N. S. M. (2017). Contractor firm strategies in delivering green project: A review. *AIP Conference Proceedings*.
- Presley, A., & Liles, D. H. (1995, 1995). The use of IDEF0 for the design and specification of methodologies.
- PWC, & CIF. (2019). *Brexit and the Irish Construction Sector*. https://cif.ie/wp-content/uploads/2019/03/CIF-Brexit-report_February-2019-pwc.pdf
- Qi, G. Y., Shen, L. Y., Zeng, S. X., & Jorge, O. J. (2010). The drivers for contractors' green innovation: an industry perspective. *Journal of Cleaner Production*, 18(14), 1358-1365. <https://doi.org/10.1016/j.jclepro.2010.04.017>
- Quinlan, C. (2011). *Business Research Methods*. Cengage Learning EMEA. Hampshire.
- Reefke, H., & Sundaram, D. (2018). Sustainable supply chain management: Decision models for transformation and maturity. *Decision Support Systems*. <https://doi.org/https://doi.org/10.1016/j.dss.2018.07.002>
- Rial, A., Rial, J., Varela, J., & Real, E. (2008). An application of importance-performance analysis (IPA) to the management of sport centres. *Managing Leisure*, 13(3-4), 179-188.
- Rickaby, M., & Glass, J. (2017, 13-14th Sept). *Development of a Values-Based Framework for Predicting Project Sustainability Performance* 3rd International Conference, Sustainable Ecological Engineering Design for Society (SEEDS), Leeds Beckett University.
- Rietbergen, M. G., van Rheede, A., & Blok, K. (2015). The target-setting process in the CO2 Performance Ladder: does it lead to ambitious goals for carbon dioxide emission reduction? *Journal of Cleaner Production*, 103, 549-561. <https://doi.org/https://doi.org/10.1016/j.jclepro.2014.09.046>
- Riley, D., Pexton, K., & Drilling, J. (2003). Procurement of sustainable construction services in the United States: the contractor's role in green buildings. *Industry and environment*, 26(2), 66-69.

- Rizzi, F., Frey, M., Testa, F., & Appolloni, A. (2014). Environmental value chain in green SME networks: the threat of the Abilene paradox. *Journal of Cleaner Production*, 85, 265-275. <https://doi.org/https://doi.org/10.1016/j.jclepro.2014.09.001>
- RobecoSAM. (2019). *2018 Annual Corporate Sustainability Assessment*.
- Robichaud, L. B., & Anantatmula, V. S. (2010). Greening project management practices for sustainable construction. *Journal of Management in Engineering*, 27(1), 48-57.
- Rodriguez-Melo, A., & Mansouri, S. A. (2011). Stakeholder engagement: Defining strategic advantage for sustainable construction. *Business Strategy and the Environment*, 20(8), 539-552.
- Rogers, E. M. (2010). *Diffusion of innovations* (4th ed.). Simon and Schuster.
- Roland Berger. (2016). Digitization in the construction sector — Roland Berger. <https://www.rolandberger.com/en/Media/Digitization-in-the-construction-sector.html>
- Roman, A. V. (2017). Institutionalizing sustainability: A structural equation model of sustainable procurement in US public agencies. *Journal of Cleaner Production*, 143(Supplement C), 1048-1059. <https://doi.org/https://doi.org/10.1016/j.jclepro.2016.12.014>
- Roschke, P. N. (1994). Validation of knowledge-based system with multiple bridge rail experts. *Journal of transportation engineering*, 120(5), 787-806.
- Rosenow, J., Fawcett, T., Eyre, N., & Oikonomou, V. (2016). Energy efficiency and the policy mix. *Building Research & Information*, 44(5-6), 562-574. <https://doi.org/10.1080/09613218.2016.1138803>
- Ross, A., & Goulding, J. (2007). Supply chain transactional barriers to design cost management [Article]. *Construction Innovation*, 7(3), 274-287. <https://doi.org/10.1108/14714170710754759>

- Roy, V., Charan, P., Schoenherr, T., & Sahay, B. S. (2018). Ensuring supplier participation toward addressing sustainability-oriented objectives of the mid-day meal supply chain insights from the akshaya patra foundation [Conference Paper]. *International Journal of Logistics Management*, 29(1), 456-475. <https://doi.org/10.1108/IJLM-12-2016-0297>
- Ruivo, P., Oliveira, T., & Neto, M. (2015). Using resource-based view theory to assess the value of ERP commercial-packages in SMEs. *Computers in Industry*, 73, 105-116.
- Ruparathna, R., & Hewage, K. (2015a). Sustainable procurement in the Canadian construction industry: challenges and benefits. *Canadian Journal of Civil Engineering*, 42(6), 417-426.
- Ruparathna, R., & Hewage, K. (2015b). Sustainable procurement in the Canadian construction industry: current practices, drivers and opportunities. *Journal of Cleaner Production*, 109, 305-314.
- Russell, E., Lee, J., & Clift, R. (2018). Can the SDGs provide a basis for supply chain decisions in the construction sector? [Article]. *Sustainability (Switzerland)*, 10(3), Article 629. <https://doi.org/10.3390/su10030629>
- Räikkönen, M., Kunttu, S., Uusitalo, T., Takala, J., Shakeel, S. R., Tilabi, S., . . . Koivunen, J. (2016). A framework for assessing the social and economic impact of sustainable investments [Article]. *Management and Production Engineering Review*, 7(3), 79-86. <https://doi.org/10.1515/mper-2016-0027>
- Saieg, P., Sotelino, E. D., Nascimento, D., & Caiado, R. G. G. (2018). Interactions of Building Information Modeling, Lean and Sustainability on the Architectural, Engineering and Construction industry: A systematic review. *Journal of Cleaner Production*, 174, 788-806. <https://doi.org/https://doi.org/10.1016/j.jclepro.2017.11.030>
- Sancha, C., Gimenez, C., & Sierra, V. (2016). Achieving a socially responsible supply chain through assessment and collaboration. *Journal of Cleaner Production*, 112, Part 3, 1934-1947. <https://doi.org/https://doi.org/10.1016/j.jclepro.2015.04.137>

- Sancha, C., Wong, C. W. Y., & Gimenez Thomsen, C. (2016). Buyer–supplier relationships on environmental issues: a contingency perspective. *Journal of Cleaner Production*, *112*, Part 3, 1849-1860. <https://doi.org/https://doi.org/10.1016/j.jclepro.2014.09.026>
- Sanchez, A., Lehtiranta, L., Hampson, K. D., & Kenley, R. (2014). Evaluation framework for green procurement in road construction. *Smart and Sustainable Built Environment*, *3*(2), 153-169.
- Santos, D., & Lane, R. (2017). A material lens on socio-technical transitions: The case of steel in Australian buildings. *Geoforum*, *82*, 40-50. <https://doi.org/https://doi.org/10.1016/j.geoforum.2017.03.020>
- Sarkis, J., & Liles, D. H. (1995). Using IDEF and QFD to develop an organizational decision support methodology for the strategic justification of computer-integrated technologies. *International Journal of Project Management*, *13*(3), 177-185.
- Sarkis, J., & Lin, L. (1994). An IDEF0 functional planning model for the strategic implementation of CIM systems. *International Journal of Computer Integrated Manufacturing*, *7*(2), 100-115.
- Sarkis, J., Zhu, Q., & Lai, K. H. (2011). An organizational theoretic review of green supply chain management literature [Article]. *International Journal of Production Economics*, *130*(1), 1-15. <https://doi.org/10.1016/j.ijpe.2010.11.010>
- Saunders, M., Lewis, P., & Thornhill, A. (2009). Research methods for business students 5th edition. *Perntice Hall*.
- Saunders, M., Lewis, P., & Thornhill, A. (2015). Research Methods for Business Students. In *Understanding Research Philosophy and Approaches to Theory Development* (pp. 122-161).
- Schulz, S. A., & Flanigan, R. L. (2016). Developing competitive advantage using the triple bottom line: A conceptual framework. *Journal of Business & Industrial Marketing*, *31*(4), 449-458.

- Sci-Network. (2011). *Procuring Innovation*. http://www.sci-network.eu/fileadmin/templates/sci-network/files/Resource_Centre/Reports/Innovation_in_construction_procurement_-_Preliminary_report.pdf
- SCSI, & PwC. (2017). *Construction Survey Report*
- SCSI, & PwC. (2018). *Construction Market Monitor*
- SEAI. (2017). *Nearly Zero Energy Building Standard*. Retrieved 14th May, from <https://www.seai.ie/business-and-public-sector/standards/nearly-zero-energy-building-standard/>
- Seuring, S., & Müller, M. (2008). From a literature review to a conceptual framework for sustainable supply chain management. *Journal of Cleaner Production*, 16(15), 1699-1710. <https://doi.org/https://doi.org/10.1016/j.jclepro.2008.04.020>
- Seymour, D., Crook, D., & Rooke, J. (1997). The role of theory in construction management: a call for debate. *Construction Management & Economics*, 15(1), 117-119.
- Sfakianaki, E. (2015). Resource-efficient construction: Rethinking construction towards sustainability. *World Journal of Science, Technology and Sustainable Development*, 12(3), 233-242. <https://doi.org/10.1108/wjstd-03-2015-0016>
- Shapiro, S. (2016). The realpolitik of building codes: overcoming practical limitations to climate resilience. *Building Research & Information*, 44(5-6), 490-506. <https://doi.org/10.1080/09613218.2016.1156957>
- Shen, L., Zhang, Z., & Long, Z. (2017). Significant barriers to green procurement in real estate development. *Resources, Conservation and Recycling*, 116(Supplement C), 160-168. <https://doi.org/https://doi.org/10.1016/j.resconrec.2016.10.004>
- Shih, T.-H., & Xitao, F. (2008). Comparing Response Rates from Web and Mail Surveys: A Meta-Analysis. *Field Methods*, 20(3), 249-271. <https://doi.org/10.1177/1525822X08317085>

- Sim, J., Saunders, B., Waterfield, J., & Kingstone, T. (2018). Can sample size in qualitative research be determined a priori? *International Journal of Social Research Methodology*, 21(5), 619-634.
- Skanska. (2018). *Sustainability reporting | Skanska - Global corporate website.* @skanskagroup. <https://group.skanska.com/sustainability/reports-publications/sustainability-reporting/>
- Slaper, T. F., & Hall, T. J. (2011). The Triple Bottom Line: What Is It and How Does It Work? *The Indiana Business Review*, 86(1). <http://www.ibrc.indiana.edu/ibr/2011/spring/article2.html>
- SmartSheet. (2017, 2017-06-28). *Integrated Supply Chain Management: Horizontal and Vertical | Smartsheet.* <https://www.smartsheet.com/integrated-supply-chain-management-vertical-and-horizontal>
- Sparrevik, M., Wangen, H. F., Fet, A. M., & De Boer, L. (2018). Green public procurement – A case study of an innovative building project in Norway. *Journal of Cleaner Production*, 188, 879-887. <https://doi.org/https://doi.org/10.1016/j.jclepro.2018.04.048>
- Stake, R. E. (1995). *The art of case study research.* sage.
- Stannack, P. (1996). Purchasing power and supply chain management power—two different paradigms?—a response to Ramsay's 'Purchasing power'(1995). *European Journal of Purchasing & Supply Management*, 2(1), 47-56.
- Sterman, J. (2002). System Dynamics: systems thinking and modeling for a complex world. In: Massachusetts Institute of Technology. Engineering Systems Division.
- Sun, W. A., Mollaoglu, S., Miller, V., & Manata, B. (2015). Communication Behaviors to Implement Innovations: How Do AEC Teams Communicate in IPD Projects? *Project Management Journal*, 46(1), 84-96.

- Sustainable Development Commission. (2016). *What is Sustainable Development?* Retrieved 31 August from <http://www.sd-commission.org.uk/pages/what-is-sustainable-development.html>
- Sutrisna, M. (2009, 12 May). Research methodology in doctoral research: understanding the meaning of conducting qualitative research. Proceedings of the Association of Researchers in Construction Management (ARCOM) Doctoral Workshop, Liverpool John Moores University. UK.
- Sutrisna, M., & Barrett, P. (2007). Applying rich picture diagrams to model case studies of construction projects. *Engineering, Construction and Architectural Management*, 14(2), 164-179.
- Swanborn, P. (2010). *Case study research: What, why and how?* Sage.
- Tabachnick, B. G., & Fidell, L. S. (2013). *Using Multivariate Statistics* (6th ed., Vol. 5). Pearson.
- Taggart, M., Koskela, L., & Rooke, J. (2014). The role of the supply chain in the elimination and reduction of construction rework and defects: an action research approach. *Construction Management and Economics*, 32(7-8), 829-842. <https://doi.org/10.1080/01446193.2014.904965>
- Tan, Y., Shen, L., & Yao, H. (2011). Sustainable construction practice and contractors? competitiveness: A preliminary study. *Habitat International*, 35(2), 225-230. <https://doi.org/http://dx.doi.org/10.1016/j.habitatint.2010.09.008>
- Tang, Z. W., Ng, S. T., & Skitmore, M. (2019). Influence of procurement systems to the success of sustainable buildings. *Journal of Cleaner Production*, 218, 1007-1030.
- Taplin, R. H. (2012). Competitive importance-performance analysis of an Australian wildlife park. *Tourism Management*, 33(1), 29-37.
- Task Force on Climate-related Financial Disclosures (TCFD). (2017). *Final Report: Recommendations of the Task Force on Climate-related Financial Disclosures*

(June 2017) - TCFD. Retrieved 02/04 from <https://www.fsb-tcfid.org/publications/final-recommendations-report/>

Teddle, C., & Yu, F. (2007). Mixed methods sampling: A typology with examples. *Journal of mixed methods research*, 1(1), 77-100. <https://doi.org/10.1177/2345678906292430>

Tennant, S., & Fernie, S. (2014). Theory to practice: A typology of supply chain management in construction [Article]. *International Journal of Construction Management*, 14(1), 56-66. <https://doi.org/10.1080/15623599.2013.875268>

Terouhid, S. A., & Ries, R. (2016). Organizational sustainability excellence of construction firms – a framework. *Journal of Modelling in Management*, 11(4), 911-931. <https://doi.org/10.1108/jm2-06-2014-0055>

The Economist. (2018). *Supply chains based on modern slavery may reach into the West*. @TheEconomist. <https://www.economist.com/graphic-detail/2018/07/19/supply-chains-based-on-modern-slavery-may-reach-into-the-west>

The Journal. (2018). Here are the country's highest-earning construction firms. <https://www.thejournal.ie/highest-turnover-construction-firm-ireland-3-4113815-Jul2018/>

To, W. M., Lam, K. H., & Lai, T. M. (2015). Importance-performance ratings for environmental practices among Hong Kong professional-level employees. *Journal of Cleaner Production*, 108, 699-706. <https://doi.org/https://doi.org/10.1016/j.jclepro.2015.06.005>

Touboulic, A., & Walker, H. (2015). Theories in sustainable supply chain management: a structured literature review. *International Journal of Physical Distribution & Logistics Management*, 45(1/2), 16-42. <https://doi.org/10.1108/IJPDLM-05-2013-0106>

Tsang, E. W. K. (2013). Case study methodology: Causal explanation, contextualization, and theorizing. *Journal of international management*, 19(2), 195-202.

- United Nations Development Programme. (2019). *Sustainable Development Goals / UNDP*. @undp. <https://www.undp.org/content/undp/en/home/sustainable-development-goals.html>
- United Nations Environment Programme. (2017). Global Review of Sustainable Public Procurement 2017. Retrieved 2017-06-06, from <http://www.oneplanetnetwork.org/resource/2017-global-review-sustainable-public-procurement>
- United Nations Environment Programme. (2019). *Theme of the fourth Session of the UN Environment Assembly*. Retrieved 11-04-2019 from
- United Nations Framework Convention on Climate Change. (2015). *Paris Agreement*. http://unfccc.int/paris_agreement/items/9485.php
- United Nations Global Compact. (2019). *Our Participants | UN Global Compact*. Retrieved 15/04/19 from <https://www.unglobalcompact.org/what-is-gc/participants>
- United Nations Global Compact, & Accenture Strategy. (2019). *UN Global Compact-Accenture Strategy 2019 CEO Study–The Decade to Deliver:A Call to Business Action* <https://d306pr3pise04h.cloudfront.net/docs/publications%2F2019-UNGC-Accenture-CEO-Study.pdf>
- Upstill-Goddard, J., Glass, J., Dainty, A., & Nicholson, I. (2016). Implementing sustainability in small and medium-sized construction firms. *Engineering, Construction and Architectural Management*, 23(4), 407-427. <https://doi.org/10.1108/ecam-01-2015-0015>
- Upstill-Goddard, J. D., Glass, J., Dainty, A. R. J., & Nicholson, I. (2015). Analysis of responsible sourcing performance in BES 6001 certificates [Proceedings of the Institution of Civil Engineers]. *Engineering Sustainability*, 168(ES2), 71-81. <https://doi.org/http://dx.doi.org/10.1680/ensu.14.00024>

- Uttam, K., & Le Lann Roos, C. (2015). Competitive dialogue procedure for sustainable public procurement. *Journal of Cleaner Production*, 86, 403-416. <https://doi.org/https://doi.org/10.1016/j.jclepro.2014.08.031>
- Van der Heijden, J., & van Bueren, E. (2013). Regulating sustainable construction in Europe: An inquiry into the European Commission's harmonization attempts. *International Journal of Law in the Built Environment*, 5(1), 5-20.
- Visscher, H., Meijer, F., Majcen, D., & Itard, L. (2016). Improved governance for energy efficiency in housing. *Building Research & Information*, 44(5-6), 552-561. <https://doi.org/10.1080/09613218.2016.1180808>
- Vrijhoef, R., & Koskela, L. (2000). The four roles of supply chain management in construction. *European journal of purchasing & supply management*, 6(3-4), 169-178.
- Vrijhoef, R., Koskela, L. J., & Howell, G. (2001). Understanding construction supply chains: an alternative interpretation. Proceedings of 9th International Group for Lean Construction Conference.,
- Vurro, C., Russo, A., & Perrini, F. (2009). Shaping sustainable value chains: Network determinants of supply chain governance models. *Journal of business ethics*, 90(4), 607-621.
- Waissi, G. R., Demir, M., Humble, J. E., & Lev, B. (2015). Automation of strategy using IDEF0 — A proof of concept. *Operations Research Perspectives*, 2, 106-113. <https://doi.org/https://doi.org/10.1016/j.orp.2015.05.001>
- Walker, H., & Brammer, S. (2009). Sustainable procurement in the United Kingdom public sector. *Supply Chain Management: An International Journal*, 14(2), 128-137. <https://doi.org/10.1108/13598540910941993>
- Walker, H., Harland, C., Knight, L., Uden, C., & Forrest, S. (2008). Reflections on longitudinal action research with the English National Health Service. *Journal of Purchasing and Supply Management*, 14(2), 136-145. <https://doi.org/https://doi.org/10.1016/j.pursup.2008.02.003>

- Walker, H., Miemczyk, J., Johnsen, T., & Spencer, R. (2012). Sustainable procurement: Past, present and future. In: Elsevier.
- Walton, D. (2001). Abductive, presumptive and plausible arguments. *Informal Logic*, 21(2).
- Warren-Myers, G., & Heywood, C. (2018). A new demand-supply model to enable sustainability in new Australian housing [Article]. *Sustainability (Switzerland)*, 10(2), Article 376. <https://doi.org/10.3390/su10020376>
- Watts, G., Higham, A., & Alotaibi, A. (2020, 2020). Stakeholder perceptions of the Considerate Constructors Scheme in UK construction.
- Welch, C., Piekkari, R., Plakoyiannaki, E., & Paavilainen-Mäntymäki, E. (2011). Theorising from case studies: Towards a pluralist future for international business research. *Journal of International Business Studies*, 42(5), 740-762.
- Wessels, J.-A., Retief, F., & Morrison-Saunders, A. (2015). Appraising the value of independent EIA follow-up verifiers. *Environmental Impact Assessment Review*, 50, 178-189. <https://doi.org/https://doi.org/10.1016/j.eiar.2014.10.004>
- WGBC. (2017). *World Green Building Council (Rating tools)*. <http://www.worldgbc.org/rating-tools>
- Williamson, O. E. (1975). Markets and Hierarchies, Analysis and antitrust implications”, the Free Press, New York. *Williamson Markets and Hierarchies: Analysis and Antitrust Implications 1975*.
- Witjes, S., & Lozano, R. (2016). Towards a more Circular Economy: Proposing a framework linking sustainable public procurement and sustainable business models. *Resources, Conservation and Recycling*, 112, 37-44. <https://doi.org/http://dx.doi.org/10.1016/j.resconrec.2016.04.015>
- Wong, J. K. W., & Kuan, K. L. (2014). Implementing 'BEAM Plus' for BIM-based sustainability analysis [Article]. *Automation in Construction*, 44, 163-175. <https://doi.org/10.1016/j.autcon.2014.04.003>

- Woo, C., Kim, M. G., Chung, Y., & Rho, J. J. (2016). Suppliers' communication capability and external green integration for green and financial performance in Korean construction industry. *Journal of Cleaner Production*, 112, 483-493. <https://doi.org/https://doi.org/10.1016/j.jclepro.2015.05.119>
- World Economic Forum. (2016a). *Shaping the Future of construction- A breakthrough in mindset and technology*. http://www3.weforum.org/docs/WEF_Shaping_the_Future_of_Construction_full_report_.pdf
- World Economic Forum. (2016b). *Shaping the Future of construction- A breakthrough in mindset and technology*. http://www3.weforum.org/docs/WEF_Shaping_the_Future_of_Construction_full_report_.pdf
- World Economic Forum. (2018). *Building the Future of Construction*. <https://www.weforum.org/press/2018/06/building-the-future-of-construction/>
- Wu, C., & Barnes, D. (2016). An integrated model for green partner selection and supply chain construction. *Journal of Cleaner Production*, 112, Part 3, 2114-2132. <https://doi.org/https://doi.org/10.1016/j.jclepro.2015.02.023>
- Wu, S. R., Kim, S.-K., Park, H., Fan, P., Ligmann-Zielinska, A., & Chen, J. (2017). How Do Green Buildings Communicate Green Design to Building Users? A Survey Study of A LEED-Certified Building. *Journal of Green Building*, 12(3), 85-100. <https://doi.org/10.3992/1943-4618.12.3.85>
- Yanarella, E. J., Levine, R. S., & Lancaster, R. W. (2009). Research and Solutions: "Green" vs. Sustainability: From Semantics to Enlightenment. *Sustainability: The Journal of Record*, 2(5), 296-302.
- Yang, Y. N., Kumaraswamy, M. M., Pam, H. J., & Mahesh, G. (2011). Integrated qualitative and quantitative methodology to assess validity and credibility of models for bridge maintenance management system development. *Journal of Management in Engineering*, 27(3), 149-158.

- Yevu, S. K., Yu, A. T. W., & Darko, A. (2021). Digitalization of construction supply chain and procurement in the built environment: Emerging technologies and opportunities for sustainable processes. *Journal of Cleaner Production*, 322, 129093. <https://doi.org/https://doi.org/10.1016/j.jclepro.2021.129093>
- Yin, R. K. (2009). *Case study research and applications: Design and methods* (Vol. 5). Sage publications.
- Yolles, M., & Fink, G. (2014). The Sustainability of Sustainability. *Business Systems Review*, 3 (2), 1-32. <https://doi.org/https://ssrn.com/abstract=2634328>
- Yusof, N. A., Abidin, N. Z., & Iranmanesh, M. (2016). Environmental Practices in Construction Firms. *Procedia Engineering*, 145(Supplement C), 242-249. <https://doi.org/https://doi.org/10.1016/j.proeng.2016.04.070>
- Zander, S., Trang, S., & Kolbe, L. M. (2016). Drivers of network governance: a multitheoretic perspective with insights from case studies in the German wood industry. *Journal of Cleaner Production*, 110, 109-120. <https://doi.org/https://doi.org/10.1016/j.jclepro.2015.03.010>
- Zhang, L., & Zhou, J. (2016). The effect of carbon reduction regulations on contractors' awareness and behaviors in China's building sector. *Journal of Cleaner Production*, 113, 93-101. <https://doi.org/https://doi.org/10.1016/j.jclepro.2015.12.032>
- Zhang, X., Wu, Y., & Shen, L. (2015). Embedding “green” in project-based organizations: the way ahead in the construction industry? *Journal of Cleaner Production*, 107, 420-427. <https://doi.org/http://dx.doi.org/10.1016/j.jclepro.2014.10.024>
- Zhu, Q., Sarkis, J., & Lai, K.-h. (2007). Initiatives and outcomes of green supply chain management implementation by Chinese manufacturers. *Journal of environmental management*, 85(1), 179-189.

Zuo, J., & Zhao, Z.-Y. (2014). Green building research—current status and future agenda: A review. *Renewable and Sustainable Energy Reviews*, 30(Supplement C), 271-281. <https://doi.org/https://doi.org/10.1016/j.rser.2013.10.021>

Zuo, J., Zillante, G., Wilson, L., Davidson, K., & Pullen, S. (2012). Sustainability policy of construction contractors: A review. *Renewable and Sustainable Energy Reviews*, 16(6), 3910-3916. <https://doi.org/http://dx.doi.org/10.1016/j.rser.2012.03.011>

APPENDICES

Appendix A: Questionnaire survey instrument

A Sustainable Procurement Framework for The Construction Industry in Ireland

1. Research Participant Information Sheet

You are being invited to take part in a research study as part of a doctoral degree research project. Before you decide it is important for you to understand, why the research is being done and what it will involve. Please take a few minutes to read this information sheet carefully before making up your mind about whether or not you would like to take part in this research. If there is anything that is not clear or if you would like more information, please ask and be sure you are satisfied with the answers before participating.

2. What is the purpose of the study?

The purpose of the research is to explore how construction-contracting firms in the Republic of Ireland embed sustainability issues in their procurement process. The research is intended to identify an area of improvement in the way construction firms embed issues of sustainability in the procurement process.

3. Why have I been invited?

Your participation is voluntary. I would appreciate it if you can complete the online survey because your role and experience in your organisation have made you knowledgeable in managing construction projects from inception to completion. In addition, your response will help in achieving the purpose and aim of the research. It is estimated that if 80-120 participants complete the online survey it will provide a satisfactory response rate for the study. In addition, if 10-15 participants agreed to be interviewed it will add more to the understanding of the research problem

4. Do I have to take part?

If you do not wish to participate you do not have to do anything in response to this request, therefore you need not to tick the box to continue with the survey but if you want to take part kindly check the box and continue.

5. What will happen to me if I take part?

If you agree to take part in the research, it should take approximately 25 minutes to complete an online survey, which will require your responses on issues relating to sustainable construction and sustainable procurement practices. The level of your organisation's adoption of digital technology tools and the level of engagement of your supply chains in driving your firm's sustainability agenda. The study is only concerned about your experience on the subject matter that will help in gaining a better understanding of sustainable procurement.

6. What are the possible disadvantages and risks of taking part?

There are no risks or disadvantages in participating in this research because all information shall be treated with utmost confidentiality.

7. What if there is a problem?

If you have a concern about any aspect of this study, you should ask to speak to the researcher who will do his best to answer your questions (Duga Ewuga, Work: +353-1-4022974 Mobile: +353899725221 duga.ewuga@mytudublin.ie).

If you have further questions, having spoken to the researcher, you should contact the researcher's supervisors (Dr Mark Mulville +353-1402 3740 mark.mulville@tudublin.ie, and Dr Alan Hore +353 1 402 3873 alan.hore@tudublin.ie)

If you are still not satisfied, you can contact the researcher's Head of School (Mr Thomas Dunne School of Surveying and Built Environment +353-01-4023678 tom.dunne@tudublin.ie).

8. Will my taking part in the study be kept confidential?

All information provided by you will always be kept confidential. All responses to the questions and information provided by you will be anonymised i.e. no personal details relating to you will be identified anywhere. Only the researcher will have access to the information you provide. All online resources will be kept in a coded file for a period of 3 years only.

9. What will happen to the results of the research study?

The results of the study will be used in my doctoral thesis and may be presented at a regional conference and local seminars, academic and professional conferences and in academic journals. The findings may also be shared you're your organisation and professional organisations like the Society of Chartered Surveyors of Ireland (SCSI) and

Construction Industry Federation (CIF) and the Nigerian Institute of Quantity Surveyors to help in championing innovations in practice and academic institutions. Anonymity and confidentiality will be maintained in all cases. Findings from this study will contribute to enhancing the organisational processes in the implementation of sustainable procurement practice.

Thank you for reading this information sheet, and if it is possible, participating in the study.

Consent form Kindly tick

- a. Have you been fully informed of the nature of this study by the researcher?
- b. Have you had an opportunity to ask questions about this research?
- c. Have you received satisfactory answers to all of your questions?
- d. Have you received sufficient information about the potential health and/or safety implications of this research?
- e. Have you been fully informed of your ability to withdraw participation and/or data from the research?
- f. Have you been fully informed of what will happen to data generated by your participation in the study and how it will be kept safe?
- h. Do you agree to take part in this study, the results of which may be disseminated in scientific publications, books or conference proceedings?
- i. Have you been informed that this consent form shall be kept securely and in confidence by the researcher?

I agree to take part in the research study being carried out by the PhD researcher from the School of Surveying and Built Environment, Technological University Dublin, Dublin, Republic of Ireland and agree that the information provided by me may be used in the manner described in the participant information details previously given on page

QUESTIONNAIRE

Section I: General Information

1. Your role in the company

- Managing Director
- Regional Director
- Director
- Commercial Manager
- Sustainability Manager
- Contracts Manager
- Strategy and Business Development Manager
- Procurement Manager
- Other roles not mentioned.....

2. How long have the company been in the construction business

- 15 years below
- 15-34 years
- 35-49 years
- 50 years and above

4. What is the annual turn over of the company?

- Less than €10million
- Between €10-€50 million
- Over €50 million

3. What is the total number of employees in the business?

- 250 and above
- 50-249
- 10-49

5. Nature of work undertaking predominantly?

- Building and Civil works
- Civil Works only
- Building works only
- Mechanical and Electrical works
- Mechanical works only
- Electrical works only
- Others.....

SECTION II: PERFORMANCE OF SUSTAINABLE PROCUREMENT PRACTICE

5. How will you assess the level of your organisation compliance in embedding sustainable procurement practices in the delivery of your projects?

- Excellent
- Good
- Average
- Poor

6. Is your organisation's sustainability policy effectively complied with at the procurement phase of all your projects?

- Yes
- No

7. How have the following factors impacted your organisation's practice in adopting sustainable practices?

Factors	Very High	High	Moderate	Low	Very Low
Markets (Gaining competitive advantage, client requirements)					
Values (by paying attention to human and social values)					
Transparency (disclosing to the public your organisation sustainability performance)					
Life-cycle technology (focusing on the impact of the product throughout its lifespan)					
Partnership (engaging closely with all stakeholders and community)					
Time (long term business strategies)					
Corporate governance (transformation in an organisation's structure)					

8. How would you assess the level of clarity of sustainability requirements in the various bidding documents or client's requirement documents?

- Precise
- Variable
- Not Precise

9. How important is sustainability requirement in the selection of suppliers and sub-contractors in your organisation?

- Very important
- Important
- Less important
- Not important

10. What is the level of importance attached by your organisation to the following delivery strategies

Factors	Extremely Important	Very Important	Moderately Important	Slightly Important	Not at all
Recruitment of experienced technical staff					
Education and training					
Employee empowerment					
Employee reward system					
Improving communication system through information technology					
Surety, bonds and insurance policies Monitoring and evaluation of projects					
Inter-firm collaboration					
Continual professional development					
Collaboration with international sustainable construction body					
Collaboration with international bodies					
Collaboration with international sustainable construction firms					
Collaboration with varying size contractors					
Partnering with suppliers					
Research and Development					
Compliance with sustainability legislation					
Compliance with the voluntary rating and Environmental Management System (EMS)					
Industrialised Building Systems (IBS)/ Prefabricated building units					
Project and Client requirement					
Stakeholders engagement					

11. Please Identify other strategies not identified.....

12. How do you rate the level of performance of your organisation in implementing the following delivery strategies

Factors	Excellent	Very Good	Fair	Poor	Not applicable
Recruitment of experienced technical staff					
Education and training					
Employee empowerment					
Employee reward system					
Improving communication system through information technology					
Surety, bonds and insurance policies Monitoring and evaluation of projects					
Inter-firm collaboration					
Continual professional development					
Collaboration with international sustainable construction body					
Collaboration with international bodies					
Collaboration with international sustainable construction firms					
Collaboration with varying size contractors					
Partnering with suppliers					
Research and Development					
Compliance with sustainability legislation					
Compliance with the voluntary rating and Environmental Management System (EMS)					
Industrialised Building Systems (IBS)/ Prefabricated building units					
Project and Client requirement					
Stakeholders engagement					

13. Please Identify other strategies not identified.....

SECTION III: COLLABORATION WITH SUPPLY CHAINS

14. At what phase of the project do you engage your supply chain members (Multiple answers allowed)

- Tender Phase
- Pre-contract phase
- Contract phase

15. How do the following factors determine the long-term relationship with your supply chains

Factors	Extremely High	Very High	Moderately High	Slightly High	Not at all
Level of commitment					
Trust					
Win-win situation					
High purchasing power					
Regularity of workload					
High Knowledge of construction process					
A common goal and mutual support					
Internal and External alignment (through coordinated teams and cross-functional integration)					
Sharing of information					
Effective communication					
Continuous innovation					

16. How often do you utilise the following mechanism to improve your supply chain performance?

Factors	Always	Often	Sometimes	Rarely	Never
Suppliers assessment					
Providing incentives for improved performance					
Instigating competition amongst supply chains					
Training of Supply chains members					
Helping in organisational restructuring/ Investing resources in supply chain organisation					

SECTION IV: LEVEL AND POTENTIALS OF ADOPTING DIGITAL TECHNOLOGIES

17. How have digital technologies improved your procurement process in the delivery of sustainable projects

- Highly Significantly
- Significantly
- Fairly Significantly
- Not Significant

18. What is the level of compliance of your supply chains in utilising or adopting digital technologies

- Very High
- High
- Average
- Low
- Not aware

19. Which of these technologies has your firm employed during the procurement of a sustainable project? (Multiple answers allowed)

Higher-definition surveying and geolocation

Building information modelling

Digital collaboration and mobility

The Internet of Things (IoT) and Advanced analytics

Future-proof design and construction

Please kindly add any other digital technologies tools not listed.....

20. How often has your organisation utilised the above digital technologies in implementing the following activities

Activities	Always	Often	Sometimes	Rarely	Never
Life-cycle costing					
Construction Demolition					
Calculation of Carbon Emission					
Material Selection					
Recycling and material recovery					
Energy savings analysis					
Reality capturing					
Others.....					

Please specify and rate other activities not mentioned above.....

21. How important do you think digital technologies will help your organisation in implementing the following activities during procurement.

Activities	Extremely Important	Very Important	Moderately Important	Slightly Important	Not at all
Life-cycle costing					
Construction Demolition					
Calculation of Carbon Emission					
Material Selection					
Recycling and material recovery					
Energy savings analysis					
Reality capturing					
Others.....					

Section V: General Comment

Any other comment on sustainable procurement practices?.....

Interview Questions

The interview focuses basically on three main issues:

- 1. How firms implement sustainable procurement practices in their organisation**
 - At the corporate level
 - At the project level
 - Involvement of the various actors
 - Team collaboration and sharing of experience
 - Training and recruitment
- 2. How do firms influence or motivate their supply chains in driving sustainable construction practices?**
 - In terms of responsible sourcing (bribery, child labour, anti-slavery etc)
 - Health and Safety consideration
 - Collaboration with stakeholders
 - Certifications requirement for the various products
 - Sharing of information and getting feedback in terms of quality of a product
 - Sharing of information and knowledge with trade contractors
 - Suppliers development
 - Suppliers assessment
 - Reward system
- 3. The level of adopting digital technologies in driving sustainable procurement**
 - Level of usage of IT resources in gaining competitive advantage
 - Supply chains behaviour in adopting and utilising Digital technologies
 - Potentials of utilising digital technologies tools
- 4. Other issues like government regulations, clients demand etc.**
 - Influence of government policies
 - Clients demand on sustainability (e.g energy demand, health and safety, water usage, responsible sourcing etc)

06/06/2019

Dear Duga Ewuga,

The Research Ethics and Integrity Committee of Technological University Dublin - City Campus has reviewed your application entitled A framework for an effective sustainable procurement practice in the Irish construction sector., our reference REC-18-220. The committee was positive towards your application but had a number of queries in relation to your application and has requested clarifications on the following items:

The REIC notes that it was difficult to understand the different stages of the project and the data collection methodologies to be used at each stage. Please provide a revised summary of the approaches which has been reviewed by the research supervisor.

1. Please clarify the consent approach - who is consent being sought from and for what (i.e. phase one survey and/or phase two interviews)? Please note that separate consent and information sheets should be used in each case. In the event that the survey is delivered online, it should explicitly ask if the respondent would like to participate via an 'opt in' approach/question.
2. Consent form should include an explicit reference to the subject understanding that they can withdraw and that the information is being used for this research and possibly for related research in the future.
3. Please clarify how participants will be able to i) withdraw and ii) be recontacted for case studies in the event that all respondents are anonymised.

The committee considers these to be relatively minor in nature and has agreed that the application is approved subject to the condition that these points are addressed within ten working days of the receipt of this letter. To expedite subsequent review of your application, please provide a point-by-point response to the committee and clearly reference any new documentation which has been uploaded in response to these queries. Please note that additional documentation should be appended to your original application using the edit link provided on initial submission.

Yours sincerely,

A handwritten signature in blue ink, appearing to read 'Steve Meaney', is written over a horizontal line.

Steve Meaney, PhD
Chair - Research Ethics and Integrity Committee, Technological University Dublin - City
Campus

Appendix B: Framework validation Instrument

Invitation to a Focus Group discussion



Duga Ewuga
To Duga Ewuga

Reply Reply All Forward ...

Tue 13-Oct-20 1:04 PM

Dear Participant,

I will first want to thank you for participating in the first phase of the research through interview and completion of the questionnaire survey. The results were analysed, and a framework for an effective, sustainable procurement practice for construction-contracting firms was proposed.

This email is to invite you to participate in a focus group discussion through the Microsoft teams platform. The meeting is to help ascertain the validity of the framework and to identify areas of improvement. I am inviting you to participate because of your experience and expertise in the procurement process and project delivery in a Main Contractor's organisation. Your participation will help to fine-tune the framework and make it as effective as possible.

The proposed date is 23rd October 2020 between 1pm to 2pm

Please reply to this email if you are interested in participating. Feel free to reply with any questions and the suitability of the date and time.

Thank you very much for your consideration.

Duga Ewuga

(PhD student Technological University Dublin).

Framework for Sustainable Procurement Practice for Irish Construction Contracting Firms

Part 1: Interview Questions

1. What do you consider the main benefits of the framework for in the implementation of sustainable procurement practice, or what do you particularly like about the framework?
2. What improvements would you suggest for the framework?
3. What do you think are the likely obstacles to the use of the framework for sustainable procurement practice in the construction-contracting firm?
4. Please make any other comments

Part 2: Framework Evaluation Questions

1. Job title/position

2. Experience in construction (in years)

Please answer each question by clicking the appropriate option (To a very high extent, To a high extent, To some extent, To a Limited Extent, To no Extent at all)

3. How useful would you rate the overall framework for implementing sustainable procurement in the construction industry?

4. How easy would it be to follow the IDEF0 process in the framework (clarity of the framework)?

5. To what extent can following the framework help in implementing an effective sustainable procurement?

6. How effectively can the framework facilitate the overall success of construction projects?

7. How effectively does the framework focus on sustainable procurement issues relevant to the construction firms?

8. How would you rate the applicability of the framework in driving sustainable procurement?

9. How would you rate the logical structure of the framework?

10. How would you rate the comprehensiveness of the framework?

11. How would consider the user-friendliness of the framework?

12. How would consider the value-adding of the framework

Appendix C: Tables of Statistical Results

		Annual Turnover		Total
		€10-€50m	Over €50m	
Role in Organisation	Managing Director	3	4	7
	Regional Director	1	6	7
	Director	1	6	7
	Commercial Manager	0	9	9
	Contracts Manager	3	6	9
	Sustainability Manager	0	1	1
	Strategy and Business Development Manager	0	1	1
	Procurement Manager	1	3	4
	Chief Estimator	0	3	3
	Others	1	13	14
Total		10	52	62

Appendix C1: Role in Organisation * Annual Turnover Crosstabulation

Appendix C2: Role in Organisation * Number of Employees Crosstabulation

		Number of Employees		Total
		250 and above	50-249	
Role in Organisation	Managing Director	5	2	7
	Regional Director	6	1	7
	Director	6	1	7
	Commercial Manager	9	0	9
	Contracts Manager	6	3	9
	Sustainability Manager	1	0	1
	Strategy and Business Development Manager	1	0	1
	Procurement Manager	3	1	4
	Chief Estimator	3	0	3
	Others	12	2	14
Total		52	10	62

Appendix C3: Role in Organisation * Nature of Work Undertaking Crosstabulation

		Nature of Work Undertaking				Total
		Building and Civil works	Building works only	Mechanical and Electrical works	Mechanical works only	
Role in Organisation	Managing Director	2	1	4	0	7
	Regional Director	5	1	1	0	7
	Director	3	2	1	1	7
	Commercial Manager	8	0	0	1	9
	Contracts Manager	9	0	0	0	9
	Sustainability Manager	1	0	0	0	1
	Strategy and Business Development Manager	1	0	0	0	1
	Procurement Manager	3	1	0	0	4
	Chief Estimator	2	0	1	0	3
	Others	14	0	0	0	14
Total		48	5	7	2	62

Appendix C4: Impact of Drivers to Sustainable Practice

Reliability Statistics

Cronbach's Alpha	N of Items
0.789	7

Inter-Item Correlation Matrix

	Impact_Market	Impact_Values	Impact_Transparency	Impact_Life Cycle tech	Impact_Partnership	Impact_Time	Impact_Corporate Governance
Impact_Market	1.000	0.350	0.245	0.413	0.496	0.438	0.265
Impact_Values	0.350	1.000	0.197	0.266	0.317	0.348	0.533
Impact_Transparency	0.245	0.197	1.000	0.248	0.201	0.182	0.115
Impact_Life Cycle tech	0.413	0.266	0.248	1.000	0.539	0.367	0.346
Impact_Partnership	0.496	0.317	0.201	0.539	1.000	0.551	0.396
Impact_Time	0.438	0.348	0.182	0.367	0.551	1.000	0.661
Impact_Corporate Governance	0.265	0.533	0.115	0.346	0.396	0.661	1.000

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Impact_Market	23.19	9.109	0.541	0.758
Impact_Values	23.27	9.481	0.488	0.768
Impact_Transparency	23.40	10.015	0.277	0.809
Impact_Life Cycle tech	23.60	8.704	0.532	0.760
Impact_Partnership	23.35	9.085	0.628	0.744
Impact_Time	23.08	8.829	0.634	0.740
Impact_Corporate Governance	23.16	8.924	0.564	0.753

Appendix C5: Analysis of Sustainable Procurement Strategies

Inter-Item Correlation Matrix

	Level of IMPORTANCE_Recruitment of experienced technical staff	Education and training	Employee empowerment	Employee reward system	Improving communication system through information technology	Surety, bonds and insurance policies	Monitoring and evaluation of projects	Inter-firm collaboration	Continual professional development	Collaboration with international sustainable construction body	Collaboration with international bodies	Collaboration with international sustainable construction firms	Collaboration with varying size contractors	Collaboration amongst the various teams in your organisation	Post-project evaluation and review	Partnering with suppliers
Level of IMPORTANCE_Recruitment of experienced technical staff	1.000	0.753	0.647	0.458	0.503	0.437	0.635	0.547	0.568	0.368	0.340	0.389	0.560	0.656	0.599	0.636
Education and training	0.753	1.000	0.720	0.625	0.647	0.532	0.652	0.650	0.696	0.419	0.415	0.426	0.518	0.722	0.648	0.681
Employee empowerment	0.647	0.720	1.000	0.729	0.620	0.423	0.545	0.487	0.599	0.460	0.468	0.490	0.421	0.569	0.516	0.554
Employee reward system	0.458	0.625	0.729	1.000	0.532	0.409	0.504	0.484	0.597	0.412	0.457	0.396	0.420	0.519	0.448	0.451
Improving communication system through information technology	0.503	0.647	0.620	0.532	1.000	0.525	0.610	0.521	0.656	0.415	0.431	0.429	0.433	0.585	0.482	0.450
Surety, bonds and insurance policies	0.437	0.532	0.423	0.409	0.525	1.000	0.720	0.496	0.504	0.288	0.365	0.352	0.345	0.491	0.513	0.475
Monitoring and evaluation of projects	0.635	0.652	0.545	0.504	0.610	0.720	1.000	0.597	0.601	0.439	0.431	0.394	0.396	0.632	0.735	0.572
Inter-firm collaboration	0.547	0.650	0.487	0.484	0.521	0.496	0.597	1.000	0.528	0.473	0.505	0.484	0.566	0.684	0.593	0.542
Continual professional development	0.568	0.696	0.599	0.597	0.656	0.504	0.601	0.528	1.000	0.529	0.496	0.456	0.512	0.702	0.646	0.641
Collaboration with international sustainable construction body	0.368	0.419	0.460	0.412	0.415	0.288	0.439	0.473	0.529	1.000	0.735	0.683	0.539	0.486	0.520	0.462
Collaboration with international bodies	0.340	0.415	0.468	0.457	0.431	0.365	0.431	0.505	0.496	0.735	1.000	0.763	0.671	0.518	0.587	0.462
Collaboration with international sustainable construction firms	0.389	0.426	0.490	0.396	0.429	0.352	0.394	0.484	0.456	0.683	0.763	1.000	0.578	0.502	0.458	0.533
Collaboration with varying size contractors	0.560	0.518	0.421	0.420	0.433	0.345	0.396	0.566	0.512	0.539	0.671	0.578	1.000	0.634	0.544	0.492
Collaboration amongst the various teams in your organisation	0.656	0.722	0.569	0.519	0.585	0.491	0.632	0.684	0.702	0.486	0.518	0.502	0.634	1.000	0.794	0.710
Post-project evaluation and review	0.599	0.648	0.516	0.448	0.482	0.513	0.735	0.593	0.646	0.520	0.587	0.458	0.544	0.794	1.000	0.697
Partnering with suppliers	0.636	0.681	0.554	0.451	0.458	0.479	0.573	0.543	0.643	0.462	0.463	0.535	0.493	0.716	0.697	1.000
Research and Development	0.470	0.609	0.616	0.472	0.494	0.333	0.303	0.495	0.529	0.562	0.469	0.506	0.546	0.488	0.437	0.533
Compliance with sustainability legislation	0.438	0.509	0.471	0.429	0.357	0.468	0.618	0.463	0.584	0.372	0.325	0.251	0.353	0.549	0.616	0.483
Compliance with the voluntary rating and Environmental Management System (EMS)	0.433	0.381	0.463	0.321	0.210	0.334	0.470	0.318	0.401	0.567	0.429	0.480	0.327	0.447	0.566	0.594
Industrialised Building Systems (IBS)_ Prefabricated building units	0.566	0.544	0.485	0.422	0.371	0.474	0.511	0.405	0.560	0.511	0.557	0.572	0.598	0.636	0.698	0.620
Project and Client requirement	0.587	0.573	0.436	0.307	0.359	0.571	0.694	0.470	0.567	0.346	0.311	0.245	0.386	0.618	0.620	0.600
Level of IMPORTANCE_Stakeholders engagement	0.521	0.561	0.400	0.279	0.377	0.503	0.585	0.482	0.551	0.525	0.400	0.378	0.509	0.635	0.652	0.585

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Recruitment of experienced technical staff	81.15	199.241	0.719	0.747	0.955
Education and training	81.08	197.780	0.800	0.808	0.954
Employee empowerment	81.58	202.149	0.727	0.762	0.955
Employee reward system	82.03	198.884	0.626	0.668	0.956
Improving communication system through information technology	81.21	203.054	0.652	0.692	0.956
Surety, bonds and insurance policies	81.60	201.130	0.611	0.625	0.956
Monitoring and evaluation of projects	81.21	199.152	0.751	0.860	0.955
Inter-firm collaboration	81.84	200.170	0.705	0.629	0.955
Continual professional development	81.32	199.402	0.777	0.709	0.954
Collaboration with international sustainable construction body	81.98	201.033	0.663	0.733	0.956
Collaboration with international bodies	82.13	199.393	0.671	0.806	0.956
Collaboration with international sustainable construction firms	82.37	197.549	0.642	0.734	0.956
Collaboration with varying size contractors	82.06	196.520	0.678	0.728	0.956
Collaboration amongst the various teams in your organisation	81.60	196.343	0.823	0.804	0.954
Post-project evaluation and review	81.66	195.867	0.805	0.844	0.954
Partnering with suppliers	81.58	197.854	0.769	0.732	0.954
Research and Development	81.92	200.239	0.654	0.739	0.956
Compliance with sustainability legislation	81.13	203.754	0.638	0.735	0.956
Compliance with the voluntary rating and Environmental Management System (EMS)	81.47	203.860	0.600	0.704	0.956
Industrialised Building Systems (IBS)_ Prefabricated building units	81.71	198.537	0.733	0.697	0.955
Project and Client requirement	80.95	206.211	0.674	0.844	0.956
Stakeholders engagement	81.24	203.531	0.697	0.796	0.956

Component Matrix^a

	Component		
	1	2	3
Collaboration amongst the various teams in your organisation	0.850		
Post-project evaluation and review	0.836		
Education and training	0.830		-0.304
Continual professional development	0.806		
Partnering with suppliers	0.800		
Monitoring and evaluation of projects	0.788	-0.341	
Industrialised Building Systems (IBS)_ Prefabricated building units	0.760		
Recruitment of experienced technical staff	0.758		
Employee empowerment	0.751		-0.371
Stakeholders engagement	0.738		0.408
Inter-firm collaboration	0.733		
Project and Client requirement	0.721	-0.485	
Collaboration with varying size contractors	0.702	0.330	
Improving communication system through information technology	0.684		-0.473
Collaboration with international bodies	0.684	0.543	
Compliance with sustainability legislation	0.684	-0.336	
Collaboration with international sustainable construction body	0.681	0.476	
Research and Development	0.681		
Collaboration with international sustainable construction firms	0.660	0.568	
Employee reward system	0.660		-0.457
Surety, bonds, and insurance policies	0.654	-0.302	
Compliance with the voluntary rating and Environmental Management System (EMS)	0.636		0.466

Extraction Method: Principal Component Analysis.
a. 3 components extracted.

	Pattern Matrix ^a			Structure Matrix			
	Component				Component		
	1	2	3		1	2	3
Project and Client requirement	0.966			Project and Client requirement	0.900	0.309	-0.416
Stakeholders engagement	0.836			Stakeholders engagement	0.849	0.519	-0.333
Compliance with sustainability legislation	0.728			Post-project evaluation and review	0.825	0.603	-0.541
Monitoring and evaluation of projects	0.675		-0.353	Monitoring and evaluation of projects	0.806	0.377	-0.646
Post-project evaluation and review	0.651			Compliance with sustainability legislation	0.765	0.341	-0.463
Compliance with the voluntary rating and Environmental Management System (EMS)	0.565	0.490		Collaboration amongst the various teams in your organisation	0.757	0.587	-0.678
Surety, bonds and insurance policies	0.551		-0.336	Partnering with suppliers	0.745	0.591	-0.562
Partnering with suppliers	0.528			Industrialised Building Systems (IBS)_ Prefabricated building units	0.707	0.695	-0.414
Industrialised Building Systems (IBS)_ Prefabricated building units	0.500	0.474		Recruitment of experienced technical staff	0.681	0.431	-0.680
Collaboration amongst the various teams in your organisation	0.487		-0.351	Surety, bonds, and insurance policies	0.665		-0.560
Collaboration with international sustainable construction firms		0.864		Compliance with the voluntary rating and Environmental Management System (EMS)	0.659	0.638	
Collaboration with international bodies		0.854		Collaboration with international bodies	0.400	0.876	-0.449
Collaboration with international sustainable construction body		0.821		Collaboration with international sustainable construction firms	0.364	0.869	-0.441
Collaboration with varying size contractors		0.609		Collaboration with international sustainable construction body	0.455	0.856	-0.391
Research and Development		0.468	-0.410	Collaboration with varying size contractors	0.480	0.742	-0.515
Improving communication system through information technology			-0.797	Research and Development	0.428	0.646	-0.612
Employee reward system			-0.765	Education and training	0.676	0.461	-0.845
Employee empowerment			-0.706	Improving communication system through information technology	0.436	0.402	-0.830
Education and training	0.339		-0.671	Employee empowerment	0.501	0.515	-0.818
Continual professional development	0.347		-0.498	Employee reward system	0.382	0.446	-0.798
Inter-firm collaboration			-0.468	Continual professional development	0.665	0.530	-0.734
Recruitment of experienced technical staff	0.447		-0.448	Inter-firm collaboration	0.571	0.521	-0.676

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.
a. Rotation converged in 18 iterations.

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.

Component Correlation Matrix

Component	1	2	3
1	1.000	0.469	-0.490
2	0.469	1.000	-0.424
3	-0.490	-0.424	1.000

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization.

Appendix C6: Influencing Supply Chains by Main Contracting firm

Reliability Statistics Long-term Relationship with Supply Chains

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N of Items
0.842	0.845	11

Item-Total Statistics-Long-term Relationship with Supply Chains

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Level of commitment	41.61	16.766	0.583	0.520	0.825
Trust	41.44	16.971	0.558	0.471	0.827
Win-win situation	41.92	17.157	0.402	0.240	0.839
High purchasing power	41.97	16.655	0.420	0.237	0.839
Regularity of workload	42.15	17.077	0.403	0.225	0.839
High Knowledge of construction process	41.58	17.100	0.505	0.339	0.830
A common goal and mutual support	41.81	15.929	0.622	0.485	0.820
Internal and External alignment (through coordinated teams and cross-functional integration)	42.26	16.818	0.513	0.400	0.829
Sharing of information	42.21	15.873	0.599	0.528	0.822
Effective communication	41.81	16.355	0.592	0.554	0.823
Continuous innovation	42.06	15.963	0.581	0.444	0.823

Reliability Statistics- Mechanism for Improving Supply Chain Performance

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N of Items
0.775	0.779	5

Item-Total Statistics- Mechanism for Improving Supply Chain Performance

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Mechanism for improvement of SC_ Suppliers assessment	12.11	7.938	0.495	0.258	0.750
Providing incentives for improved performance	13.15	7.667	0.629	0.425	0.711
Instigating competition amongst supply chains	12.48	6.811	0.585	0.381	0.722
Training of Supply chains members	12.84	7.777	0.534	0.304	0.738
Helping in organisational restructuring/ Investing resources in supply chain organisation	13.23	7.424	0.516	0.330	0.745

Appendix C7: Level of Adoption of Digital Technologies

Reliability Statistics on Utilisation of Digital Technology

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N of Items
0.830	0.836	6

Item-Total Statistics on Utilisation of Digital Technology

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Life-cycle costing	16.77	13.522	0.651	0.462	0.793
Construction Demolition	16.63	13.975	0.414	0.306	0.847
Calculation of Carbon Emission	16.97	13.278	0.642	0.571	0.794
Material Selection	16.34	13.703	0.622	0.411	0.799
Recycling and material recovery	16.53	12.909	0.671	0.486	0.787
Energy savings analysis	16.52	13.336	0.647	0.567	0.793

Reliability Statistics on Important of Digital Technologies

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N of Items
0.888	0.894	7

Item-Total Statistics on Important of Digital Technologies

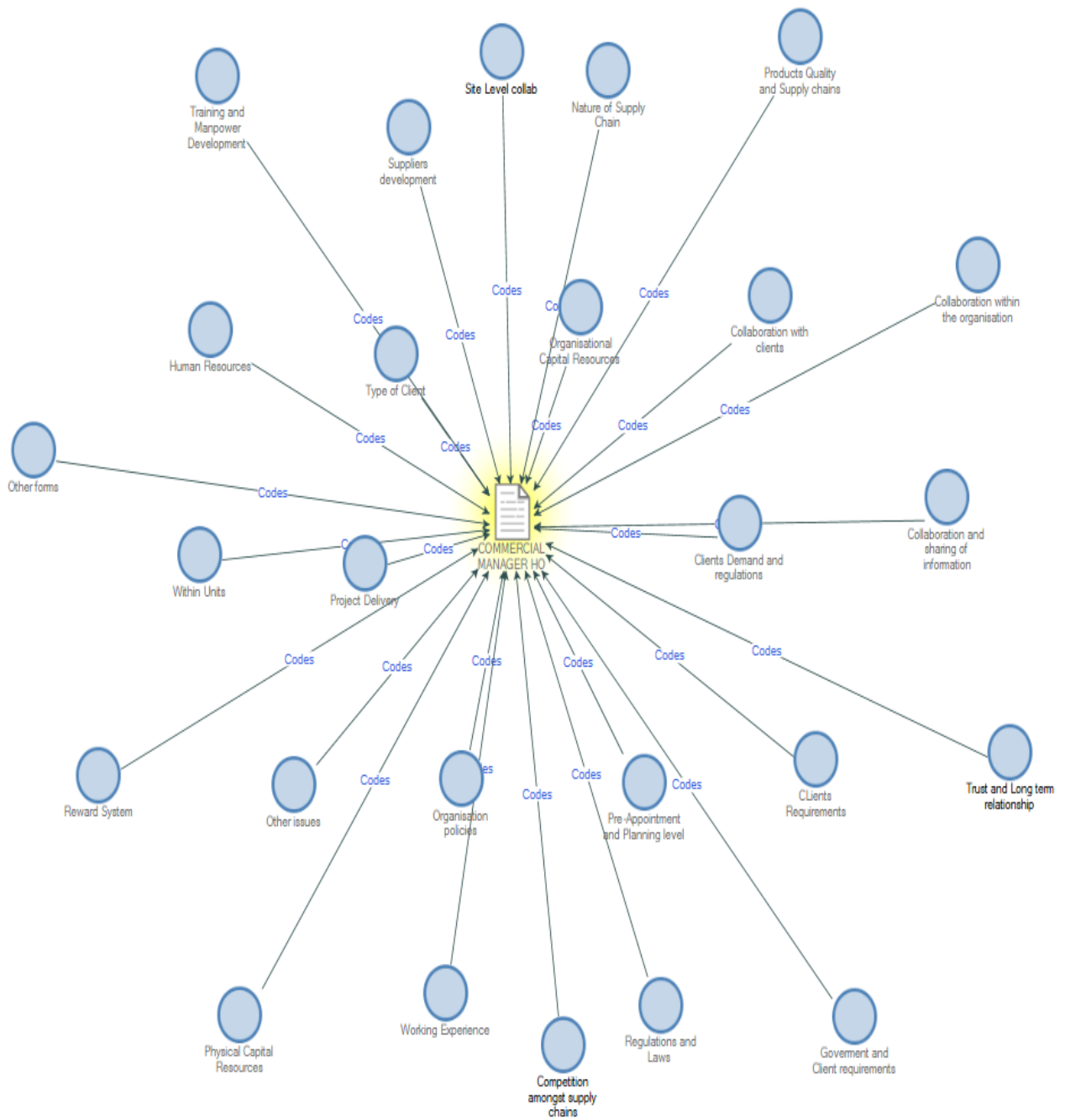
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Life-cycle costing	24.32	20.189	0.664	0.531	0.874
Construction Demolition	24.55	19.662	0.486	0.448	0.904
Calculation of Carbon Emission	24.18	18.116	0.802	0.762	0.856
Material Selection	24.11	20.233	0.689	0.642	0.872
Recycling and material recovery	24.16	18.367	0.830	0.727	0.853
Energy savings analysis	23.95	19.260	0.792	0.810	0.859
Reality capturing	24.08	20.797	0.592	0.459	0.882

Appendix D: Codes and Themes from NVivo 24

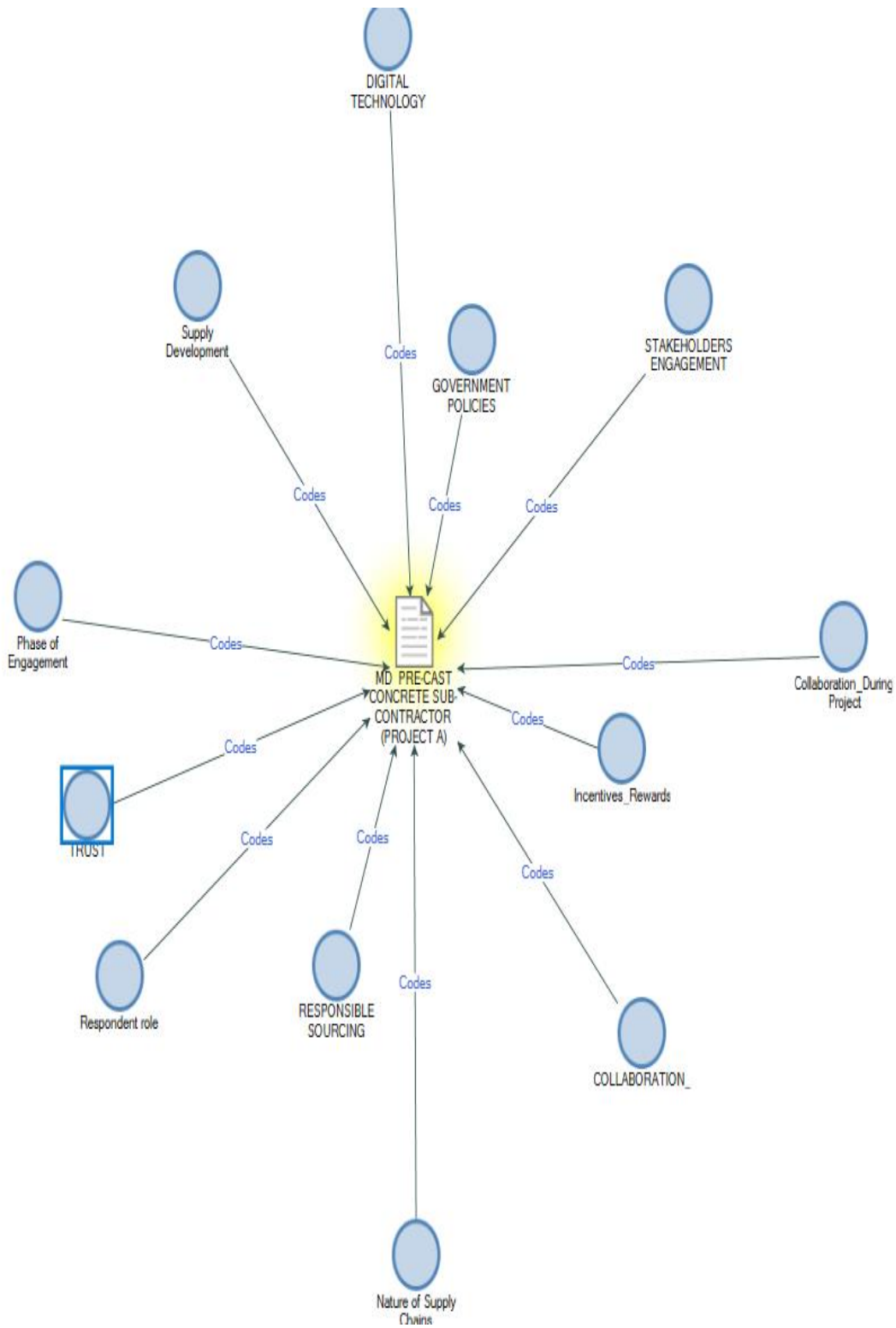
APPENDIX D1: Parent and Child Nodes

Nodes		Search Project						
Name	Files	References	Created On	Created By	Modified On	Modified		
HEAD OFFICE TEAM		0	0	23/03/2020 11:56	J	30/03/2020 19:00	J	
Government and Client requirements		4	159	11/03/2020 15:23	J	30/03/2020 18:58	J	
Human Resources		4	184	11/03/2020 15:17	J	30/03/2020 19:01	J	
Organisation policies		4	98	11/03/2020 15:15	J	28/03/2020 22:08	J	
Organisational Capital Resources		4	153	11/03/2020 15:21	J	27/03/2020 23:46	J	
Physical Capital Resources		4	46	11/03/2020 15:17	J	27/03/2020 23:41	J	
PROJECT TEAM		0	0	23/03/2020 11:59	J	23/03/2020 12:06	J	
PROJECT A		0	0	23/03/2020 12:03	J	23/03/2020 12:06	J	
PROJECT A SUPPLY CHAINS		0	0	21/06/2020 20:47	J	21/06/2020 20:48	J	
PROJECT B		0	0	23/03/2020 12:05	J	23/03/2020 12:06	J	
PROJECT B SUPPLY CHAINS		0	0	21/06/2020 20:52	J	21/06/2020 20:52	J	

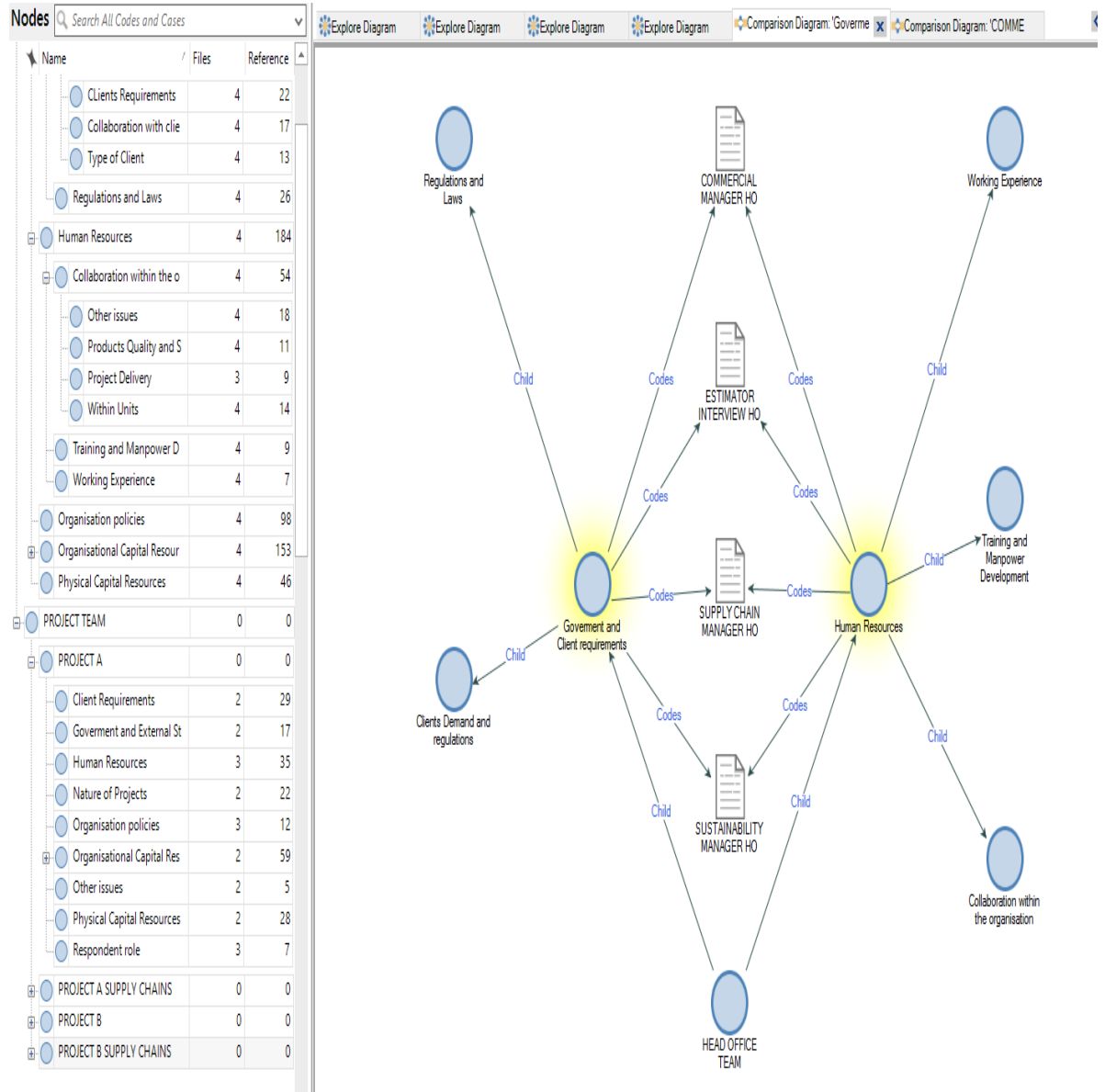
Appendix D2: Themes from Main Contractor's Organisation



Appendix D3: Themes from Supply Chains



Appendix D3: Comparing Nodes and Files



LIST OF PUBLICATIONS

1. **Ewuga, D.** Mulville, M and Hore, A. (2021). Influencing Supply Chains in Driving Sustainable Procurement: A Contractor's Perspective. *Construction Economics and Building*. (Special Issue on Lean and Sustainable Construction: State of the Art and Future Directions). **(Under Review-Abstract Accepted)**
2. **Ewuga, D.**, Hore, A., & Mulville, M. Applying the Resource-Based View (RBV) Theory In Sustainable Procurement Practice In The AEC Sector. In *14th INTERNATIONAL POSTGRADUATE RESEARCH CONFERENCE 2019: Contemporary and Future Directions in the Built Environment* (p. 457).
3. Brooks, T., **Ewuga, D.**, Scott, L. and Spillane, J.P., 2018. The impact of Brexit on cross-border trade by the construction sector in Ireland: an exploratory study.
4. **EWUGA, D.** and SCOTT, L. An Examination of Irish Contracting Firms Policies on Sustainable Construction Practice. In: SCOTT, L. & GORSE, C., eds. 4th International Sustainable Ecological Engineering Design for Society (SEEDS) Conference Proceedings, 2018 Dublin. 615-626.
5. **Duga J. Ewuga**, and Lloyd M. Scott (2017) *Development of a Sustainable Procurement Model for the Construction Industry (Poster)* 53rd ASC Annual International Conference Proceedings, 819 Seattle USA.

LIST OF EMPLOYABILITY AND DISCIPLINE SPECIFIC SKILLS

TRAINING

1. GRSO 1001: Research Methods
2. PRJM 2000: Project Management: Tools and Techniques for Academic Researchers
3. SOC 9005: Organisations: Culture Change and Learning
4. GRS1010: Introduction to Pedagogy
5. BEN9xxx: Cross-Domain in BIM Surveying and Construction Management
6. CIV9000: Introduction to Sustainable Infrastructures
7. GRS1005: Introduction to Statistics
8. RECE 9407: Collaborative Technologies