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ABOUT JCBM

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Promoting Sustainable Construction Practices in Developing Countries: Comparative Insights and Future Directions

Editorial December 2023

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Introduction

Sustainable construction practices contribute significantly to the advancement trajectory in developing and developed nations. Emphasising environmental conservation, efficient resource utilisation, and the facilitation of healthier, more productive living and working environments, sustainable construction practices are fundamental to achieving a more prosperous and ecologically balanced future. However, the effective transition to and adoption of these practices in developing nations raises significant challenges. 'Which way forward to addressing these issues as discussed in the last issue including the editorial (Windapo and Umeokafor 2023). These challenges, explored in depth in the diverse research articles featured in this issue, illuminate the ongoing difficulties developing nations face in embracing sustainable construction practices, along with potential solutions and future directions for research. They contribute to answering the question in the last issue, 'Which way forward?' (Ibid).

This twelfth issue of the Journal of Construction Business and Management offers a thought-provoking and insightful collection of five seminal research articles by 11 authors from Nigeria, South Africa, Uganda, the United Kingdom and the United States of America. The key themes of the articles include promoting awareness of Autoclaved Aerated Concrete Blocks (AACB) for construction, enhancing government construction project success through effective leadership styles, fostering the adoption of Building Information Modelling (BIM) in Quantity Surveying, examining the link between Quantity Surveyors' conflict-handling styles and personality traits, and tracking technological and organisational change in the UK construction sector. As discussed below, each theme contributes to a nuanced and comprehensive understanding of the urgent need for, obstacles to, and promising strategies for sustainable construction in developing countries.

Discussion of the papers

The articles in this issue present incisive, empirically ground analyses of critical issues regarding sustainable construction in developing countries. They reveal the complexities of shifting towards more sustainable practices and the potential solutions to such challenges. Oladiran and Simeon (2023) detail the lack of awareness of AACB in Nigeria in contrast to South Africa, a discrepancy that undermines the successful implementation of this sustainable construction material in the former. Besides proposing

strategies such as continuous development training and research, the authors underscore the need for future investigations examining the underlying reasons for the varying levels of AACB awareness among construction professionals in different countries. Accordingly, the authors recommend improving professionals' awareness level of AACB through workshops and seminars and adopting environmentally sustainable materials. They also noted the need to improve the supply chain challenges toward attracting clients, consultants and contractors. Admitted that these are required, how do we get the stakeholders, including the government, involved? Governmental interest in such issues in developing countries, including Nigeria, has always been low. Perhaps future research can focus on alternative salient strategies that defy such challenges and are independent of the government.

Despite the criticisms of the government, they are the main client of the construction industry globally. Hence, the commissioner or client of most projects in the industry. However, many of these projects are unsuccessful, and the leadership style has been argued to be one of the leading causes. Consequently, using Uganda as a case study, Ssenyange and Kudakwashe (2023) examine the role of leadership styles in completing government construction projects, contributing valuable insights. They found that leadership style contributes to the success or failure of government projects. They found that leadership style contributes to the success or failure of government projects. Their findings, emphasising the importance of effective communication and stakeholder participation, suggest promising avenues for project managers' targeted training and development, thereby enhancing project outcomes and contributing to infrastructural advancement. Some recommendations include the onus on the project manager to drive adequate dissemination of information to stakeholders and the project leader to ensure stakeholder participation at the early stages of the projects (especially the design stage), decision-making on the project site and defining the project duration. Although not without limitations, implementing digital technologies is one of the ways of addressing communication and operation issues. However, the adoption of digital technologies in the construction industry is still low, especially in developing countries.

The third paper, Ogunseiju, Odeyinka, and Yusuf (2023), expands the discourse on adopting digital technologies in the construction industry in developing countries by investigating the limited use of BIM in Nigerian QS firms. They highlight the importance of adaptive technologies in streamlining construction processes and promoting more sustainable practices. Here, the lack of BIM adoption shows missed opportunities for efficiency enhancements. Therefore, increased promotion of BIM adoption among QS firms constitutes a fundamental step towards rectifying this lacuna.

One of the significant barriers to collaborative working is conflict. It is described as a norm by construction industry experts, according to Aderibigbe et al. (2023). It has devasting effects on productivity, cost, performance, and client satisfaction (Arcadis, 2021)—human behaviours, including interpersonal relations, are determinants of conflict. The fourth paper, Verwey, Cumberlege, and Crafford (2023), delves into the interconnections between quantity surveyors' conflict-handling styles and personality traits, suggesting the importance of personal factors in achieving successful project outcomes. Future research should expand this line of inquiry to include a broader range of construction professionals and contexts.

Lastly, Lowe's (2023) examination of technology and organisational change in the UK construction sector offers a unique perspective on the evolving dynamics of construction practices and their implications for sustainability. Aimed at identifying the extent of the spread of technical and organisational change in the UK construction sector from 1997 to 2020, the author concludes that the materials sector has seen little improvement in terms of switching materials and limited increases in mechanisation. However, they found no evidence of the use of off-site prefabrication. There is a growth in subcontracting as contractors seek to transfer or reduce risks. These insights can inform strategic adjustments and policy decisions in developing countries seeking to advance their construction sectors.

Conclusion

This issue highlights interconnected challenges and potential solutions for promoting sustainable construction practices in developing nations. They range from raising awareness of sustainable construction materials and fostering the adoption of innovative technologies to optimising leadership

styles and understanding personal factors impacting project outcomes. The depth and breadth of topics covered in this issue attest to the complexity of the task. However, they indicate a path forward marked by continued research, targeted interventions and policy formulation, and a collaborative effort among various stakeholders. We hope this collection of articles will stimulate further research and dialogue to accelerate the sustainability transition in the construction sectors of developing nations.

We extend our profound thanks to the authors for their valuable contributions and to the reviewers for their role in ensuring the quality and relevance of the research presented. We also appreciate the continued support of the Journal's Editorial Board and our panel of reviewers. We welcome feedback and suggestions from readers on how we may further enhance the quality and impact of the journal.

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Consciousness and Prospects of Autoclaved Aerated Concrete Blocks for Wall Construction: A Comparative Study of Nigeria and South Africa

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Abstract

Autoclaved Aerated Concrete Block (AACB) is a viable, sustainable walling material for building projects but has not been given the attention it deserves in developing countries. To increase the usage of AACB on building projects, this study examines the consciousness and prospects for its use in Nigeria and South Africa. The objectives are to evaluate the degree of knowledge about AACB in both countries; and to assess the likelihood of adopting AACB in Nigeria. The study centres on Lagos and five provinces in South Africa. Lagos was chosen in Nigeria because the State is the only place in Nigeria where AACB have been used. A total of 145 questionnaires were administered to professionals who had been involved in AAC projects. In contrast, 17 South African respondents familiar with AACB in construction projects were contacted. Convenience and snowball sampling techniques were used for construction professionals in Nigeria and South Africa respectively. Data were analysed using Statistical Package for Social Sciences (SPSS) version 23.0. Statistics such as percentages and mean scores were explored in addition to analysis of variance (ANOVA) and the Mann-Whitney U test. Findings indicate that construction professionals in Nigeria know very little about 19 of the 20 documented AACBs. However, the South African professionals are very knowledgeable about AACB grade 42.5 OPC and AACB of AP/RHA and fully aware of AACB with grade 52.5 OPC, though they know nothing about the Bamboo Leaf Ash (BLA) AACB. This means that Nigerian professionals have a moderate stance on using AACB. The study concludes that South African professionals are more aware of AACB and its variants than Nigeria. This implies that AACB manufacturing in Nigeria would not thrive in the construction market due to poor patronage since patronage is directly related to product awareness. The study therefore suggests that construction professionals should increase their understanding of AACB through continuous development training, workshops and seminars on environmentally friendly building materials. Another suggestion is for consultants, clients, developers, contractors, governments and research institutions to continuously conduct research and embrace findings on AACB and new building construction materials regarding usage, wear, tears and durability.

Keywords: Autoclaved aerated concrete block (AACB), Awareness, Professionals, Prospects, Sustainability

1. Introduction

Over the past decades, the construction industry has consistently adopted and developed sustainable building materials and technologies (Shon et. al., 2021). One of such material is Autoclaved Aerated Concrete Block (AACB), which has been gaining popularity in construction since the mid-1900s (Saad et al., 2022). AACB is adjudged an innovative material that offers features such as good strength-to-density ratio, thermal insulation capabilities, lightweight, fire resistance capacity, excellent sound insulation and simplicity of cutting and fixing (Gyurkó et al., 2019; Wang et al., 2022). These AACB attributes have enhanced widespread application and popularity in many parts of the world, including the United States, Europe and Asia (Mollaei et al., 2022). Jerman et al. (2013) posit that AACB is a structural material widely used in Europe and other developed economies, owing to its ease of manufacture, usage with mechanical and thermal qualities superiority over other materials. For these reasons, AAC is commonly used as a construction material in concrete masonry units, such as blocks (Ulykbanov et al., 2019).

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Moreover, Desani et. al. (2016) noted that lightweight concrete (LC) contains no coarse particles and is either aerated with mortar that includes gas bubbles or infused air-entraining agents. In terms of densities, Falade (2009) grouped concrete blocks into three: (i) lightweight, ranging from 300 to 1950 kg/m3; (ii) moderate weight, 2200 to 2500 kg/m3; and (iii) heavyweight, 3360 to 3680 kg/m3. LC blocks are frequently employed in the construction of high-rise buildings to reduce the dead load and distribute less weight to the foundation (Amran et al., 2020). Narayanan and Ramamurthy (2000) found that the characteristics of aerated concrete block depend on the composition and microstructure (void paste system) affected by the curing procedure, the binder used and the mechanism of pore-formation. AACB production process comprises slurry preparation where the constituents react chemically, rising or foaming, sawing and autoclaving (Cheran et al., 2017).

Curing is a significant aspect of concreting that impacts the physical and mechanical characteristics (Ikponmwosa et al., 2014; Desani et al., 2016). Based on the curing technique, Autoclaved Aerated Concrete (AAC) may be classified into Autoclaved Aerated Concrete (AAC) and Non-Autoclaved Aerated Concrete (NAAC). Modern technical advancements and innovative construction techniques have made various walling materials available, with concrete blocks, bricks, wood and glass taking centre stage (Olawuyi and Babafemi, 2013). However, in Nigeria, blocks occupy over 90% of the walling units (Baiden & Tuuli, 2004). Singh et al. (2017), in their study on innovative and environmentally friendly building materials found that conventional brick material produces significant amounts of carbon dioxide (CO2) and other greenhouse gases, many of which are hazardous or toxic, contributing to environmental pollution and health-related challenges.

According to Oo and Hlaing (2018), early bricks were sun-dried mud, while burnt bricks were subsequently discovered to be more resistant to severe weather conditions. This made them far more reliable than the early bricks used for wall construction. Fired clay bricks absorb heat during the day and release it at night. It also has naturally sustainable qualities like high-temperature resistance and durability. Notwithstanding, the kilning process has some sustainability issues emanating from brick's greenhouse gas emissions and high energy usage.

Similarly, firing of clay bricks produces significant amounts of CO2 and other hazardous gases, which increases the threat of climate change and global warming (Gautem and Sexena, 2013). Rathi and Khandve (2015) found that clay bricks are not ecologically sustainable and should be substituted with AACB. There are no documented AAC studies in Nigeria and South Africa, but AACB has been used on several buildings in both countries. Therefore, this study aims to compare the usage of AACB in Nigeria and South Africa to ascertain awareness and expose the potential of its usage in construction in Nigeria to improve patronage. The objectives are to find out the awareness of AACB variants in both countries and examine the likelihood of using AACB in Nigeria. The study also hypothesized whether the opinion of experts in Nigeria and South Africa about awareness of AACB and its variants is significantly different; and whether there is substantial variation in the potential of AACB adoption among Nigerian construction professionals.

The study is significant because it will hopefully lead to the construction of sustainable buildings in terms of materials' environmental friendliness and affordability.

2. Physical Properties and Environmental Friendliness of Autoclaved Aerated Concrete (AAC)

AAC is also known as Autoclaved Cellular Concrete (ACC), Autoclaved Lightweight Concrete (ALC), Autoclaved Concrete (AC), Cellular Concrete (CC), Porous Concrete (PC) and Aircrete. It is a low-density load-bearing construction material due to more significant porosity than other load-bearing wall construction materials (Narayanan & Ramamurthy, 2000). AAC is produced in various manufacturing parameters; the density ranges from 93 to 1800 kg/m3, though the component particle density is approximately 2,600 kg/m3. The pores account for 30% to 90% of the volume (Kadashevich et al., 2005). AAC is thus adjudged a sustainable construction material.

Sustainable construction materials are those that perform better compared to predetermined standards. Factors taken into consideration in choosing sustainable construction materials are the cost of transportation, environmental impact, availability, thermal efficiency, financial viability, occupant's needs, health considerations, recyclability from a demolished building, manufacturing process, energy consumption, waste and pollution generated in the manufacturing process, toxic emissions from the construction process and the use of renewable resources (Patil & Patil, 2017).

Construction materials play a fundamental role in infrastructural sustainability and assisting in the flourishing of the national economy. The use of eco-friendly building materials has negative impact on the environment in various dimensions due to the extensive use of non-renewable resources and the quantity of debris and pollutants produced during the

material's life cycle (Ofori, 2002). This informed Boido and Caldera's (2002) research on AAC's potential, limitations and sustainability in phases. AACB production processes were assessed: the colour, prism arrangement, face flatness, edge straightness and presence of fractures, protuberances, chipping and departure from specified nominal dimensions. The chemical composition, density, capillary absorption and freeze-thaw resistance of three samples of AACB were subjected to laboratory testing as part of the study's second phase. The edges of the Type A and Type B blocks remained firm after investigation.

In contrast, Type C displayed substantial degradation and spalling in tests for dimensional stability, capillary absorption and freeze-thaw resistance, with the edges eroding to the point where they entirely break off. A microscopic examination revealed that the Type C block's porosity is a primary weakness. The assessment factors covered in the third phase of the inquiry were the manufacturing process, transport, fixing, durability and maintainability. These show that AAC possesses the required features of a sustainable material.

AAC is ecologically beneficial because it entirely constitutes natural resources without pollutants (Subash et al., 2016); therefore, it contains no dangerous or damaging materials. Moreover, it requires little energy to produce, uses few raw materials, simple to use in construction, has high energy efficiency, improves indoor air quality and is highly recyclable. In the same vein, aerated lightweight concrete is categorised by Hamad (2014) into foamed concrete and autoclaved concrete. For both foamed and autoclaved concrete, the production process is categorised. Prakash et al. (2013) focused on calculating the physical, strength and elastic parameters of aerated concrete block units. These included the initial rate of absorption, modulus of elasticity, water absorption and density tests, compressive strength and flexural strengths of the units.

AAC production technologies are energy-efficient and use fewer raw materials than other construction materials. This can be attributed to AAC's low-density, waste-free, environmentally friendly production model. AAC offers specific advantageous properties in the context of sustainable development in the construction industry (Domingo, 2008). In dry conditions, AAC typically has a density ranging from 300 to 1,000 kg/m3. The lightweight concrete mortar is aerated with tiny bubbles from a chemical process or an air-entraining agent. Aerated concrete contains no coarse particles in its combination. Aluminium powder, cement, silica sand, quick lime and gypsum constitute AAC (Ismail et al., 2004).

Several studies have investigated the possible use of AACB as a technically viable alternative building material for construction. AACB has been successfully used as a walling material to construct residential and hotel buildings in Nepal (Khanal et al., 2020). Sarma et al. (2017) revealed a compressive strength statistic of 2.86 N/mm2 during the 28 days of normal curing for a 617.6 kg/m3 density. It however recorded a strength of more than 20 N/mm2 with the addition of silica fume, polypropylene fibre and steel mesh reinforcements. Khanal et al. (2020) discovered that the compressive strength of the AACB to be 4.324 N/mm2 even with a density as low as 617.6 kg/m3 when compared to a 3.402 N/mm2 average compressive strength of brick of 1,685.8kg/m3. According to Narayanan and Ramamurthy (2000), AAC contains tobermorite, which is much more solid than the products made in usually cured aerated concrete and, therefore, more durable.

AAC offers a microclimate since it is a sustainable material. According to Rathi and Khandve (2015), AACB meets the thermal performance standards of buildings, hence, thermally efficient. As a result of the lightweight property of AACB, it reduces the cost and robustness of foundation reinforcement significantly. This claim is supported by Rathi and Khandve (2015), who noted that the product is lightweight, easy to cut and work with, and saves steel, cement, mortar and plastering expenses. Despite the extensive research reports on the viability of AACB for buildings, Nigeria has no policy governing its use. The absence of information on eco-friendly, sustainable materials in the 2006 Nigerian National Building Code and a lack of technical know-how in processing AACB for housing supposedly explains its low awareness and acceptance as a walling material in Nigeria. Currently, the awareness of AACB as a walling material in other African countries apart from South Africa can be said to be in its infancy or non-existent. The industry's reliance on traditional bricks and blocks and its aversion to change for adopting sustainable materials such as AACB makes it challenging to accept.

3. Research Method.

The study adopted a cross-sectional survey research design. The study population was drawn from construction professionals based in Lagos State, Nigeria and five provinces of South Africa (namely Western Cape, Gauteng, Free State, Eastern Cape, and KwaZulu-Natal). Structured questionnaires were used to source data from the Nigerian construction professionals in Lagos. In contrast, online Google Forms questionnaires collected data from South African construction professionals. The study used a multi-sampling methodology, convenience sampling

technique was employed in Nigeria and snowball sampling in South Africa using experts familiar with the subject matter and involved in its application in construction projects. The questionnaire items were closed-ended to source data relevant to the study objectives from the respondents. The first questionnaire obtained data on 20 AACB variants sourced from the literature. This compared the degree of knowledge of the 20 AACB variants between construction professionals in the two countries. Each variant was presented on a Likert scale of 1 to 5. On the scale, 1 denoted 'No Awareness', 2 'Slight Awareness', 3 'Moderate Awareness', 4 'High Awareness', and 5 'Full Awareness'. The second part of the data collection instrument assessed the likelihood that AACB would be adopted in Nigeria's construction sector. This was achieved from participants who were asked again on a Likert scale of 1 to 5: 1 for Very Poor, 2 for Poor, 3 for Average, 4 for Good, and 5 for Very Good. The Nigerian respondents received 145 copies of the questionnaire, while 99 properly completed questionnaires were received, representing a response rate of 68.3%. Given the challenges of collecting survey responses in Lagos state, this is a reasonable response rate. Furthermore, 17 responses were received from South African construction experts who were familiar with the material and had been involved in its usage on building projects in five South African provinces.

Statistical Package for Social Sciences (SPSS) version 23.0 was used to analyse the data received from participants. Specific tools used were percentage, mean scores, analysis of variance (ANOVA) and Mann-Whitney U test. ANOVA, typically used to compare the means of multiple groups on several variables, was used in this study to compare the mean scores (MSs) of construction professionals on the potential of AACB adoption among Nigerian construction organisations. Similarly, the Mann-Whitney U test, generally used for comparing the mean scores (MSs) of two groups, was used in this study to compare the mean scores (MSs) of the Nigerian and South African professionals on the awareness of AACB variants (Hanneman et al., 2013).

4. Findings and Discussions

4.1 Demographic Characteristics

The demographic characteristics of Nigerian professionals in their organisations are shown in Table 1.

Table 1: Demographic Characteristics of Nigerian Respondents

Description	Frequency	%
The Profession of the Respondents and Registration with Professional Associations		
Architecture (NIA)	7	7.07
Building (NIOB)	38	38.38
Civil Engineering (NSE)	45	45.45
Quantity Surveying (NIQS)	9	9.09
Total	**99**	**100.00**
Highest Academic Qualification		
OND	0	0.00
HND	10	10.10
BSc/B.Tech	55	55.56
MSc/MBA	31	31.31
PhD	3	3.03
Total	**99**	**100.00**
Years of Experience		
1-5 Years	25	25.25
6-10 Years	29	29.29
11-15 Years	26	26.26
16-20 Years	12	12.12
21 Years and above	7	7.07
Total	**99**	**100.00**
Organisation Type		
Consulting	31	31.31
Contracting	45	45.45
Client Organisation	5	5.05
Design & Build	18	18.18
Total	**99**	**100.00**
Organisation Size		
Small-sized with 1-50	43	43.43
Medium-sized with 51-250	47	47.47
Large size with 250 or more	9	9.09
Total	**99**	**100.00**
Ownership and Management		
Fully Indigenous	27	27.27
Fully Expatriate	5	5.05
Partly Indigenous and partly expatriate	67	67.68
Total	**99**	**100.00**
Nature of works undertaken		
New Construction	27	27.27
Renovation	5	5.05
General contracting	67	67.68
Total	**99**	**100.00**

Table 1 shows that in the professional group, 7.07% were Architects registered with the Nigerian Institute of Architects (NIA), 38.38% were Builders registered with the Nigerian Institute of Building (NIOB), 45.45% were Civil engineers registered with the Nigerian Society of Engineers (NSE) and 9.09% were Quantity Surveyors who were registered with the Nigerian Institute of Quantity Surveyors (NIQS). Furthermore, 10.10% of respondents had Higher National Diploma (HND) degree, 55.56% had Bachelors degree (B.Sc./B.Tech.) while 31.31% and 3.03% had Masters and Doctoral degrees respectively. Moreover, 25.25% of the Nigerian respondents had one to five years of post-qualification experience, six to ten years experience by 29.29%, eleven to fifteen years experience by 26.26%, sixteen to twenty years by 12.12% and twenty-one years or more experience by 7.07% of the respondents.

The demographic data of the organisations show that construction project consultancy firms employ 31.31% of the respondents, 45.45% work for contracting firms, 5.05% work as clients' in-house construction professionals and 18.18% work for design and build firms. In addition, 43.43% were from Small firms, 47.47% of the respondents were from Medium-sized firms, and 9.09% were from Large firms. Furthermore, 27.27% of the companies are indigenous-owned, 5.05% are foreign-owned, and 67.68% are a mixture of expatriates and Nigerian owners. Besides, 27.27% of the organisations engage in new construction projects, 5.05% in rehabilitation and refurbishment and 67.68% in general contracting. Result of the analysis of data from South African respondents is shown in Table 2.

Table 2 shows that 5.88% of participants had one to five years work experience, 17.65% had six to ten years work experience, 47.06% had eleven to fifteen years work experience, 17.65% had sixteen to twenty years work experience and 11.76% had twenty-one years or more work experience. In addition, 35.29% of the companies were Small, 41.18% were Medium, and 23.53% were Large. Regarding Organization Ownership, 47.06% are indigenous, 17.65% are expatriate-owned and 35.29% are partially indigenous and expatriate. Regarding the nature of the work undertaken, 23.53% of the respondents' companies work on new construction, 5.88% work on renovations and refurbishments and 70.59% work as general contractors. The provinces in South Africa where the professionals were based are 52.94% in the Western Cape. Gauteng, Free State, Eastern Cape, and KwaZulu-Natal each had 11.76% by provincial location.

Table 2: The South African Respondents' Demographic Characteristics

Description	Frequency	%
Years of Experience		
1-5 Years	1	5.88
6-10 Years	3	17.65
11-15 Years	8	47.06
16-20 Years	3	17.65
21 Years and above	2	11.76
Total	**17**	**100.00**
Organisation Size		
Small-sized with 1-50	6	35.29
Medium-sized with 51-250	7	41.18
Large size with 250 or more	4	23.53
Total	**17**	**100.00**
Ownership and Management		
Indigenous	8	47.06
Expatriate	3	17.65
Partly indigenous and partly expatriate	6	35.29
Total	**17**	**100.00**
Nature of works undertaken		
New Construction	4	23.53
Renovation	1	5.88
General contracting	12	70.59
Total	**17**	**100.00**
Provinces		
Western Cape	9	52.94
Gauteng	2	11.76
Eastern Cape	2	11.76
Free State	2	11.76
KwaZulu-Natal	2	11.76
Total	**17**	**99.98**

4.2 Awareness of AACB Variants in Nigeria and South Africa

The respondents' opinions about their degree of awareness of AAC block versions are shown in Table 3. A graduated scale of 1.00 to 5.00 was used to measure the respondent's familiarity with the variations and the mean scores were computed. The following scale was used to interpret the mean values: 1.00≤MS<1.49 indicates Not at All-Aware; 1.50≤MS<2.49 indicates Slight Awareness; 2.50≤MS <3.49 indicates Moderate Awareness; 3.50≤MS<4.49 indicates High Awareness; 4.50≤MS<5.00 indicates Full Awareness.

Table 3: Awareness of AACB Variants in Nigeria and South Africa

		Nigerian Professionals			South African Professionals		
S/N	**AAC Versions**	**N**	**MS**	**Rank**	**N**	**MS**	**Rank**
1	AAC with 52.5 grade Ordinary Portland Cement (OPC)	94	2.11	1	17	4.94	1
2	AAC with 42.5 grade Ordinary Portland Cement (OPC)	95	2.07	2	17	4.24	2
3	AAC with Aluminum Powder (AP)/ Rice Husk Ash (RHA)	93	2.01	3	16	4.00	3
4	AAC with Self-ignition Coal Gangue (SCG)	95	1.98	4	17	2.47	17
5	AAC with Coal Bottom Ash (CBA)	94	1.95	5	17	2.94	6
6	AAC with Concrete Sandwich Block (CSB)/ Waste Glass (WG)	95	1.94	6	17	2.88	7
7	AAC with Natural Zeolite Additive (NZ)	95	1.94	6	17	2.76	9
8	AAC with Pulverized Fuel Ash (PFA)/ Palm Oil Fuel ash (POFA)	95	1.89	8	17	3.35	4
9	AAC with Copper Tailings (CT)/ Blast Furnace Slag (BFS)	94	1.85	9	17	2.76	9
10	AAC with Efflorescence Sand (ES)	95	1.77	10	17	2.65	12
11	AAC with Silica Fume (SF)/ Fly Ash (FA)	94	1.76	11	17	3.06	5
12	AAC with Air-cooled Slag (AS)	94	1.76	11	17	2.59	13
13	AAC with Perlite Waste (PW)/Polypropylene Fibre (PF)	95	1.71	13	17	2.35	18
14	AAC with Phosphorus Slag (PS)	92	1.70	14	17	2.59	13
15	AAC with Dune Sand (DS)	93	1.68	15	17	2.82	8
16	AAC with Halloysite Powder (HP)	93	1.68	15	17	2.59	13
17	AAC with Coal Gangue (CG)/ Iron Ore Tailings (IOT)	95	1.67	17	16	2.69	11
18	AAC with Incinerated Sewage Sludge Ash (ISSA)	93	1.66	18	17	2.59	13
19	AAC with 32.5 Grade Ordinary Portland Cement (OPC)	97	1.63	19	17	1.94	19
20	AAC with BLA	95	1.36	20	17	1.41	20

The survey showed that the Nigerian respondents, with a mean rating of 1.63 to 2.11, are only slightly aware of 19 of the 20 AAC variations. The top-ranked AAC versions that the experts were only slightly familiar with include AAC with 52.5 grade OPC (MS = 2.11), AAC with 42.5 grade OPC (MS = 2.07), and AAC with RHA/AP (MS = 2.01). The least popular AAC variant, AAC with Bamboo Leaf Ash (MS = 1.36), ranked 20th in both countries, meaning it is entirely unknown to experts, though it has an MS of 1.41 in South Africa. Further questioning revealed low patronage of AAC in Nigeria, as the South African company producing AACB had to relocate due to low patronage. On the other hand, Table 23shows that the South African respondents' mean ratings of AACB alternatives range from 1.41 to 4.94. The AAC blocks manufactured with 52.5 grade OPC are well-known to South African experts. The professionals know AACB manufactured with 42.5 and 52.5 grades OPC and AACB with RHA/AP. Also, the professionals have moderate awareness of 13 out of the 20 AACB-listed variations. The AACB manufactured using SCG has a mean rating of 2.47, PW/PF has a mean score of 2.35, and the 32.5 grade OPC has a mean rating of 1.94. The professionals are slightly aware of these three identified versions of AACB. AACB manufactured using BLA (MS = 1.41) is entirely unknown to construction professionals.

4.3 Potentials of AACB Usage in the Nigerian Construction Sector

The viewpoints of Nigerian construction professionals on the potential of AACB usage in the country's construction sector are shown in Table 4. The following criterion was used to assess the mean score for the likelihood of AACB adoption in the Nigerian building construction sector: $1.00 \leq MS < 1.49$ denotes Very Poor, $1.50 \leq MS < 2.49$ denotes Poor, $2.50 \leq M < 3.49$ denotes Average, $3.50 \leq MS < 4.49$ denotes

Good while $4.50 \leq MS \leq 5.00$ denotes Very Good. Response rates for the likelihood that AACB variants would be embraced as a walling material for building projects are: 5.2% of the participants see a very poor acceptance of the block in the Nigerian construction sector; 25.8% see a poor potential of the block being adopted in the Nigerian building market; 37.1% see average potential of the block being adopted; 26.8% of participants see the block to have a good potential of being used in the Nigerian building construction sector; while only 5.2% see very good chance of the block usage in the Nigerian building construction market. More Nigerian construction professionals see the average potential for using the AACB in future (37.1%). There is therefore average likelihood that Nigerians will embrace AACB usage. This suggests that there is a chance that the block will someday be widely accepted for wall construction in Nigeria.

Table 4: Potential for Autoclaved Aerated Concrete Block Usage in the Nigerian Construction Sector

Type	Response rate					MS	SD
	1	2	3	4	5		
Prospects	5 (5.2%)	25(25.8%)	36(37.1%)	26(26.8%)	5(5.2%)	3.01	.794

Note: 1 denotes Very Poor, 2 denotes Poor, 3 denotes Average, 4 denotes Good, and 5 denotes Very Good. The terms MS and SD represent Mean Score and Standard Deviation respectively.

4.4 Test of Hypothesis

4.2.1 Hypothesis One

H_0: The opinion of experts in Nigeria and South Africa about awareness of AACB variants is significantly different.

The results of the Mann-Whitney U test comparing the awareness of construction professionals in Nigeria and South Africa on familiarity with 20 AACB variants are shown in Table 5.

The Table shows that the awareness of professionals in both countries is significant in 19 of the 20 AACB variants. In details, AACB variants with significant difference in awareness and the null hypothesis rejected are: (AAC with 32.5 grade Ordinary Portland Cement (OPC); AAC with 42.5 grade Ordinary Portland Cement (OPC); AAC with 52.5 grade Ordinary Portland Cement (OPC); AAC with Coal Bottom Ash (CBA); AAC with Natural Zeolite Additive (NZ); AAC with Self-ignition Coal Gangue (SCG); AAC with Incinerated Sewage Sludge Ash (ISSA); AAC with Silica Fume (SF) / Fly Ash (FA); AAC with Dune Sand (DS); AAC with Rice Husk Ash (RHA)/Aluminum Powder (AP); AAC with Concrete Sandwich Block (CSB)/Waste Glass (WG); AAC with Halloysite Powder (HP); AAC with Air-cooled Slag (AS); AAC with Efflorescence Sand (ES); AAC with Phosphorus Sand (PS); AAC with Coal Gangue (CG)/Iron Ore Tailings (IOT); AAC with Pulverized Fuel Ash (PFA)/Palm Oil Fuel Ash (POFA); AAC with Copper Tailings (CT)/Blast Furnace Slag (BFS); and AAC with Perlite Waste (PW)/Polypropylene Fiber (PF). The null hypothesis is only accepted for AAC variants manufactured with BLA, for which no significant awareness (NS) exists among experts in Nigeria and South Africa.

4.2.1 Hypothesis Two

H0: There is no significant variation in the potential of AACB adoption among Nigerian professionals..

The inferential results are presented in ANOVA Table 6. It can be seen that there is no substantial variation in acceptance of the potential of using AACB in the Nigerian building construction sector (P-value 0.196).

5. Discussion of Findings

According to the assessment, it was observed that the AACB variants are slightly gaining popularity among professionals in the Nigerian construction industry, as the professionals are slightly aware of 19 out of the 20 AACB types investigated. Meanwhile, South African construction industry findings indicate they are more cognizant of most AACB variants.

AACB is not being used in walling and professionals are ignorant of its existence because it is not one of the typical walling components used in building construction in Nigeria. This finding agrees with Ikponmwosa et al. (2014), who found earlier that aerated concrete is not popular in Nigeria. The manufacturing and utilisation of AACB more regularly as a walling material in Nigeria can increase its usage with the consequent popularity.

Table 5: Mann-Whitney U Test results for a significant difference in the level of awareness of AACB between experts in Nigeria and South Africa

S/N	AAC Versions	Nigerian Professionals		South African Professionals		U	P-value	Decision
		N	MS	N	MS			
1	AAC with 32.5 grade Ordinary Portland Cement (OPC)	97	54.85	17	72.62	567.500	.024	S
2	AAC with 42.5 grade Ordinary Portland Cement (OPC)	95	49.78	17	94.03	160.500	.000	S
3	AAC with 52.5 grade Ordinary Portland Cement (OPC)	94	48.06	17	99.91	52.500	.000	S
4	AAC with Coal Bottom Ash (CBA)	94	51.68	17	79.88	393.000	.000	S
5	AAC with Natural Zeolite Additive (NZ)	95	52.54	17	78.65	431.000	.001	S
6	AAC with Self-ignition Coal Gangue (SCG)	95	53.71	17	72.12	542.000	.023	S
7	AAC with Incinerated Sewage Sludge Ash (ISSA)	93	51.17	17	79.18	388.000	.000	S
8	AAC with BLA	95	55.75	17	60.68	736.500	.457	NS
9	AAC with Silica Fume (SF) / Fly Ash (FA)	94	50.03	17	89.03	237.500	.000	S
10	AAC with Dune Sand (DS)	93	49.42	17	88.76	225.000	.000	S
11	AAC with Rice Husk Ash (RHA) / Aluminum Powder (AP)	93	48.99	16	89.91	185.500	.000	S
12	AAC with Concrete Sandwich Block (CSB) / Waste Glass (WG)	95	52.15	17	80.79	394.500	.000	S
13	AAC with Halloysite Powder (HP)	93	50.88	17	80.79	360.500	.000	S
14	AAC with Air-cooled Slag (AS)	94	51.36	17	81.68	362.500	.000	S
15	AAC with Efflorescence Sand (ES)	95	52.14	17	80.85	393.500	.000	S
16	AAC with Phosphorus Sand (PS)	92	50.36	17	80.12	355.000	.000	S
17	AAC with Coal Gangue (CG) / Iron Ore Tailings (IOT)	95	51.33	16	83.72	316.500	.000	S
18	AAC with Pulverized Fuel Ash (PFA) / Palm Oil Fuel Ash (POFA)	95	51.10	17	86.68	294.500	.000	S
19	AAC with Copper Tailings (CT) / Blast Furnace Slag (BFS)	94	51.41	17	81.35	368.000	.000	S
20	AAC with Perlite Waste (PW) / Polypropylene Fiber (PF)	95	52.43	17	79.26	420.500	.001	S

Note: N denotes the number of respondents, MS denotes mean score, P-value, significant at $P \leq 0.05$, U denotes Mann-Whitney, S denotes Significant Difference, and NS denotes No Significant difference in the awareness level.

Table 6: ANOVA on the Potential for Autoclaved Aerated Concrete Block Usage in The Nigerian Construction Sector

	Sum of Squares	df	Mean Square	F	P-value
Between Groups	3.103	2	1.552	1.659	.196
Within Groups	87.887	94	.935		
Total	90.990	96			

Note: ρ is statistically significant at $P \leq 0.05$.

On the other hand, finding from South African costruction professionals indicated that they are fully cognizant of AACB with 52.5 grade OPC. They also profoundly know AACB with 42.5 grade OPC and RHA/AP. These findings are congruent with those of Rathi and Khandve (2015), Oo and Hlaing (2018) and Manikandan et al. (2018), who discovered that grade 52.5 OPC, grade 42.5 OPC and Aluminum Powder as the primary components used in the production of AACB. However, South African professionals are unaware of using BLA in manufacturing AAC. Table 5 shows no visible difference in the amount of awareness of AACB created using BLA in the two countries. It also implies that the use of BLA as a substitute for cement in the manufacturing of AACB has not been investigated. Furthermore, the results presented in Table 4 show that the awareness of 19 out of the 20 AACB variants is statistically significant.

It can be seen that the professionals' disposition on the potentials and perceptions of the prospects for AACB usage in the Nigerian construction sector is moderate. This implies that experts will likely use the materials as walling modules in future construction projects. Table 5 further revealed no significant disparity in the acceptability of using AACB as a walling material in building projects by the Nigerians.

6. Conclusions and Recommendations

The claim that AACB is a sound and sustainable component but yet to be embraced adequately in Nigeria and South African countries motivated the study. The aim was therefore to investigate the consciousness and prospects of its use, which are likely to enhance its usage. This was conducted in the study area via a survey method using appropriate statistical tools. It was concluded from the findings that South Africa has a greater level of awareness of AACB variants than Nigeria. This implies that lack of awareness would cause poor patronage of AACB makers; therefore, businesses involving AACB would not thrive in Nigeria. Increased patronage requires improve awareness.

Additionally, there is an average propensity in Nigeria for the use of AACB in construction projects. This suggests that experts could embrace the block for construction projects in the coming years. Therefore, The research recommends that professionals update their knowledge of AAC to understand AACB better. Seminars and workshops, training on AACB, and environmentally friendly building materials can be used to accomplish this. Additionally, the study suggests that governments, stakeholders and research institutions exert more effort on manufacturing and optimising AACB to attract the interest of consultants, clients/developers and contractors.

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Impact of Leadership Styles on Government Construction Project Success: A Structural Equation Modelling Approach

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Abstract

Government construction projects play an important role in both developed and developing countries. They contribute about 80% of total capital assets, 10 % of GDP, and more than 50% of the wealth invested in fixed assets, and employment opportunities. As such several countries like Sweden in Europe, Indonesia in Asia, South Africa and Kenya in East Africa have invested heavily and achieved success in construction projects. Similarly, Uganda has also invested heavily in construction projects however majority of these projects been unsuccessful, yet projects contribute to economic development. The aim of this study was to determine the contribution of leadership styles to the success of government construction projects in Uganda. The study was cross-sectional with a quantitative research design. A self-administered questionnaire was used to collect data from a sample of 100 Kampala Capital City Authority construction projects from a population of 120 projects that were stratified according to the five divisions of Kampala district. Four respondents were selected from each of the 100 projects selected resulting into a total of 400 respondents for the study. Structural Equation Modelling was conducted using SPSS. Results show that leadership styles especially communication and participation are positively and significantly associated with government construction project success. Therefore government project managers should communicate effectively as well as involve stakeholders at every stage of the project cycle to realise project success. It is recommended that for purposes of replicating the study, the path goal theory be adopted. Also, government ministries need to adopt the proposed model as it serves as a valuable resource for researchers and practitioners, especially those involved in government construction projects. Similarly, government through the ministry of works and transport should constantly remind government project managers to always ensure adequate internal and external communication and allow participation of stakeholders during the implementation of government projects.

Keywords: Communication, Leadership styles, Government Construction Projects, Participation, Project Success, Structural Equation Modeling, Uganda

1. Introduction

One of the prevailing questions regarding successful implementation of Government construction projects is whether leadership styles contribute to government construction project success. This follows the realization that government construction projects play a significant role in economic growth and development (Oyaya, 2016). The contribution of construction projects in both developed and developing countries is considerable; about 80% of total capital assets, 10 % of GDP, and more than 50% of the wealth invested in fixed assets, and creates various employment opportunities (Owoo and Lambon-Quayefio, 2018). In order to transform the economy into a middle-income status and achieve Vision 2040, the government of Uganda has highlighted construction projects as key drivers of growth. It has embarked on several construction projects aimed at boosting the economy; improving the health, standard of living, and development of its citizens. Despite the benefits, majority of government construction projects in Uganda perform below expectations, have challenges including poor quality, delayed completion, overshoot budgets, and in most extreme cases face total shutdown (Office of Auditor General, 2018; Tayebwa, 2014). For example, Uganda incurred US$ 132 million instead of US$ 111 million in extra project requirements for Bujagali dam project due to miscommunications among stakeholders (Mwesigwa et al., 2018).

Furthermore, the construction of Ajeleck, Opot and Ojanal bridges in northern Uganda was cancelled due to disagreements among stakeholders (Civil Society Budget Advocacy Group, 2018). A further 15 engineering projects

undertaken by Kampala Capital City Authority, National Roads Authority (UNRA) and National Water and Sewerage Corporation (NWSC) failed (Office of Auditor General, 2017). Also, nine UNRA and NWSC construction projects between 2010 and 2016 suffered delays and costs increased by approximately US$17 million over the estimated cost due to poor site information, disagreements, and a lack of stakeholder involvement (Auditor General's report, 2017). This leads to questions about what strategies can be employed to avoid such a situation, our study sought to suggest some.

Various researchers have tried to explore project success from various perspectives including teamwork (Kariuki, 2015), project managers' skills (Sunindijo, 2015), and total quality management (Jong et al., 2019). A few that have used the Ugandan evidence have concentrated on project communication, individual commitment, social networks, and perceived project performance (Ahimbisibwe & Nangoli, 2010), procurement procedures, and project performance (Onencan, 2020). Besides most of these studies have examined aspects related to project success based on the stakeholder theory (Dwivedi & Dwivedi, 2021) and others on Resource based view theory (Engelbrecht et al., 2017). As such there is scant theoretical and empirical research on leadership styles and the success of government construction projects. As findings on government construction projects vary across nations, some studies are needed in the local setting to increase the relevance and accuracy of results.

Literature has not distinctively identified the role of leadership styles on project success yet it is a critical factor in ensuring project success. This research thus adds to the literature by taking results from a geographically distinct context, a developing country such as Uganda. Also, this research uses the path-goal theory to explain the relationship between leadership styles and success of government construction projects in Uganda. Consequently, this article aims to provide a more informed and empirically based image of leadership styles and government construction project success, using structural equation modeling. Therefore, this article seeks to attain the following research objectives:

- To examine the relationship between leadership styles and government construction project success in Uganda.
- To generate a model that explains government project success

This article discusses the impact of leadership styles on government construction project success and it is organized as follows; first, the empirical literature is presented. The theory and hypothesis are then presented, followed by the study methodology, results, and discussion. The final sections of the article present the conclusion, implications, and future research direction.

2. Literature review

2.1. Path goal theory

To help understand the role of leadership styles in project success, the path-goal theory as reformulated by House (1996) was adopted. The theory assumes that there is no one best or unique style of leadership that transcends all project situations (House 1996). The theory explains that leaders that choose leadership styles that suit the project environment clarify the path stakeholders take to attain individual and project goals and remove roadblocks that stand in the way to achieve project goals (House, 1996). Such leaders provide expected performance levels and means of achieving them and guide stakeholders to choose the best path for reaching their individual goals (Mwaisaka, 2019).

Stakeholders are assigned specific duties for which they are held accountable (Babirye et al., 2022). Armed with a clear path, stakeholders become confident, motivated, enthusiastic, and empowered to work hard to deliver set project goals (Atsebeha, 2016). Therefore, project leaders need to provide enough information about tasks and also allow their participation in project decisions in order for stakeholders to accomplish tasks. This way a project leader reduces the roadblocks that occur in the path of the project stakeholders and makes their journey easier toward the achievement of project goals (Mwaisaka et al., 2019). In addition, Grimm (2018) confirms that this makes stakeholders feel satisfied to commit, trust and cooperate towards the project while performing project activities when they have enough information on how the project benefits them.

Accordingly, the path-goal theory advances participation and communication leadership styles among others that can be adopted by leaders to achieve the desired level of project performance (House, 1996). Under communication style, the theory explains that leaders exchange information with stakeholders; give chance to stakeholders to be heard; and emphasize collaborative and positive interactions as well as self-satisfying relationships that enhance work unit cohesion, reduce work stress and attrition (Atencio, 2012; House, 1996). Since government construction projects involve group tasks performed in a series of interdependent phases that form the life cycle of projects (Archibald et al., 2012). The activities and tasks in one phase feed into the next phase and must be completed first before another phase sets in (Archibald et al., 2012).

As per the theory, collaborative interactions among project teams, and sharing information on each completed phase activity (reports) enable a smooth project transition from one phase to another. Under participative leadership, the theory explains that when leaders involve stakeholders in defining performance goals, strategies for executing tasks, standards, and rewards, project targets become clear, and stakeholders feel valued (Monzani *et al.,* 2015; House, 1996). This results in their motivation, commitment, trust, and support as well as the acquisition of creative change ideas and knowledge that trigger project success (Taylor, 2018).

2.2 Leadership styles

Leadership style refers to the approach, method, outlook (Hersey and Blanchard, 1982), attitude, and behavior that a project leader employs to influence stakeholders toward the accomplishment of project objectives (Nakato, 2019). Accordingly, leaders choose styles they are comfortable with (House, 1996) and believe will motivate those individuals who can affect or be affected by the project (Freeman, 1984) to accomplish set goals.

2.3 Project success

A construction project is regarded as successful when it's completed on time, and within budget while meeting quality expectations (Shah, 2016; Musekura, 2013; Pinto, 2010). The desire to achieve set government construction project goals worldwide has become a concern to project leaders (Pollack et al., 2018; Tunji-Olayeni et al., 2016). This sets the foundation of the next section which will review literature on the relationship between leadership styles and project success as hypothesised in the study.

2.4 The relationship between leadership styles and project success

Leadership styles influence and facilitates the performance of stakeholders to achieve desired project goals (Nemaei, 2012). The styles project leaders adopt play a vital role in construction projects whose success is measured by completion on time, within budget while meeting quality expectations (Famakin and Abisuga, 2016; Yukl, 2006). Within government construction projects, exists a number of stakeholders with specific interests and coordinated activities with start as well as end dates (Msengana, 2012). Equally projects post a series of interdependent group activities, stakeholders with varying interests, competencies, backgrounds and objectives (Akpoviroro et al., 2018).

Suitable leadership styles help to communicate ideas, mobilise resources, coordinate activities and mobilise stakeholder engagement towards project success (Mwaisaka, 2019; Somech, 2005). With Communication leadership relevant project information is shared, exchanged and interpreted among internal and external stakeholders (Mugo and Moronge, 2018). This information may include performance reports, requested changes, drawings, architectural designs, specifications, project objectives, rules, roles, and tasks construction methods (Muszynska, 2015; Olsson and Johansson, 2011). This helps to build harmony, trust, commitment , satisfaction, interactions and reciprocal collaborative relationships among project stakeholders are realised that are key in realising project success (Ssenyange et al., 2017:78; Bilczynska-Wojcik, 2014; Coombs, 2007). In agreement, Mezgebu (2014) adds that the purpose of communication in construction projects whether informal, formal, internal, or external is to facilitate the exchange of ideas, and clarify roles and misunderstandings in order to execute the project successfully.

Equally, in a study conducted by Maame (2012) on the effect of communication leadership on construction projects in Ghana, it was revealed that communication is a vital factor in project success and whenever it is poor projects there is project delay, escalation of costs, and abandonment of projects. In fact, Safapour, Kermanshachi, Kamalirad, and Tran (2019) conceptualized that the more stakeholders acquire timely information and interact with project leaders the less role ambiguity and conflict there is in a project toward success Therefore, it is important for project leaders to communicate effectively with different groups of stakeholders to remove any roadblocks that stand in the way of achieving project goals (Grimm, 2017; House and Mitchell, 1974). Moreover, participation leadership enables project information sharing, stakeholder motivation, commitment, and support, cooperation which are key in completion of projects on time, within budget and quality expectations (Monzani, Ripoll, and Peiro, 2015; House, 1996).

Participation of stakeholders periodically help leaders to create a sense of shared values about the project that help to build support and cooperation among stakeholders (Dolatabadi and Safa, 2010). For example, periodic stakeholders' consultation and exchange of ideas at the project design and execution stage enables leaders to develop empathy and a sense of ownership among stakeholders that triggers their support and cooperation (Daniel et al., 2019). It also enhances stakeholders' connection to the project and inspires them to cooperate and work hard to ensure that they realize the set project (Mwaisaka, 2019). Moreover, consulting and exchange of ideas with stakeholders especially the local community on matters pertaining to tasks, execution plans, rewards, designs, project goals, and benefits, makes them feel part of and indebted to the project (Kiplangat, 2017). This triggers their cooperation and offers support to the project to ensure that the project succeeds (Ndifuna, 2015; Williams and Walton, 2013). Thus, it's important to note that project leaders guide the performance of project members throughout the project towards project success and also to achieve their goals (Taylor, 2018). However, in the absence of good leadership styles and skills, projects will stagnate, experience hostilities and post poor results yet several countries invest in construction projects (Liphadzi et al., 2015).

Several studies have continued to report and document a positive relationship between leadership styles (participation and communication) and project success. However, few scholars revealed that there is a negative relationship between leadership styles and project success (Wu, *et al.,* 2017; Saha and Kumar, 2017; Leenders et al., 2003: Watt, 2014). This justifies the need for this study.

3. Methodology

3.1 Research design and approach

The study adopted a cross-sectional with a quantitative research design where a self-administered questionnaire was used to collect. Data was analyzed using SPSS and Structural Equation Modelling (SEM) was used to evaluate the relationships among the set of variables as well as develop a model that explains the success of government construction projects. Since SEM employs a confirmatory approach when analysing structural theory about a phenomenon (Bollen and Brand, 2010), it was chosen because it enabled the researchers to examine a series of interdependent relationships concurrently (Clark, Black and Judson, 2017). This method was also ideal because compared to CFA; SEM gives the possibility of interrelationships among unobserved variables through measurement and structural model (Lee & Song, 2014).

3.2 Population and sample procedure

This study adopted a sample of 100 projects from a population of 120 government construction projects implemented by KCCA (Krejcie and Morgan, 1970). These projects were stratified according to the divisions that make up Kampala namely; central, Makindye, Rubaga, Nakawa, and Kawempe. The researcher chose a

stratified random sampling method to reduce bias and to get deeper insights from all respondents in all the divisions (Sharma, 2017). Additionally, the limited availability and efficiency of internet communication services in Uganda could not support timely data collection by mailing questionnaires to respondents (Nsereko et al., 2018). From each selected project 4 participants (project manager, contractor, engineer, and local council leader) were purposively selected based on their roles, experience, and perception to arrive at 400 participants for the study (Polit and Beck, 2012; Pinsonneault and Kraemer, 1993). Useable questionnaires were physically received from 335 out of 400 respondents representing a response rate of 83.8% adequate enough for analysis ((Debela, et al., 2021; Mugambi and Kinyua, 2020). In this study, the unit of analysis was a government construction project while the unit of inquiry were the stakeholders.

3.3 Validity and reliability

The internal reliability of the questionnaire was assessed by computing the Cronbach's Alpha coefficients using the inter-item test method (Cho and Kim, 2015; Saunders, et al., 2007), and as seen in Table 1 below all results for the variables are above 0.7 confirming that the measurement instrument was reliable (Bajpai and Bajpai, 2014; Nunnally, 1967).

Table 1: Reliability results

	Cronbach Alpha Coefficient
Leadership Styles	0.869
Project Success	0.868

Source: Primary data

The validity of the study instrument which is the extent to which given dimensions of the study variables adequately represented the core construct was assessed through first content validity where expert opinions from researchers and colleagues were sought which helped build a content validity index (CVI). In addition, convergent validity and discriminant validity were tested by assessing the Average Variance Extracted (AVE) and composite reliability for each of the study variables. As seen in Table 2, the results of composite reliability of all latent variables are above 0.7 (leadership styles=0.854, project success=0.847), and the Average variance extracted of all latent variables is above 0.5, which meets the acceptance level (Henseler et al., 2015; Field, 2009; Fornell and Larker, 1981). So, this reveals that the construct measures were valid and could correctly measure the study variables.

Table 2: Reliability and Validity results

	Composite Reliability	***Average Variance Extracted (AVE)***
Communication	.877	.641
Participation	.831	.552
Leadership Styles	**.854**	**.597**
Cost	.834	.626
Quality	.844	.574
Time	.864	.761
Project Success	**.847**	**.654**

Source: Primary Data

3.4 Measurement of variables

Project success was measured using time, cost, and quality (Atkinson, 1999; Chan, 2003). Leadership styles were operationalized into participation and communication. Participation was measured using modified tools of Arnstein (1969) adopted by Kanungo (1982), and communication was measured using an abridged version of Goldhaber and Rogers (1979) communication audit survey questionnaire also adopted by Nangoli (2010).

3.5 Data analysis

During analysis, Quantitative data were analyzed using Statistical Package for Social Scientists (SPSS) 27. The researcher conducted quantitative data analysis through descriptive and inferential statistical analysis (Bulti, 2016). Descriptive statistical analysis provided a summary of the population or the sample under study while Inferential statistics (structural equation modeling) aided the researcher to test for a relationship between study variables (Sinkovics and Alfoldi, 2012; Marshall and Jonker, 2011; Zikmund et al., 2009). A two–step method as proposed by Anderson and Gerbing (1988) was followed. The first stage involved the estimation of the measurement model using confirmatory factor analysis and then estimating the hypothesized structural model using structural equation modeling as the second stage. The structural model fit helped to assess whether the hypothesized theory matched the collected data. Generally, the structural equation model was assessed for validity using the goodness of fit indices as summarised in Table 3 before assessing whether the structural relationships in the model were consistent with theoretical expectations (Hair et al., 2018; Hair et al,.2010)

Table 3: Summary of fit indices used in this study

Fit index	Acceptance level	Remarks
Absolute fit indices		
GFI	0.90 or greater	a value close to 1 indicates a perfect fit
RMSEA	0.05 – 0.08	value less than 0.50 is considered
Incremental fit indices		
NFI	0.90 or greater	a value close to 1 indicates a perfect fit
TLI	0.90 or greater	a value close to 1 indicates a perfect fit
CFI	0.90 or greater	a value close to 1 indicates a perfect fit
Parsimonious fit indices		
CMIN/DF	$1.0 \leq \chi 2/df \leq 5$	The lower limit is 1.0, the upper limit is 3.0 or as high as 5

Source: Hair et al. (2018) and Hair et al.(2010)

4. Findings

4.1 Respondents profile

Table 4 shows that out of the 335 questionnaires received and used, males accounted for 59.1% compared to females who accounted for 40.9%. Again, in terms of age, the majority of project stakeholders who participated in the study were aged between 31-45 years (54.6%), followed by those aged between 46-65 (20.9%). Those aged between 18-30 years (17.6%) came next, followed by those aged 66-74 years (5.7%) and those above 75 years came last (1.2%). In terms of the highest level of education (see Table 5), the majority of government construction project stakeholders who participated in this study were diploma qualification holders (31.0%), followed by bachelor's degree holders (29.6) and postgraduate holders followed (17.6%). Results also revealed that those with a master's degree accounted for only 3% and certificate holders were only 9%. These results showed that the majority of the respondents were knowledgeable and could easily understand the items in the questionnaire which partly accounted for a good response rate of 83.8%.

Table4: Age group

Variable	Measurement	Count	Valid Percentage
Age group	18-30	59	17.6
	31-45	183	54.6
	46-65	70	20.9
	66-74	19	5.7
	75+	4	1.2
	Total	**335**	**100.0**

Table 5: Highest level of education

Variable	Measurement	Count	Valid Percentage
Highest level of education	Primary	7	2.1
	O' Level	13	3.9
	A' Level	12	3.6
	Certificate	30	9.0
	Diploma	104	31.0
	Bachelors	99	29.6
	PostgraduateDegree	59	17.6
	Masters	10	3.0
	Others	1	0.3
	Total	**335**	**100.0**

4.2 Descriptive statistics for latent variables

A summary of the standard deviation and mean scores for leadership styles and project success variables is indicated in Table 6. As seen in Table 6 the mean score for leadership styles is 3.559 and 3.623 for project success on a six Likert scale with standard deviations of 0.819 for leadership styles and 0.886 for project success. Because of small standard deviations compared to mean values, it is clear that the data was well spread out, data points were close to the means and hence calculated means highly represented the observed data (Warsame, 2021; Field, 2018). This also implied that the respondents' understanding of study variables and the views about the questions asked were closely the same (Bashir, 2018).

Table 6: Descriptive statistics

Latent variables	No.	Min.	Max.	Mean	Std. Error	SD
Leadership Styles	335	1.000	5.882	3.559	0.049	0.819
Project Success	335	1.375	5.938	3.623	0.048	0.886

4.3 Measurement Model estimation

To arrive at valid conclusions in the study it was necessary to use a measurement model that was valid (Field, 2017). Therefore, in this study, Confirmatory Factor Analysis (CFA) with the Amos program was conducted for leadership styles and project success to assess the validity and reliability of the measurement models for this study.

4.3.1 CFA Measurement model for leadership styles

The leadership styles concept was measured using participation and communication. Communication originally had 16 items (LDCM1-LDCM16) and participation had 18 items (LDPT1 - LDPT18). The initial stage of the inter-item correlation matrix revealed that communication dimension items like LDCM5, LDCM6, LDCM7, LDCM10, LDCM12, LDCM14, LDCM16, and participation items like LDPT3, LDPT4, LDPT5, LDPT6, LDPT8, LDPT9, LDPT12, LDPT14, LDPT15, LDPT16 were deleted at EFA because their loadings were below the recommended 0.5 thresholds. On subjecting the retained items (EFA model appemdix 1) to CFA, communication dimension items like LDCM1, LDCM8, LDCM11, and LDCM13 and participation items like LDPT13, and LDPT18 were removed. The removal of the weakly correlated items reduced the number of items of the construct as it was conceptualized (see Figure 1). In addition, the retained items were significant and had standardized factor loadings higher than the recommended level of 0.5 thus preserving the meaning of factors (Hair et al., 2018; Hair et al., 2010). These findings confirmed the validity of the final model with excellent model fit statistics for the leadership styles construct as the Confirmatory analysis fit indices are within the recommended range (Hair et al., 2010), for example, the Goodness – of fit (GFI) is greater than 0.95, Comparative fit index (CFI) is greater than 0.95 and Tucker – Lewis Index (TLI) is greater than 0.95. The CFA measurement model, fit statistics, and standardised regression estimates output are indicated in Figure 1 and Table 7 respectively.

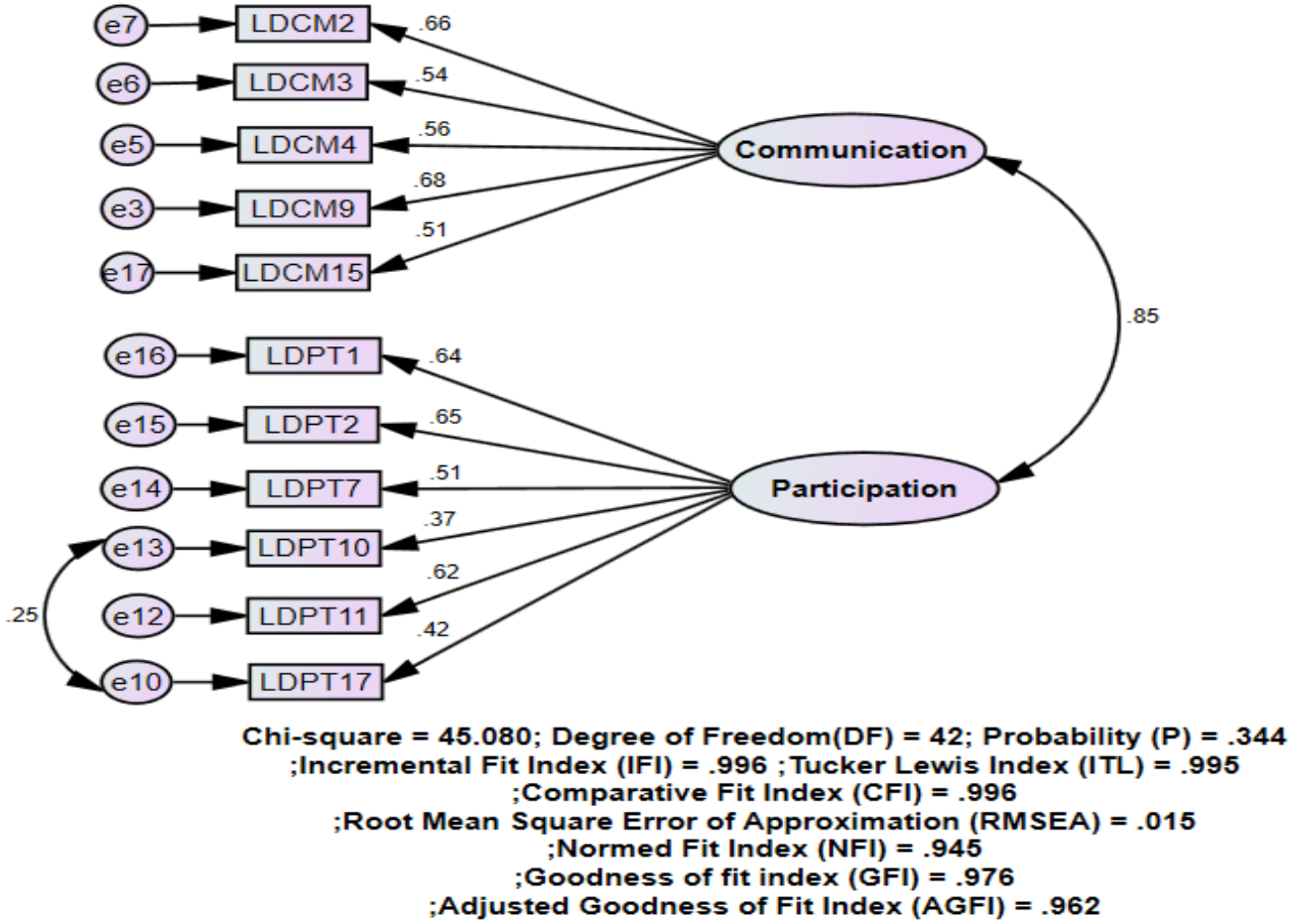

Figure 1: CFA Measurement Model for Leadership Styles

Table: 7: Standardised Model Estimates for Leadership Styles

			β	S.E.	C.R.	*p*
LDCM15	◄—	Communication	.514			
LDCM9	◄—	Communication	.680	.160	7.929	***
LDCM4	◄—	Communication	.559	.153	7.134	***
LDCM3	◄—	Communication	.538	.149	6.968	***
LDCM2	◄—	Communication	.658	.163	7.803	***
LDPT17	◄—	Participation	.420			
LDPT11	◄—	Participation	.621	.230	6.356	***
LDPT10	◄—	Participation	.373	.157	5.661	***
LDPT7	◄—	Participation	.507	.213	5.816	***
LDPT2	◄—	Participation	.653	.220	6.470	***
LDPT1	◄—	Participation	.638	.242	6.419	***
LDPT17	◄—	Participation	.420			
		*** p<.01				

Note:β : standard Beta coefficients, S.E: standard error, C.R:critical ratio, *p: probability value*

4.3.2 CFA Measurement model for project success

Project success was measured using Time, Quality, and Cost. Time originally had 6 items (PSTM1- PSTM16), Cost had 4 items (PSCO1 – PSCO4) and Quality had 6 items (PSQU1- PSQU6). The initial verification of the inter-item correlation matrix revealed that Quality item PSQU3, time dimension items PSTM3, PSTM6, and cost dimension item PSCO2 were deleted by EFA because the loadings were below 0.5.(Appendix 2) The remaining items were subjected to a CFA. Under CFA, the EFA model was re-specified by iteratively removing quality items PSQU1, PSQU6; cost item PSCO4, and time item PSTM3. During re-specification by deleting those items that did not meet the acceptable criteria and retained only those that met the criteria. During the re-specification process, we aimed at retaining at least three items for each construct because constructs with a lesser number are viewed as weak and unstable (Costello and Osborne, 2005:5). At the end of this process 3 items for Time (PSTM1, PSTM2, PSTM5), 3 items of Cost (PSCO1, PSCO2, PSCO3) and 3 items of Quality (PSQU2, PSQU4, PSQU5) were retained in the final model. The retained items were significant and had standardized factor loadings higher than the recommended level of 0.5 thus preserving the meaning of factors. These findings confirmed the validity of the final model with excellent model fit statistics for the project success construct (see Table 8). Again, results under Figure 2 reveal that the Confirmatory analysis fit indices are within the recommended range (Hair et al 2010), for example, the Goodness – of fit (GFI) is greater than 0.95, the Comparative fit index (CFI) is greater than 0.95 and Tucker – Lewis Index (TLI) is greater than 0.95.

Table 8: Standardised Model Estimates for *Project* Success

			β	S.E.	C.R.	*p*
PSCO1	◄—	COST	.708			
PSCO2	◄—	COST	.578	.061	10.236	***
PSCO3	◄—	COST	.636	.064	10.238	***
PSTM1	◄—	TIME	.717			
PSTM2	◄—	TIME	.707	.066	11.428	***
PSTM5	◄—	TIME	.372	.065	6.171	***
PSQU2	◄—	QUALT	.660			
PSQU4	◄—	QUALT	.651	.108	9.967	***
PSQU5	◄—	QUALT	.632	.110	9.725	***
		*** *p*<.01				

Note:β : standard Beta coefficients, S.E: standard error, C.R:critical ratio, *p: probability value*

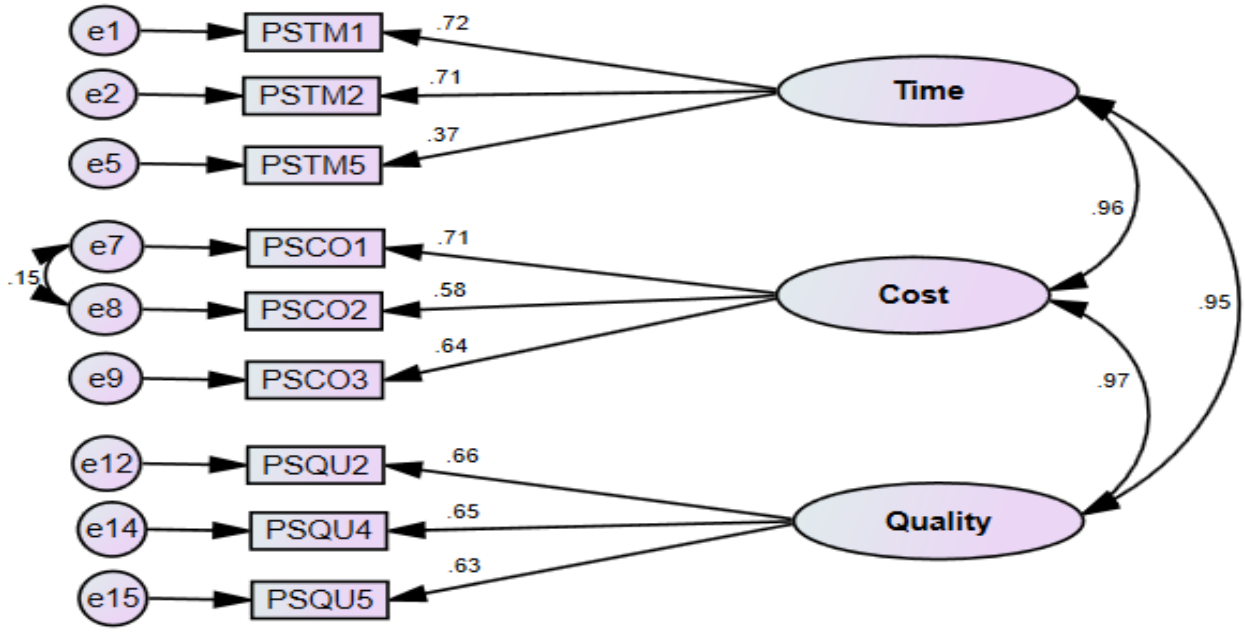

Figure 2: CFA Measurement Model for Project Success

4.4 Structural Equation Modeling

Structural equation modeling (SEM) was employed to measure the relationships among study variables following the set study hypothesis. Prior to undertaking structural equation modelling, it was necessary to establish how well the manifest variables converged as valid indicators of the global latent variables (Bedi, Kaur, and LaI, 2017; Anderson and Gerbing, 1988). As such, two (2) models (leadership styles, and project success were assessed for the goodness of fit and subsequently, the manifest and global latent variables were specified into a structural model to represent exogenous and endogenous constructs. One exogenous variable (leadership styles) and one endogenous variable (project success) were specified in the structural model. Conversely, not all manifest variables of the latent constructs in CFA were retained while estimating the structural model. Accordingly, the CFA measurement model for leadership styles confirmed eleven (11) manifest variables as indicators of leadership styles. However, only four manifest variables namely; LDCM9 for communication and LDPT2, LDPT2, LDPT10, and LDPT11 for participation were retained in the structural model as measurements of the leadership styles variable after estimating the structural model to establish model fit. Equally, the project success measurement model established nine manifest variables as indicators of project success in the model. However, four manifest variables (PSTM1, PSTM2, PSTM5, and PSCO1) were dropped while estimating the overall structural model for theory fit. As such, the endogenous variable project success in the final structural model was measured by seven (7) manifest variables (PSQU2, PSQU4; PSQU5 for quality, PSTM2 for time, and PSCO1, PSCO2, PSCO3 for cost). Again, premising on Hair et al. (2010:646), all the indices for the goodness of fit were within the acceptable range (Chi-Square ($\chi 2$) = 62.665, the degree of freedom = 43, CFI = .981 and TLI= .976, AGFI= .951 and lastly RMSEA was .037). Hence, was subsequently used to test for the direct relationship between leadership styles and project success as hypothesized in the study. The results for the overall structural equation model that explains project success are shown in Figure 3.

Hypothesis testing

It was hypothesized that there is a relationship between leadership styles and project success. Accordingly, testing direct paths between leadership styles and project success was conducted and the results are reflected in Table 9.

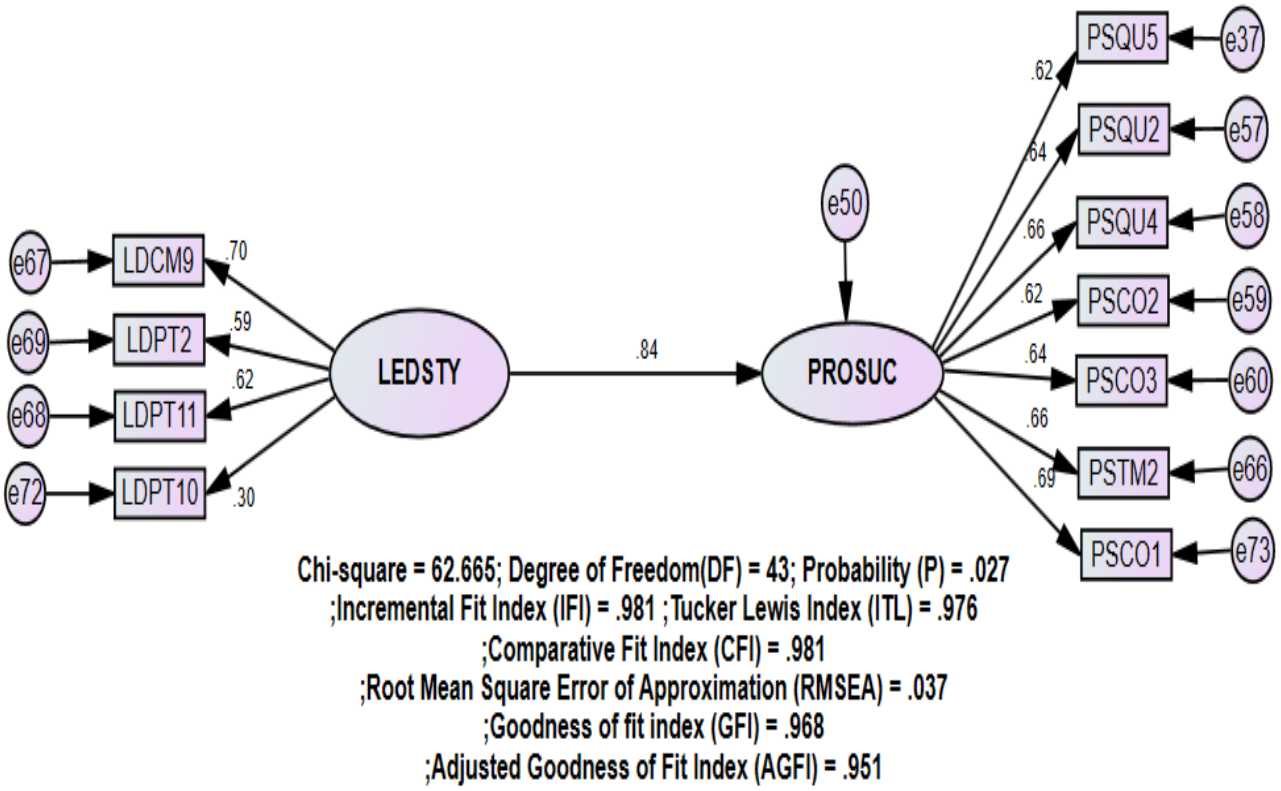

Figure. 3: Overall Model Explaining Government Construction *Project Success*

Table 9: Structural Model Estimates

			Unstandardized coeff	S.E.	C.R.	Standardised coeff	P
Project success	◄—	Leader styles	.756	.090	8.440	.840	***

Note: S.E: Standard Error, C.R: Critical Ratio, *p: probability value*

As seen in the table above, results indicate that there is a positive relationship between leadership styles and project success (Beta=0.840, SE=0.90, CR=8.440). Thus, that hypothesis was supported. This means that positive changes in the leadership style are associated with positive changes in project success. In other words, when leaders adopt a suitable leadership style in projects such as communication and allow the participation of stakeholders, projects are completed on time, within the set cost while meeting quality specifications.

5. Discussion

5.1 Leadership style and project success

For a while, the debate on the success of government-funded construction projects has been on-going, earlier studies established factors like team effectiveness (Azmy, 2012), professional teamwork (Mungeria, 2012), and stakeholder engagement process (Bal et al., 2013) as key in influencing the success of government-funded construction projects. Yet attaining success remains a big challenge to most government construction projects specifically in developing countries like Uganda. The study findings, however, contribute to this debate by showing how leadership styles influence the success of government-funded construction projects in Uganda. Indeed, the study results revealed that there is a positive relationship between leadership styles and project success. This implies that leaders that adopt suitable leadership styles such as communication and participation during the implementation of projects realize project success. Drawing from the path-goal theory, these leaders are flexible; choose leadership styles that correspond to the project situation and nature of the stakeholders to achieve project success.

The above result is not surprising because Rana et al. (2019) already established that there is no single leadership style that fits all project situations. In line with this, Oyaya (2016) and Robbins (2001) alluded that government construction projects that post good results have leaders who keep interchanging leadership styles depending on the

project situations. In agreement, Zulch (2014) and Martin (2012) discovered that this increases stakeholders' motivation and zeal toward achieving set project goals. In addition, Olowoselu et al. (2019) and Bulti, (2016) discovered that adopting suitable leadership styles enhances stakeholders' empowerment and satisfaction, and the stakeholders' work effectiveness. Lategan and Fore (2017) noted that leadership is a skill that is different from other skills and most of these skills manifest in the style a leader adopts. Therefore, government construction project managers have the ability to persuade stakeholders by adopting suitable leadership styles depending on the situation always get the best results for projects (Acquah and Xing, 2021; Frigenti and Cormninos, 2002).

This finding lends support to the path-goal theory which posits that leaders that are flexible and adopt appropriate leadership styles are able to clarify and remove obstacles that stand in the path stakeholders take to attain their goals and organization goals. The theory notes that leaders who choose styles they are comfortable with that suit project situations and stakeholders always motivate stakeholders to accomplish set goals. In this study, it was confirmed that leadership styles especially participation and communication affect government construction project success.

6. Conclusion, Implications and future research direction

6.1 Conclusion

From the results of this study, it can be concluded that leadership styles contribute to government construction project success. More specifically when project leaders allow stakeholders' participation and communicate effectively about project tasks, goals, strategies, and processes they are able to enhance the stakeholders' levels of commitment, trust, and cooperation that enable them to execute timely, cost-effective, and quality government construction projects.

6.2 Implications

This study provides both theoretical, practical and policy implications. Theoretically, the study contributes to the adoption of path goal theory as adequate in studying government construction projects success as it sets the foundation for empirical evidence of the relationship between leadership styles (communication and participation) and government construction projects in Uganda success. Also, the study contributes to the body of literature concerning the relationship between leadership styles and government project success.

Practically for managers of government construction projects and stakeholders, since leadership styles contribute to government construction projects' success, project managers should ensure that there is adequate internal and external communication with stakeholders through the right channels to make project goals, benefits, and tasks clear, stakeholders and managers understand each other which limits on disagreements in projects that may delay projects. Secondly, there is a need to ensure openness and constant communication during project implementation to help a project transit smoothly from one project stage to another easier. The existence of clear and open communication limits waste reworks, and costly litigations as well as fosters stronger cooperation among stakeholders. Again, project managers should adopt leadership styles (communication and participation) that suit the nature of the project situation and stakeholders such as participation leadership that encourages delegation of authority, consultation, and joint decision-making, stakeholders and leaders strive hard to complete quality projects on time and within the set budget. Lastly, project managers should devise strategies to realize project success. This can be achieved by adopting communication and participation leadership styles that suit the nature of stakeholders and the project situation. Once this is in place stakeholders will become committed and cooperative and trust each other to deliver projects as planned.

Under Policy contributions, having established that leadership styles especially communication and participation contribute greatly to government construction projects success, governments through project implementation organs such as the Ministry of Works and Transport in uganda should put in place vibrant communication policies that ensure project managers and practitioners adequately share Information about the project among stakeholders through the stakeholders' desired channels to make project goals, benefits and tasks clear to limit on disagreements in projects that delay projects. This should happen concurrently with designing a strong policy towards stakeholders' inclusiveness in government construction projects.

Collective decision making involving all key stakeholders in construction projects can promote efficiency and proper resources allocation to achieve construction milestones. This may reduce on shoddy works and promote timely and certified construction project completion to eliminate resource wastage by controlling government development fund leakages. Also, government through the Ministry of Education and Sports should consider incorporating project practice and implementation literacy education in the secondary education curriculum. This will impart project knowledge and skills onto learners at an early stage. Additionally, the learners will develop a positive attitude towards projects. Furthermore, the National Council for Higher Education should encourage institutions of higher learning to introduce construction project education in their programmes.

6.3 Model that explains construction project success.

The second objective of this study was to develop a model that success of government funded projects. From the review of literature and path goal theory it was hypothesised that leadership styles especially communication and participation explain government

construction project success. This relationship is diagrammatically illustrated in Figure 4.

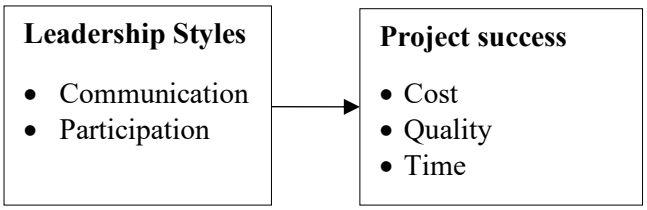

Figure 4: Model that explains Project Success

To generate a model that explains project success, structural equation modeling was conducted in order to confirm the hypothesised model in Figure 4. Responses in form of quantitative data were solicited from project stakeholders to capture their views on whether leadership styles especially communication and participation explain project success. Accordingly, a model that explains project success was developed as indicated in Figure 4. As seen in Figure 4 the model reveals that to realise project success project leaders need to adopt suitable leadership styles especially communication and participation leadership.

Specifically, with communication, project managers should ensure that Information about project is shared adequately among stakeholders. Under participation, project leaders should ensure project stakeholders participate in project design, participate in deciding the project site and also participate in deciding the time frame that project will take to realise project success. As such the path stakeholders take to realise project goals will be made easier. Also, the results revealed that government project success means adherence to project cost, time and quality as the case was in the hypothesised model (Figure 4). In terms of time project leaders who adopt suitable leadership styles should aim at meeting the set time frame for the project to be judged successful. In terms of quality measurement project success is means improvement in the performance of stakeholders, project outputs meeting stakeholder's expectations and ensuring that project comply with the set project requirements. In terms of quality project leaders should ensure that reliable project costs estimates are always set before commencement of the project; ensure that the total cost of the project is always below the authorised budget and lastly ensure that final budget for each phase of the project is essentially the same as planned.

6.4 Limitations and research direction

Despite the highlighted significant contributions of this research, it also presents some limitations and opportunities for future researchers. First, the study examined leadership styles in terms of participation and communication. Therefore, future research can examine leadership styles by focusing on laissez-faire, achievement-oriented leadership, and autocratic leadership. Also, the study has been conducted in a developing country, Uganda. Future research should look into the comparison between developed countries and less developed countries in this regard.

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Appendix 1: **Exploratory Factor Analysis for Leadership Styles (Rotated component matrix)**

Item scale		communication	participation
LDCM1	Information concerning project activities is always shared to project stakeholders	.777	
LDCM2	The language used in project correspondences is familiar to all project stakeholders	.572	
LDCM3	The channel used to share information is liked by all project stakeholders	.625	
LDCM 4	New project Information usually circulates amongst project stakeholders on time	.595	
LDCM8	Meetings are held to share information regarding performance of project tasks	.796	
LDCM9	Information about project progress is always shared among project members	.585	
LDCM11	Project targets are always explained to project stakeholders in a meaningful way	.639	
LDCM13	Sharing of information has improved commitment among project stakeholders	.589	
LDCM15	The project information provided clearly indicates the roles and responsibilities of each stakeholder	.526	
LDCM 5	There are reliable avenues for receiving reactions about project activities from project stakeholders	.322	
LDCM 6	Opinions from project stakeholders are always given attention	.124	
LDCM 7	Reactions from project stakeholders are always given attention	.452	
LDCM10	Interactions amongst project stakeholders is guided by a communication policy	.278	
LDCM 12	Sharing of information has resulted into improved cooperation among project stakeholders	.301	
LDCM 14	Sharing of information has improved the level of trust among project stakeholders	.426	
LDCM16	Sharing information among stakeholders improves performance of projects	.311	
LDPT1	Project stakeholders are always asked for suggestions on how to carry out project assignments		.567
LDPT2	Project stakeholders participate in project design.		.554
LDPT7	Project supervisors/ leaders do not require project stakeholders to get their input or approval before making decisions		.511
LDPT10	Project stakeholders participate in deciding the project site.		.526
LDPT11	Project stakeholders participate in deciding the time frame for the project.		.512
LDPT13	Project stakeholders participate in deciding the sanction measures for the project misuse.		.608
LDPT17	Project stakeholders participation has improved the level of cooperation among project stakeholders		.670
LDPT18	Project stakeholder's participation contributes to project success		.624
LDPT3	Project stakeholders participate in needs identification for the project.		.434

LDPT4	Project stakeholders participate in the monitoring and evaluation of the project.	.034
LDPT5	Project stakeholders are left to make decisions on their own without consulting their leaders.	.345
LDPT6	Duties and tasks are delegated amongst project stakeholders according to the capacity of each project stakeholder	.278
LDPT 8	Project supervisors/leaders permit project stakeholders to get the necessary information from them and then make decisions on their own.	.389
LDPT 9	Project stakeholders are involved in making decisions on how project tasks and duties should be performed	.287
LDPT12	Project stakeholders participate in deciding the budget for the project	.345
LDPT14	Project stakeholders participate in deciding the sanctions imposed for not participating in project maintenance.	.456
LDPT15	Project stakeholders' participation has improved on their commitment towards projects	.326
LDPT16	Project stakeholders' participation has improved the level of trust among project stakeholders	.434

Appendix 2: Exploratory Factor Analysis results for Project Success (Rotated component matrix)

Eigen Value	13.393	7.429	
Variance %	39.391	21.849	
Cumulative %	39.391	61.240	

Item scales		time	cost	quality
PSTM1	Reliable time estimates are often set ahead of project	.705		
PSTM2	Project stakeholders are always committed to beating set deadlines	.733		
PSTM4	The project was completed on schedule	.862		
PSTM5	Necessary project information is provided to stakeholders on time	.886		
PSTM3	Project activities from initiation to closure are always timely	.478		
PSCO1	The actual total cost of the project was significantly under authorized budget		.607	
PSCO3	Reliable cost estimates are often set before project implementation		.580	
PSCO4	The cost objectives were met for the project		.836	
PSCO2	The final budget for each phase of the project was essentially the same as planned		.701	
PSQU1	Projects outputs have greatly improved the livelihood of many stakeholders			.803
PSQU2	The project's deliverables complied with the set requirements			.605
PSQU4	The project's output meets stakeholders' expectations			.513
PSQU5	The project improved performance for stakeholders			.624
PSQU6	Project end product is accepted and used by the stakeholders for whom the project is intended			.588
PSQU3	The quality of the project targets achieved is always high			.403
PSQU6	Project end product is accepted and used by the stakeholders for whom the project is intended			.098
Eigen Value		3.666	1.874	1.606
Variance %		45.830	11.711	10.036
Cumulative %		45.830	57.541	67.577

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Usage of Building Information Modelling in Quantity Surveying Firms in Nigeria

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Abstract

Despite the enormous benefits of building information modelling (BIM) in the project delivery process, quantity surveying (QS) firms have the lowest level of BIM usage among other professionals in Nigeria. Also, beyond the generic importance of BIM to project delivery, in the context of developing countries, not much attention has been paid to investigating the importance that QS firms place on the benefits of BIM usage. Hence, it is necessary to assess the importance of BIM usage by QS firms in Lagos State, Nigeria to improve BIM adoption and consequently enhance project delivery. Primary data were collected using well-structured questionnaires that were self-administered to QS firms. The respondents were asked to assess the level of importance attached to the benefits of BIM usage. Eighty-six (86) valid questionnaires were used for analysis. The data collected were analyzed using mean ranking analysis and Student t-test. The results showed that only a small proportion of QS firms had adopted BIM. Also, all QS firms place considerable importance on the benefits of BIM usage, but QS firms that have adopted BIM attached greater importance to its usage at the post-contract stage. The essential benefits of BIM usage to QS firms are those related to the preparation of bills of quantities (BOQ), such as 'faster generation of quantity take-off' and 'ease of pre-estimation'. QS are often tasked with generating accurate and reliable BOQ, which can be mentally demanding and challenging. The recognized significance of BIM for BOQ preparation highlighted in this study can revolutionize QS tasks and motivate other QS firms yet to adopt BIM to invest in BIM. The study highlights the need for increased promotion of BIM adoption among QS firms, recognition of the varying importance of BIM benefits at different project stages, and the potential for BIM to enhance the capabilities and efficiency of QS firms in the construction industry. These implications can guide future efforts in promoting BIM adoption and its effective utilization within the QS profession.

Keywords: BIM usage, building information modelling, construction professional, quantity surveying firm, questionnaire.

1. Introduction

The fragmentation of the construction industry, resulting from the traditional method of project delivery, has been identified as the bane of the construction industry in many countries (Yusuf *et al.*, 2022b). However, building information modelling (BIM) has yielded positive outcomes in dealing with fragmentation for improved project delivery (Eadie *et al*., 2015; Sawhney *et al*., 2014). BIM has been described as a medium for developing an electronic model of a facility for better visualization, budgeting, engineering analysis, code criteria checking, and conflict analysis. This affords different construction professionals the privilege to make decisions considering the constructability and maintainability of the building *(*Kreider and Messner, 2013; Nagalingam *et al*., 2013). After so many years of working mainly with paper and, lately, Computer Aided Design (CAD) to develop plans and drawings (a process seen to be error-prone), the construction industry is switching to the adoption of BIM (Kugbeadjor *et al*., 2015). According to Sahil (2016), BIM is now the global standard for assessing efficiency in building design, construction, and maintenance. BIM offers a variety of benefits, such as a drastic reduction in errors during the design and construction phase, automation of construction activities, which effectively reduces inefficiencies, and improved collaboration among construction professionals (Ryal-Net and Kaduma, 2015). For Quantity Surveyors (QSs), BIM has the potential to

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eradicate many mundane elements of traditional quantity surveying by automating tasks, removing errors, and increasing efficiency (Naamane and Boukara, 2015). Many countries in the developed world have been reaping the benefits of embracing BIM (Yusuf *et al*., 2022a). For example, the UK government regulated that any public sector project over £5milllion must adopt the BIM technology for its execution (Eadie *et al*., 2013). However, in Nigeria, the usage of BIM is low, especially among quantity surveying (QS) firms, when compared with other professionals (Olugboyega, 2015; Owadokun, 2017; Aluko, 2017).

In the developed world, the importance of BIM in project delivery has been shown to cut across the entire project lifecycle (Subhi and Uma, 2018). Studies such as Franco *et al*. (2015) and Ismail *et al*. (2016) further emphasized the benefits of BIM usage. However, Smith (2016) indicated that some QS firms still use traditional quantification and have not adopted the new trend in technology. QS firms in Nigeria are still lagging in adopting automated quantities (Babatunde *et al*., 2019). However, the role of QSs would be reformed drastically from their current duties as BIM allows for the analysis of buildings, including the structure, materials, and performance, in real-time as they are being designed. The reliance on the production of bills of quantities as the main role of QSs is gradually increasing due to the automation of this task (Okereke *et al*., 2021). Akinsiku (2016) opined that BIM is a big confrontation with traditional QS services. QSs that can defeat these challenges will be at an upper hand in the future in this technologically growing industry (Nagalingam *et al*., 2013).

BIM was conceived to solve the challenge of fragmentation and common errors in managing information required by construction professionals throughout the project lifecycle (Egwunatum *et al*., 2016). One of the many advantages of BIM is that as a project develops, project drawings are consistently updated upon every alteration in the model. BIM has been said to contribute immensely to the three strong pillars of the construction industry: cost, time, and quality (Raphael and Priyanka, 2014; Ismail *et al*., 2016). More so, BIM has been found to significantly impact the estimating practices found in the industry, which was often observed to be prone to errors and inaccuracies. One of its most significant benefits is the swift, secure and accurate generation of quantities from a digital model (Ismail *et al*., 2016). Considering this, it is expected that the QS firms saddled with the cost and contract management of construction projects will be at the forefront of BIM usage. Olugboyega (2015) and Akerele and Etiene (2016) showed that QSs' awareness of BIM was satisfactory. Still, the use of BIM by QS firms ranked the least among other professionals in Nigeria.

Although studies (Olugboyega and Aina, 2016; Ugochukwu *et al*., 2015) have investigated BIM usage in the Nigerian construction industry, there is scarce evidence on studies investigating BIM usage by QS firms. Therefore, an in-depth understanding of the usefulness of BIM to QS firms in the construction industry cannot be overlooked. Hence, it is expedient to know the level of importance QS firms ascribe to the benefits of BIM usage in Nigeria. This will reveal their attitude towards adopting BIM for executing their traditional duties.

2. Background

2.1 Concept of BIM

BIM is a means to create a data-enriched, object-oriented, intelligent, and digital illustration of the project in which drawings and important information for different stakeholders can be extracted for project delivery and decision-making (Rogers et al., 2015). The concept of BIM is to build a building virtually before constructing it physically so that potential problems can be seen, analyzed, and resolved (Haron, 2013). Shen and Issa (2010) found an increase in speed and efficiency when using 3D models compared to traditional 2D. This innovative technology provides extensive support to project management via its capacity to integrate building models and finished projects, which reveals the high potentiality of BIM in project lifecycle management (Gourlis and Kovacic, 2017). BIM also nullifies distance barriers among the key players in the project (Ede, 2014). Aouad et al. (2013) stated that BIM has seven dimensions. This begins a three-dimensional (3D) model (i.e., X, Y and Z) with parametric properties. This extends to scheduling and sequencing, cost estimating, green/sustainable design, and facility management, which are 4D, 5D, 6D and 7D, respectively. An nth dimension (nD) is allowed for further model development.

2.2 Benefits of BIM to Quantity Surveying Practice

The roles of QSs span from the pre-contract stage to the post-contract stage; these include preliminary costing, cost planning, quantities measurement, preparation of bills of quantities, preparation of final accounts, and insurance valuation, amongst others (Wu et al., 2014). As BIM's usefulness and advantages span the construction industry, it has been observed that BIM poses several advantages to QSs in pre- and post-contract activities. BIM makes it possible to achieve precision in estimating and take-offs (Gourlis and Kovacic, 2017). Ali et al. (2013) asserted that at the feasibility stage, BIM can help achieve pre-estimation in a shorter time, and it could help automatically update changes in the design. BIM also helps to develop a better integration between designers and clients; thus, clients will make sound decisions using the anticipated model (Ali et al., 2013). BIM enables QSs to be more involved in the early design stages of a construction project through automation in producing bills of quantities, early management of costs, and more reliable cost estimation (Raphael and Priyanka, 2014). BIM also ensures ease in understanding building requirements at the design stage (Ali et al., 2013).

BIM has many benefits at the construction stage, which include curtailing construction waste, reduction in construction time duration, moderation of variation orders, extension of time due to variation, and synchronization of the design and construction phases (Ali et al., 2013). Sahil (2016) stated that BIM helps to

create a smooth and easy transition from the design phase of a project to the construction phase. Ali et al. (2013) discovered some benefits of BIM in the maintenance stage, including its ability to preserve historical information as a benchmark for new projects, obtain a pre-estimation of the maintenance cost, and faster execution of maintenance. McGraw-Hill Construction (2014) reported after an online investigation that benefits of utilizing BIM in construction operations are observed in error reduction and omissions, increased profits, aided collaboration, enhanced image, better cost control, reduced cost, reduced time, reduced rework, better marketing opportunities, new services, minimized workload duration, accelerated client's approval, better safety, and quicker governing permission cycles.

5D BIM mainly entails the cost aspect being added to the BIM model. QSs should adopt 5D BIM to ease the workload and provide a more effective and accurate service, improved value management services to the client, and quick notification of design changes (Harrison and Thurnell, 2015). Greater exactitude can be achieved through the adoption of an automatic estimating method (Franco et al., 2015). Working with blueprints makes it easier to do quantity take-off in a shorter period (Ali et al., 2013). Harrison and Thurnell (2014) concluded that 5D BIM improves decision-making, limits the incorrect interpretation of the drawings, and limits assumptions made by QSs. 5D BIM gives a better knowledge of the construction fundamentals and helps to reduce the possibility of omitting important building items while costing (Sampaio, 2017). Harrison and Thurnell (2015) revealed that BIM allows for collecting information for preliminary estimation. Furthermore, BIM measurement is reported to impact preconstruction activities (Monteiro et al., 2014). This is also evident according to the findings of Aluko (2017), who found a remarkable reduction in the final account sum, final project duration, and time taken for BOQ preparation after BIM was adopted on projects.

According to Harrison and Thurnell (2014), 5D BIM improves coordination by integrating clash detection and specification, as centralized BIM models can consequently update changes and disburse these data to stakeholders. This differs from the regular process whereby a QS uses corrected documentation to find modifications or changes. According to Choi and Kim (2016), to achieve clash detection, tools like Solibri (also operable in tools like Navisworks and VICO Office) can detect potential complications in construction, search for overlaps, clashes, connections, et cetera to redesign before construction.

BIM offers an accurate quantity take-off and cost estimate early in the design stage and provides cost effects of additions and modifications with the ability to save time and money and reduce exceeding of budget to the barest minimum or altogether remove such (Ibrahim and Abdullahi, 2016). Sharing the BIM model with the contractor drastically reduces the time used in detailed estimations and ensures precision (Dossick and Neff, 2010). Cost planning is essential in any project as it makes the contract sum available by accurately allocating costs to target areas of the project, which, in the long run, serves as a basis for cost control (Kirkham, 2014). Unlike the conventional method, BIM offers a 5D cost-planning model with several advantages. Aside from cost planning, BIM aids with an automated cost estimation system via quantity allocation, which tends to be faster and more reliable. Mouflard (2013) states that real 5D results from 4D, 3D and 2D data. Defining 5D as only an embodiment of cost data and parameters is a shallow definition. This capability of BIM provides a real-time option for modelling and facilitates project simulations and testing, which aid building designs, cost, efficiency, and performance (Monteiro et al., 2014).

Several QS tasks can be carried out more efficiently using BIM. Harrison and Thurnell (2015) stated some of these QS tasks as data extraction for detailed estimation, efficient data extraction for producing schedules and bills of quantities, communication and access to information in the project team, improved coordination and detection of clashes and many more. Although Aibinu and Venkatesh (2012) concluded that many QSs have migrated from manual taking off to electronic quantification of quantities, nevertheless, Akerele and Etiene (2016) revealed that several QSs in Nigeria still do taking-off manually. It is forecasted that in the near future, many duties will have to be redefined due to the implementation of BIM. Furthermore, according to Beukes (2014), various BIM tools exist for different QS tasks. Several BIM tools can be used for taking-off and estimating, some for planning and scheduling, and some for material estimation. Beukes (2014) reported some sets of QS tasks and the appropriate BIM tools that can be used to execute them. This is summarised in Table 1.

Table 1: Quantity Surveying Tasks and the BIM Tools for Their Execution

Traditional Quantity Surveying Task	BIM tools capable of performing the task
Quantity Take-off	Autodesk QTO, BIM Measure from Causeway
BOQ Preparation	CostOSTM, Nomitech
Cost Estimation	DProfiler, Beck Technology
Cost Planning	Vico Cost Planner
Cost Reporting	Vico Office Client
Cost Control	Vico Cost Explorer
Material Procurement	Quantities of material extracted using BIM tools for QTO
Payment Applications	Bentley
Value management	BIM estimating packages can be used to get the cost for the different design alternatives
Life Cycle Costing	Integrated Environmental Solutions Virtual Environment

Adapted from: Beukes (2012)

2.3 Barriers to BIM Adoption

Despite the numerous benefits of BIM, several barriers are preventing construction professional organizations (QS firms inclusive) from adopting the innovation. BIM adoption requires a network of activities, and the necessary conditions, resources and expertise for its adoption must be provided (Onungwa *et al.*, 2017). According to Yusuf (2021), adopting BIM requires specific organizational capabilities such as adequate power supply, speedy internet connection, data sharing skills, adequate information technology infrastructure, process redesign and collaborative team culture. The required competence, resources, and enabling environment are barriers to BIM adoption (Yusuf *et al.*, 2022a). For example, lack of understanding and trust among project stakeholders, absence of required expertise, poor awareness, and cost of BIM adoption are barriers to the adoption of BIM (Hardin and McCool 2014).

Adekunle *et al.* (2021) identify the high cost of adoption, lack of demand for BIM usage by clients, poor government support, and lack of support by top management as primary barriers to BIM adoption among quantity surveyors. Amuda-Yusuf *et al.* (2017) revealed barriers to BIM adoption from the perspective of architects, QS, engineers, and builders. The study showed that lack of knowledge about BIM technology by construction professionals, poor awareness, fragmented nature of the industry, absence of financial support and lack of collaborative culture in the industry are primary barriers to BIM adoption among construction professionals. Eadie *et al.* (2014) highlighted disparities in the perceived barriers to BIM adoption between contracting organizations that have adopted BIM and those that have not. For organizations yet to adopt BIM, the most significant barriers include a lack of support from the supply chain, a substantial cultural shift required, a shortage of technical proficiency, and the expense associated with software. Conversely, the primary barriers among firms that have adopted BIM are a limited understanding of BIM benefits, the magnitude of cultural adjustment needed, and the costs associated with training.

3. Methodology

To assess the usage of BIM amongst QS firms in Nigeria, this study considered only QS firms in Lagos State. Lagos is a former Federal Capital and is now the country's commercial hub. Lagos is also the most populous city in Africa and the sixth-largest city in the world (Ojuri and Bankole, 2013). Therefore, the study adopted a total enumeration method considering the relatively small size of the study population. Kumar (2018) defined total enumeration as a complete selection of all items in a population under study. Respondents were randomly selected to prevent bias and ensure that every member of the population had an equal chance of being selected. With a target of one respondent per firm and according to the 2019 directory of the Nigerian Institute of Quantity Surveying (NIQS) Lagos State chapter, 125 QSs of varying positions in QS firms in Lagos were considered for this study. The target respondents were identified by their positions/roles in QS firms within Lagos State.

3.1 Data Collection

Primary data were collected using self-administered questionnaires (Easterby-Smith *et al.*, 2021). The questionnaire was well-structured and designed as a close-ended type to facilitate anonymity, freedom of expression, and confidentiality (Patten, 2016). The questionnaire has two parts and was developed based on the review of extant studies. The first part of the questionnaire was designed to gather data on the respondents' demographics, and the second part was designed to assess the importance of BIM usage by QS firms in Lagos State, Nigeria. To measure the level of importance attached to the benefits of BIM usage amongst QS firms in Lagos State, Nigeria, the benefits of BIM were scored on a six-point Likert–type scale of 0-5, where 0 = no importance, 1 = very low importance, 2 = low importance, 3 = moderate importance, 4 = high importance, 5 = very high importance.

3.2 Data Analysis

The collected data was analyzed using descriptive and inferential statistics, including frequency distribution, percentage, and mean score analysis. A further analysis was carried out using a Student *t*-test to compare the mean response of firms that have adopted BIM with those that have not adopted BIM at a 5% significance level. The data set shows normality and homogeneity of variance. A total of 86, which represent a response rate of 68.88%, were the valid questionnaires returned and used for the analysis. The total retrieved questionnaires made the breakdown of the study sample to be 75 (87.21%) from QS firms yet to adopt BIM and 11 (12.79%) from QS firms that have already adopted BIM. The response rate of 68.88% for a questionnaire survey is considered adequate by Naoum (2012). Similar sample sizes have been used in prior studies (Amuda-Yusuf *et al.*, 2017; Babatunde *et al.*, 2019).

Cronbach Alpha was used to test the internal consistency and reliability of the responses provided for the level of importance attached to BIM benefits by QS firms since the Likert scale was adopted for the study. Cronbach's Alpha for the importance of BIM benefits by the QS firms is 0.95. Cronbach's Alpha ranges between 0 and 1. Bonett and Wright (2015) stated that Cronbach's Alpha (α) > 0.9 is excellent. This implies that the responses provided are reliable for carrying out this research.

4. Results

4.1 Respondents Demographics

An analysis of the respondent's background information, as shown in Table II, reveals that the highest proportion is from organizations with employees ranging from 6 to 10, representing 48.84% of the total respondents. This was followed by respondents with organization sizes of 1 to 5

employees, representing 26.74% of the total respondents, and respondents from organizations with 11 to 15 employees, 13.95% of the total respondents. Lastly, respondents from organizations with 16 to 20 employees accounted for 10.47% of the total respondents. This shows that all the firms surveyed are small to medium firms, typical of practicing QS firms, as Ogunsemi *et al*. (2013) stated. It is evident from Table II that the respondents with B.Sc./B. Tech had the most significant proportion (56.98%). This was followed by respondents with M.Sc./M.Tech/MBA (27.91%). While respondents with HND represented 6.98% of the total respondents, those with PGD represented only 5.81%. Respondents with MPhil/Ph.D. had the lowest proportion, 2.33%. This shows that the respondents are well-educated, and the responses provided could be relied upon for this study.

Regarding professional qualification, Table II also shows that the respondents were professionally qualified, as 59.3% of them were members and fellows of the Nigerian Institute of Quantity Surveyors (MNIQS/ FNIQS). In comparison, 31.4% were probationer members of NIQS. Only 9.3% were members and fellows of the Royal Institution of Chartered Surveyors (MRICS/FRICS). The distribution of respondents by their position shows that respondents who were senior QSs constitute 66.27% of the total respondents. This is followed by respondents who were graduate QSs (17.44%). Respondents with the position of principal QS and partner QS were 9.30% and 6.98%, respectively. About 12.79% of the respondents were from QS firms that have adopted BIM, while 87.21% of the respondents were from QS firms that have not adopted BIM. This further buttressed the low adoption of BIM by QS firms, as established by previous research (Babatunde *et al*., 2019).

The respondents' years of experience, as evident from Table 2, show that those 6-10 years are the highest, with 51.16% of the total respondents. This is followed by those with 11-15 years of experience (27.91%). Respondents with 16-20 years of experience constitute about 11.63%, while respondents with 0-5 years of experience have the lowest percentage, which is 5.81%. The preceding background information implies that the respondents surveyed were academically and professionally qualified. They are also well-experienced and work with well-established QS firms. As a result, they are considered competent to provide reliable responses to the questionnaire survey, and it is adjudged that their responses could be trusted.

Table 2: Respondents Demographics

Background Information	Frequency	Percentage (%)
Size of Organization		
1-5	23	26.74
6- 10	42	48.84
11- 15	12	13.95
16-20	9	10.47
Total	**86**	**100.00**
Highest Academic Qualification		
HND	6	6.98
PGD	5	5.81
B.Sc/B.Tech	49	56.98
M.Sc/M.Tech/MBA	24	27.91
MPhil/PhD	2	2.32
Total	**86**	**100.00**
Professional Qualification		
Probationer	27	31.40
MNIQS/ FNIQS	51	59.30
MRICS/FRICS	8	9.30
Total	**86**	**100.00**
Position of Respondents		
QS	15	17.44
Senior QS	57	66.27
Principal QS	8	9.30
Partner QS	6	6.98
Total	**86**	**100.00**
Years of Experience		
0-5	5	5.81
6-10	44	51.16
11-15	24	27.91
16-20	10	11.63
21-25	3	3.49
Total	**86**	**100.00**
Type of QS Firms		
Already adopted BIM	11	12.79
Yet to adopt BIM	75	87.21
Total	**86**	**100.00**

4.2 Importance attached to benefits of BIM usage by QS firms

Data were collected to assess the importance of BIM usage by QS firms in the study presented in Table 3, which shows the mean scores (MS) and the rank of each BM benefit. The five (5) top-ranking BIM benefits considered most important are 'faster generation of quantity take-off (MS = 4.30)', 'ease of pre-estimation (MS = 4.29)', 'better design management through easy detection of clashes (MS = 4.28)', 'efficient data extraction for preliminary estimation (MS = 4.24)', and 'design visualization (MS = 4.21)'.

Benefits of BIM usage include 'automatic corrections when changes are made to design (MS = 4.06)', 'better collaboration with other professionals in the industry (MS = 4.02)', 'synchronization of the design and construction phases (MS = 4.02) ', which had moderate ranking. The low-rated benefits of BIM usage are 'promotes the implementation of lean construction techniques (MS = 3.72)', 'reduction in variation orders (MS = 3.68)', 'reduction in extension of time due to variation orders and disputes (MS = 3.61)', 'improved commissioning and

handover of project's information (MS = 3.45)', and 'streamlining workloads (MS = 3.23)'.

QS firms that have adopted BIM have only 7 out of 33 benefits, with MS below 4.0. Meanwhile, QS firms that have yet to adopt BIM have 18 (more than 50%) benefits of BIM with MS below 4.0. QS firms that have adopted BIM attached greater importance to 'reduction in variation order' as a benefit of BIM usage, with a rank of 17th and MS of 4.18, while QS firms that have not adopted BIM rated it 30th with MS of 3.61. Similarly, QS firms that have adopted BIM attached greater importance to 'reduces discrepancies between drawings and bill of quantities' and 'data storage throughout the building's lifecycle as references for new projects', rated 7th with an MS of 4.36. In contrast, QS firms yet to adopt BIM rated the same 22nd with an MS of 3.81. This is also the case with 'automatic corrections when changes are made to design', rated 2nd by QS firms that have adopted BIM but rated 14th by QS firms that have not adopted BIM. In addition, as shown in Table 3, 'data storage throughout the building's lifecycle as references for new projects', 'reduction in construction wastage' and 'reduction in variation order' which are all post-contract related benefits of BIM were ranked 7th, 11th, and 17th respectively by QS firms that have adopted BIM while same were rated 22nd, 28th and 30th by QS firms that have not adopted BIM.

QS firms that have adopted BIM ascribed the highest importance to 'affirm all items are considered when taking off (MS = 4.73)' as the benefit of BIM usage, while QS firms that are yet to adopt BIM rated it 24th (with MS = 3.80). This is followed by 'faster generation of quantity take-off', 'ease of pre-estimation', 'accurate BOQ preparation', 'reduces tendering process due to faster generation of quantity take-off', and 'automatic corrections when changes are made to design (MS = 4.45). These benefits of BIM usage, which are all critical factors required to produce an accurate bill of quantities (BOQ) early in the project delivery process all ranked 2nd for QS firms that have adopted BIM. On the other hand, QS firms that are yet to adopt BIM ascribed highest importance to 'faster generation of quantity take-off (MS = 4.28)', then 'ease of pre-estimation' and 'better design management through easy detection of design clashes (MS = 4.27)'. This is followed by 'efficient data extraction for early stage (preliminary) estimation (MS = 4.23) and 'design visualization (MS = 4.21)'.

4.3. Comparisons of BIM benefits between QS firms adopting BIM and QS firms yet to adopt BIM

Further analysis was conducted using a Student t-test at a 95% confidence level to compare the MSs of QS firms that have adopted BIM and those yet to adopt BIM on the level of importance attached to the benefits of BIM usage. Table III, which shows the t-statistics and p-values, revealed no significant differences in the MSs of the two categories of respondents except for 'affirming all items are considered while taking off' (p-value = 0.000). This benefit of BIM usage ranked 18th overall, 1st for QS firms that have adopted BIM, and 24th for QS firms that are yet to adopt BIM.

5. Discussion

The five (5) top BIM benefits considered most important are 'faster generation of quantity take-off', 'ease of pre-estimation', 'better design management through easy detection of clashes', 'efficient data extraction for preliminary estimation', and 'design visualization'. These BIM benefits are all associated with the planning and design stages of the project delivery process, indicating that QS firms perceive BIM as very important for carrying out their pre-contract duties. This corroborates the findings of (Hellum, 2015), who stated that more emphasis is placed on the benefits of BIM at the early stages of a project. Although the emergence of BIM arose due to the demand for a better and more efficient way of running pre-contract activities (Ibrahim and Abdullahi, 2016), its usage cut across all stages of project delivery (Egwunatum *et al*., 2016).

The high ranking of 'faster generation of quantity take off' among benefits shows that the QS firms identified BIM as necessary for generating take-off quantities and preparing BOQ. This is supported by the findings of Stanley and Thurnell (2014) and Ibrahim and Abdullahi (2016), who opined that BIM offers an accurate quantity take-off and cost estimate early in the design stage, which is very important during the preparation of cost estimates at the early stages of a project lifecycle. The high importance attached to 'ease of pre-estimation' as shown by the result is in accordance with previous researchers such as Harrison and Thurnell (2015) and Ali *et al*. (2013), who opined that with BIM, pre-estimation can be achieved in a lesser time, and the changes in the design will affect pre-estimation.

The high ranking of 'better design management through easy detection of clashes', 'efficient data extraction for preliminary estimation', and 'design visualization' shows that BIM enables QSs to be more involved in the early design stages of a construction project through clashes detection, early management of the costs and design visualization. This finding aligns with the assertions of Raphael and Priyanka (2014), Fung *et al*. (2014), and Harrison and Thurnell (2014). Notably, most top-ranking benefits of BIM belong to the planning and design stages of the project delivery process, which are used mainly for in-house duties peculiar to QS firms (Adekunle *et al*., 2021).

This suggests that the state of BIM usage in Nigeria is still mainly at the 'sole-BIM' level, where individual professionals use BIM within their organization while industry-wide implementation for collaboration and interoperability is still grossly lacking (Yusuf *et al*., 2022b, Yusuf *et al*., 2022a). Thus, individual professionals benefit from BIM usage, but fragmentation persists in the industry. This agrees with Hamma-Adama and Kouider (2018), who asserted that the present adoption level of BIM in Nigeria is still at the individual and organizational level, representing BIM Stage 1, called "lonely BIM". However, the moderate ranking of other benefits of BIM usage, such as 'automatic corrections when changes are made to design', 'better collaboration with other professionals in the industry', and 'synchronization of the design and construction phases'

could suggest that some level of collaboration is already taking place among built environment professionals even with the current state of usage at individual, organizational level.

Furthermore, QS firms rated BIM usage highly for enhancing collaboration among professionals. This implies that they perceive BIM as having the ability to improve communication in the construction industry due to smooth information flow. This is supported by the study of Chimhundu (2016), who identified improving communication or collaboration within project teams and better design management as the most important benefits of BIM. The low ranking of benefits of BIM usage such as 'promotes implementation of lean construction techniques', 'reduction in variation orders', 'reduction in extension of time due to variation orders and disputes', ''improved commissioning and handover of project's information', and 'streamlining workloads' is reflective of the low uptake of BIM among QS firms as earlier opined by Olugboyega (2015), Owadokun (2017), and Aluko (2017). In addition, these benefits of BIM usage are those peculiar to the construction and commissioning stages of the project delivery process; if QS firms are yet to deploy BIM at these stages of project delivery, it would be difficult to appreciate BIM usage. Also, the low ranking of 'promotes the implementation of lean construction techniques' could suggest that implementing methods and techniques like lean construction is still in the infancy in the Nigerian construction industry, as opined by Hamma-Adama and Kouider (2018). More so, the low importance attached to 'reduction in variation order' could result from the fact that most QS firms have not used BIM during the construction stage. This is perhaps the case because most respondents (87.21%) are from QS firms that have not adopted BIM, which could have significantly influenced the result. It is evident from the result that QS firms that have adopted BIM attached greater importance to the core benefits of BIM usage beyond the pre-contract stage when compared with QS firms that have yet to adopt BIM usage.

Although only 12.79% of the QS firms have adopted BIM, it is noteworthy that none of the benefits of BIM usage has an MS of less than 3. This reveals that QS firms, regardless of whether they have adopted BIM or not, ascribed a considerable level of importance to all benefits of BIM. However, the result shows that generally, QS firms that have adopted BIM attached greater importance to the benefits of BIM usage. The differences in the importance attached to the benefits of BIM usage by these categories of firms are unsurprising. This is because firms adopting BIM are expected to understand better and appreciate the benefits of BIM usage. This finding further underscores the importance of BIM to quantity surveying practice and how it can significantly improve the discharge of QSs' responsibilities in construction projects. In addition, the results reveal that all post-contract-related benefits of BIM were rated higher by QS firms that have adopted BIM. It could be inferred that QS firms that have adopted BIM are already using it in the construction phase and not only at the pre-contract stages. Also, the benefits of BIM usage, which are all critical factors required to produce an accurate bill of quantities (BOQ) early in the project delivery process, were ranked very high by QS firms that have adopted BIM. This shows that these QS firms also prioritized the ability of BIM to help carry out their duties at the pre-contract stages. This agrees with Beukes's (2014) findings that BIM benefits are significant to QSs because they greatly assist in carrying out their traditional services. The higher ranking of 'design visualization' by firms that have not adopted BIM is probably due to the preponderance of BIM usage among construction professionals in Nigeria for 3D visualization, as opined by Onungwa *et al*. (2017), which is also what previous 3D CAD systems can help to do.

The results further reveal that QS firms that have adopted BIM and those yet to adopt BIM were unanimous in their scoring of the importance attached to the benefits of BIM usage except for 'affirming all items are considered while taking off', which was perceived differently. This suggests that BIM has helped to provide a more accurate take-off for QS firms that have adopted BIM. This supports the findings of Boon and Prigg (2012), who stated that it is expedient for QS to identify cost items missing from the model when taking off, which BIM helps to achieve. Hence, QS firms adopting BIM consider it the most important benefit of BIM usage. This is not unrelated to the fact that these QS firms have started using BIM and have hereto experienced a more accurate quantity take-off.

Given that only a small proportion of QS firms have adopted BIM, there is a need for increased efforts by professional organizations, regulatory bodies, and other stakeholders to promote and encourage BIM adoption among QS firms, as it is a technology that can potentially enhance their cost and contract management capabilities (Babatunde *et al.*, 2019). Also, the study reveals variations in how QS firms perceive the importance of different BIM benefits depending on whether they have adopted the technology. This suggests that tailored approaches may be necessary when advocating BIM adoption, addressing the specific needs of different groups of firms. Also, QS firms need to consider the potential advantages of BIM for their core functions and explore ways to integrate BIM practices into their workflows to improve efficiency and effectiveness. In addition, QS firms that have adopted BIM also need to explore how BIM can be leveraged for pre-contract activities and post-contract management to maximize its benefits.

6. Conclusion

This study assessed the importance attached to the benefits of BIM usage by quantity surveying firms. The result shows that regardless of whether BIM has been adopted, QS firms are aware of BIM and attach a reasonable level of importance to the benefits of its usage. However, the study concluded that only a small fraction (12.79%) of the QS firms sampled had adopted BIM. This is quite subpar and appalling, considering that BIM can improve the cost and contract management of construction projects, which are critical functions of QS firms.

Table 3: Importance Attached to BIM Usage by QS Firms

Benefits of BIM Usage	Overall		Adopt BIM		Not Adopt BIM			
	Mean Score	Rank	Mean Score	Rank	Mean Score	Rank	T- statistics	*P* Value
Faster generation of quantity take-off	4.30	1	4.45	2	4.28	1	0.805	0.423
Ease of pre-estimation	4.29	2	4.45	2	4.27	2	0.923	0.359
Better design management through easy detection of design clashes	4.28	3	4.36	7	4.27	2	0.346	0.730
Efficient data extraction for early-stage (preliminary) estimation	4.24	4	4.36	7	4.23	4	0.531	0.597
Design visualization	4.21	5	4.18	17	4.21	5	-0.138	0.891
Easy update of cost plan as more detailed design develops	4.14	6	4.18	17	4.13	6	0.190	0.850
Makes Value management easier and faster	4.10	7	4.27	12	4.08	7	0.733	0.466
Accurate BOQ preparation	4.09	8	4.45	2	4.04	10	1.743	0.085
Cost checking for better and faster and good design choices	4.09	8	4.27	12	4.07	8	0.837	0.405
Reduces tendering process due to faster generation of quantity take-off	4.08	10	4.45	2	4.03	12	1.817	0.073
Automatic corrections when changes are made to the design	4.06	11	4.45	2	4.00	14	1.326	0.189
Better collaboration with other professionals in the industry	4.02	12	4.00	23	4.03	12	-0.079	0.937
Synchronization of the design and construction phases	4.02	12	3.91	27	4.04	10	-0.368	0.714
Efficiency in energy usage	4.01	14	3.73	31	4.05	9	-1.010	0.315
Improves planning and scheduling	4.00	15	4.00	23	4.00	14	-0.000	1.000
Cost reduction and cost controlling	3.99	16	4.27	12	3.95	16	1.010	0.315
Ability to obtain pre-estimation on maintenance cost.	3.98	17	4.18	17	3.95	16	0.813	0.419
Affirm all items are considered when taking off	3.92	18	4.73	1	3.80	24	3.644	0.000*
Improved communication among construction participants	3.92	18	4.00	23	3.91	18	0.796	0.259
Improved information sharing	3.91	20	4.27	12	3.85	19	1.385	0.169
Effortless outlining of materials and resources required for the project	3.89	21	4.18	17	3.85	19	1.061	0.291
Reduces discrepancies between drawings and bills of quantities	3.88	22	4.36	7	3.81	22	1.817	0.073
Data storage throughout the building's lifecycle as references for new projects	3.88	22	4.36	7	3.81	22	1.793	0.077
Improves site coordination	3.87	24	4.09	22	3.84	21	0.782	0.437
Sustainability of the facility	3.83	25	4.27	12	3.76	26	1.415	0.161
Reduction in construction wastage	3.82	26	4.30	11	3.76	28	1.636	0.106
Reduction in construction duration	3.81	27	4.00	23	3.78	25	0.655	0.514
Improves facility operation and management system	3.77	28	3.82	29	3.76	26	0.159	0.874
Promotes implementation of lean construction techniques	3.72	29	3.91	27	3.69	29	0.519	0.605
Reduction in variation orders	3.68	30	4.18	17	3.61	30	1.576	0.119
Reduction in extension of time due to variation orders and disputes	3.61	31	3.82	29	3.59	31	0.931	0.355
Improved commissioning and handover of project information	3.45	32	3.72	32	3.41	32	0.908	0.367
Streamlining workloads	3.23	33	3.64	33	3.17	33	1.139	0.258

"*" = significant at p-value ≤ 0.05

Therefore, among other professional firms, QS firms are expected to be more proactive in BIM usage. The study further highlighted that the benefits of BIM usage that are most important to QS firms yet to adopt BIM are those in the pre-contract stage, such as faster generation of quantity take-off and ease of pre-estimation. However, from the comparison, it can also be concluded that QS firms that have adopted BIM regarded the capacity of BIM to affirm that all items are considered when taking off to avoid omission as the most important benefit of BIM usage. Also, these QS firms attached greater importance to the benefits of BIM usage during the post-contract stage of the project delivery process than QS firms that have not adopted BIM. Therefore, generally, QS firms that have adopted BIM attach greater importance to the benefits of BIM usage than QS firms that are yet to adopt BIM.

Therefore, QS firms that have adopted BIM should explore its usage in other areas, such as value engineering and risk management, which they have not considered very important. Given that the number of QS firms that have adopted BIM is low, this study recommends that professional organizations and regulatory bodies should provide greater sensitization to QS firms on the need to transition into BIM adoption. Also, the government should provide policies and interventions that could enhance the BIM adoption level by QS firms. It is also recommended that principal partners of QS firms invest in their workforce to acquire the necessary skills and competence required for BIM adoption. While this study provides insights into the perception of BIM benefits by QS, it does not investigate the difference in the performance of QS firms that have adopted BIM and those that are yet to adopt BIM, which can be explored in future studies.

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Exploring the interplay between Quantity Surveyors' Conflict-handling Styles and Personality Traits

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Abstract

Construction projects are prone to conflict; thus, effective conflict management is more important than ever to avoid disputes and ensure project success. This study explores the link between conflict-handling styles and personality traits used by clients' quantity surveyors in South Africa. The study used an online web survey based on how clients' quantity surveyors dealt with conflict according to their personality traits. The population of this study included registered professional quantity surveyors and candidate quantity surveyors. The most common way of dealing with conflict and the most dominant personality trait among quantity surveying professionals were determined using descriptive statistics. A Spearman rank correlation analysis was subsequently conducted to establish whether there was a link between management of conflict and personality traits. The collaborating style was primarily used as a conflict management style by quantity surveyors, while the most common personality trait amongst client's quantity surveyors was Conscientiousness. Generally, most of the conflict-handling styles do not significantly interplay with personality traits. However, a collaborating conflict-handling style was found to have a negative correlation with the neuroticism personality trait. Also, the accommodating conflict handling style positively correlates with the agreeableness personality trait, and the avoiding conflict handling style correlates with the neuroticism personality trait. Quantity surveying firms will benefit from this information regarding their employees' conflict-handling styles and personalities by training professionals on managing conflict successfully by combining their personalities with the appropriate style. The focus on registered and candidate quantity surveyors was a limitation of the study, as other construction professionals could add value to the study. Further studies may include conflict-handling styles from a contractors' quantity surveyor's perspective.

Keywords: Conflict-handling styles, Construction Industry, Personality, Quantity Surveyors

1. Introduction

The Association of Arbitrators (Southern Africa) administered 571 dispute cases between 2017 and 2020. Construction projects are prone to conflict; thus, effective conflict management is more critical than ever to avoid disputes and ensure project success. Conflict is defined by Rauzana (2016: 44) as occurring when the values or goals that must be achieved differ, both individually and in relation to others. According to Sudhakar (2015: 215), the existence of conflict is determined by individual perception. To successfully resolve conflict, parties must be open-minded and flexible in their thinking to reach long-term mutual gain rather than short-term personal gain. These solutions imply that there will be a mutual benefit for all parties, reducing the possibility of conflict.

Rauzana (2016: 44) referred to the construction industry as a complex and competitive environment, bringing together members with various opinions, skills and knowledge of construction work. Conflict is inevitable since these differences exist in perception and goals among partners on a construction project (Akiner, 2014: 1039). Furthermore, the construction industry frequently poses a hostile environment due to the competitive delivery method commonly employed. Contractors, on the one hand, are often expedient in terms

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of recovering costs, while clients, on the other hand, are unwilling to compensate contractors for legitimate claims (Assaf *et al*., 2019: 598). When the various parties, with possibly conflicting goals, participate in a project, they are required to prioritise their interests and benefits since the industry is characterised by risk and uncertainty and highly competitive (Akiner, 2014: 1040). However, this approach provides the catalyst for continued conflict during a project.

The stakeholders' performance, namely the client, the design team and the contractors, is negatively affected by the conflicts and disputes on construction projects (Khahro & Ali, 2014: 116). Ultimately, conflict affects a project's outcome if not adequately managed. However, McKibben (2017: 102) contends that conflict has a positive outcome if it is managed effectively since it has the potential to stimulate and encourage change where the team has become stagnant in its functions, in addition to increasing productivity, improving decision-making and inspiring critical thinking to find solutions to previously unidentified problems.

Several variables determine the successful outcome of a construction project, one of which is how the building team approaches conflict regarding a project (Ntiyakunze, 2011: 67). According to Desivilya *et al.* (2020: 30), conflict management refers to behaviours the team members employ to deal with both their natural and perceived differences. Some of these differences arise from emotions and relationships, while others address more functional issues during conflict management; the negative impact of conflict in an organisation is minimised while its positive aspects are enhanced (Maiti & Choi, 2018: 2). fFive conflict-handling styles can be employed to manage conflict: collaborating, compromising, avoiding, competing and accommodating (Rahim, 2002: 216). According to the contingency view of conflict, these strategies determine how constructive conflict can be, which is determined by the conflict management strategies employed (Chen *et al*., 2012: 157).

Managing and resolving conflict effectively can be beneficial (McKibben, 2017: 101). This relies on transparent communication between parties, active listening, and mutual respect. In addition, both parties should clearly understand what they regard as the focus of the conflict. Increased conflict can be prevented by identifying the signs thereof, after which resolutions can be determined.

Personality traits are the most critical factor in managing disagreements (Ahmed *et al*., 2010: 268). The *"Big Five"* personality model consists of five traits: Conscientiousness, Extroversion, Openness, Agreeableness, and Neuroticism. Ayun *et al.* (2017: 673) define Conscientiousness as self-control and achievement orientation, openness as being intellectual and creative, extraversion as stimulation-seeking, Agreeableness as friendliness, and Neuroticism as a tendency towards nervousness and misery. Project team members often lack the knowledge and people skills to address conflict situations in their projects successfully. Excellent conflict-handling skills depend on managing personal emotions and will not usually result in negative emotions that cause dysfunctional project outcomes (Ann & Yang, 2012: 1021).

While limited information is available regarding quantity surveyors' conflict-handling styles, it is essential to identify the conflict-handling styles of quantity surveying professionals and examine the personality traits that affect their choices of conflict-handling styles. The quantity surveyor is responsible for managing payments and negotiations with contractors and, therefore, plays a vital role in handling conflict with contractors to ensure the project's success.

2. Literature Review.

The following section critically reviews the strategies for dealing with conflict and the various personality traits. The effect of personality on conflict-handling styles is also explored.

2.1 Conflict-Handling Styles

Managing conflict in construction companies is so critical that no firm would deny its crucial impact on their successful operation (Coleman & Kugler, 2014: 963). Successful conflict management minimises the negative impact of conflict in an organisation. At the same time, positive aspects are enhanced (Maiti & Choi, 2018: 2). People have various behavioural instincts and intuitions that affect how they manage conflict. These are known as conflict-handling styles. Models for dealing with conflict are determined through various techniques that individuals or leaders may adopt when interacting with peers or subordinates in organisations, in contrast to social or business relationships (Yang *et al*., 2015: 68).

Many models of handling interpersonal conflict range from two to five styles. Rahim's model of five conflict-handling styles has proven most useful in research since the model differentiates the styles of handling conflict into two components: assertiveness (self-concern) and cooperation (concern for others). Figure 1 shows various conflict management styles that can manage conflict, namely, collaborating, compromising, avoiding, competing and accommodating (Rahim, 2002: 216).

2.1.1 Collaborating style

The collaborating style, namely a high level of cooperation and assertiveness, is associated with problem-solving, such as diagnosing and intervening with the correct solutions (Rahim, 2002:218). This style is identified by a preparedness to exchange information, deal with differences constructively, and be determined to find a mutually acceptable outcome for both parties, according to Özkalp *et al*. (2009: 423). Because the relationship is important, as well as mutual satisfaction and the improvement of the project performance, the antagonism must be reduced and commitment obtained from both sides (Lu & Wang, 2017: 1485).

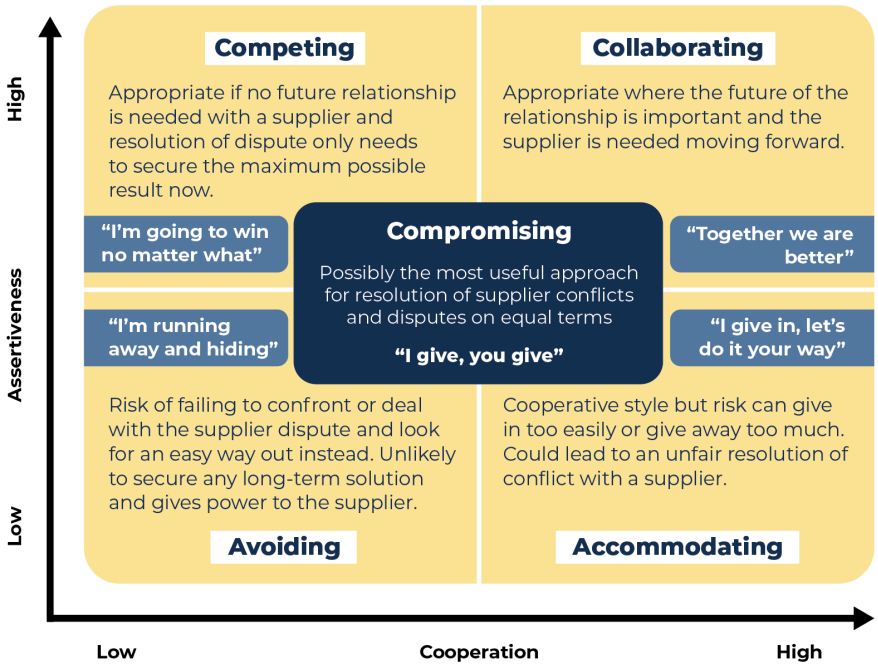

Figure 1: Conflict management styles
Source: Rahim (2002)

2.1.2 Accommodating style

According to Őzkalp *et al.* (2009: 424), the accommodating style is characterised by a high level of cooperation and a low level of assertiveness. The focus is on preserving relationships rather than satisfying individual needs. This style works well when one party is willing to sacrifice something in exchange for some benefit from the other party. This style would also be employed when one person occupies a position of weakness or values the relationship more than achieving the desired goal (Rahim, 2002: 220).

2.1.3 Competing style

The competing style is characterised by a low level of cooperation and a high level of assertiveness. It involves one party imposing their views on the other and gaining at the expense of the other's loss. It is known as a win-lose situation (Lu & Wang, 2017: 1485). The competing style is appropriate when an unfavourable decision is taken by one party, which may be detrimental to the other party involved or where the other party does not have the necessary experience in making technical decisions (Rahim, 2002: 220). This style is also valuable for implementing unpopular courses of action or when a quick decision is required. However, when conflict issues are complex with both parties equally influential, using this style by either party may lead to a standoff. A deadlock may be reached unless either party changes its strategy (Rahim, 2002: 220).

2.1.4 Avoiding style

The avoiding style, characterised by a low level of cooperation and assertiveness, has been associated with removing or avoiding certain situations of possible conflict. Rahim (2002: 220) stated that this style is useful in minor conflict matters or when a moratorium period is required before a complicated problem can be dealt with effectively. Furthermore, the style is appropriate when the potentially negative results of confrontation are more significant than the benefits of resolving the conflict. However, this style is inappropriate when a decision has to be made or when an immediate decision is required (Rahim & Bonoma, 1979: 1327).

2.1.5 Compromising style

The compromising style, regarded as an intermediate level of cooperation and assertiveness, is applicable where both parties are prepared to concede to reach a mutually acceptable decision (Rahim, 2002: 220). This style is useful when both parties have the same status and cannot reach a consensus (Özkalp *et al*., 2009: 424). This style is unsuitable when dealing with complicated problems as it fails to identify the real issues or formulate effective solutions (Rahim, 2002: 221).

2.2 Personality Traits

The response to conflict usually depends on a person's personality, training and experience (annbayo, 2013: 142). Personality traits are crucial in managing conflict (Ahmed *et al*., 2010: 268). The *"Big Five"* personality model, also known as the Five-Factor model, consists of five traits: openness, Conscientiousness, Extroversion, Agreeableness and Neuroticism, as illustrated in Figure 2.

2.2.1 Openness

The personality trait of openness is associated with being imaginative and non-conformist. It could lead to a direct, aggressive attitude towards conflict, which could benefit conflict resolution (McCrae & Costa, 1997: 512).

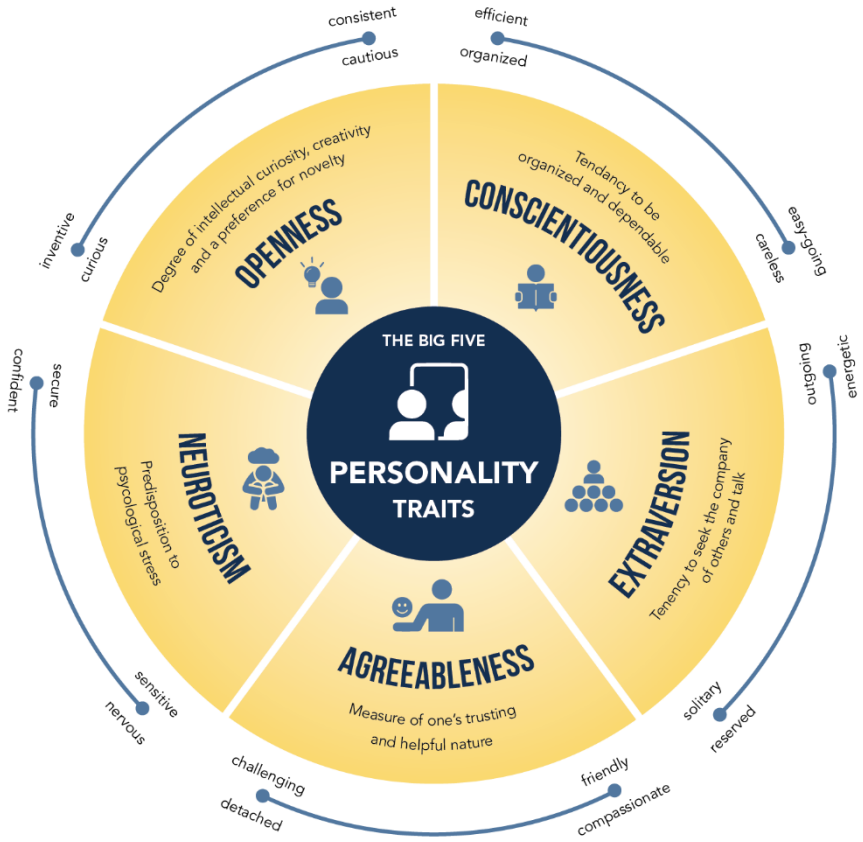

Figure 2: The Big Five personality model
Source: McCrae & Costa (1997)

This trait reveals how complex an individual's mental and experiential life can be. It relates to the varying degrees of people's range of interests, imagination, creativity and willingness to consider new ideas (Ome, 2013: 5514). Openness marks open-mindedness and reflectivity in individuals, resulting in higher divergent thinking to create innovative solutions.

2.2.2 Conscientiousness

The trait of Conscientiousness is classified as someone with impulse control, task orientation, and responsibility. Such a person can be expected to be disciplined, dutiful, and a high achiever (Ome, 2013: 5514). People who exhibit this trait are known for their sense of responsibility, dependability, diligence, and high organisation (Anwar *et al*., 2012: 3731). Conflict among colleagues due to this personality trait could result from differing lifestyles, habits and work ethics.

2.2.3 Extroversion

According to Anwar *et al.* (2012: 3730), the extroverted trait is related to being sociable, assertive, energetic, talkative, enthusiastic, and ambitious. Such people desire to be wealthy and enjoy high levels of status, power and recognition. Extroversion relates to individuals who prefer working with people in groups, are decisive, and are more able to communicate their opinions in an influential way (McCrae & Costa, 1987: 512).

2.2.4 Agreeableness

The preferences can characterise Agreeableness for cooperation instead of competition (McCrae & Costa, 1987: 512). This trait describes those who are considered to be good-natured, understanding, forgiving, cooperative and trusting as opposed to being suspicious and antagonistic toward others (Ome, 2013: 5514).

2.2.5 Neuroticism

Neuroticism is characterised by emotional instability and negative affectivity (McCrae & Costa, 1987: 512). Neurotic persons repeatedly exhibit negative emotions, affecting their personal relationships and escalating conflicts with others (Anwar *et al*., 2012: 3731).

2.3 Personality Effects On Conflict-Handling Styles

A study conducted by Ejaz *et al*. (2012: 35), which investigated the connection between how conflict is managed and personality characteristics, revealed that the collaborating and accommodating approaches to conflict handling were positively correlated with being open, agreeable and conscientious. On the other hand, the

compromising and competing conflict styles had a positive link to being open and extroverted.

Anwar *et al*. (2012: 3730) examined the connection between personality and interpersonal conflict and tested an individual's concept of temporary personality transformation. Their study showed that being an extrovert is linked to and a prediction of interpersonal conflict. Extroverts' assertiveness and forcefulness lead to their always wanting to be dominant; therefore, their handling of conflict situations tends to be effective but autocratic, thereby increasing interpersonal conflict. The relationship between extraversion and interpersonal conflict is mediated by Conscientiousness, while Neuroticism moderates the relationship between Conscientiousness and interpersonal conflict.

Ayub *et al*. (2017: 674) examined the role played by personality characteristics in determining conflict, deliberating the moderating relationship between personality and performance through the ways of managing conflict. Extroverts use collaborating, accommodating, compromising, and avoiding conflict-handling styles. These findings contradict the results of the study by Anwar *et al*. (2012: 3730), who suggest that extroverts use competing styles. Performance is directly and positively impacted by conscientious, open and emotionally stable people. However, interactions between conflict and conflict management styles determine the correlation between personality traits and performance (Ayub *et al*., 2017: 674).

3. Methodology

This section will discuss the methods used for identifying, selecting, processing, and analysing information regarding the relationship between personality characteristics and conflict-handling styles amongst quantity surveyors.

3.1 Paradigm

The researcher was independent of that being researched; the study was highly structured and used a scientific method to determine the relationship between observable and measurable facts objectively. Therefore, the epistemological basis of this research is grounded on empirical knowledge, while the ontological basis is objectivism. The positivism paradigm is determined by using deductive logic, formulating hypotheses and their testing, and suggesting operational definitions to explain questions and make projections based on measurable outcomes—the research aimed to develop generalised findings from experimentation and structured observations of reality. Therefore, the philosophical stance of the study was grounded in positivism.

3.2 Research design

This study used the deductive approach, an online survey, a mono-method research choice, and a cross-sectional time horizon to investigate how the client's quantity surveyors manage conflict, identify their personality traits and examine the effect of their personality on their choice of conflict handling style. A pilot questionnaire was designed and distributed to twelve registered professional quantity surveyors to ensure its viability. The pilot questionnaire received no suggestions for amendments.

The online questionnaire was divided into four sections. The first section relates to the participants' demographic information; the second and third sections comprised Likert-scale-response questions pertaining to the research literature to establish the causes of conflict and Rahim's five conflict-handling styles. The fourth section investigated the participants' personality traits using scaled-response questions.

The online questionnaire was designed using QuestionPro to have a simplistic layout and appearance. The main benefits of using QuestionPro are the professionally pre-constructed survey templates and sharing of the survey with the target population, which can be done in various ways, either online or offline, as well as top-grade security, ensuring compliance and anonymity.

3.3 Data collection methods

Probability sampling is primarily used in quantitatively oriented studies. It involves random sampling, which means each unit in a clearly defined and accessible population stands an equal chance of inclusion in the sample. Stratified sampling, on the other hand, refers to the researcher's division of the population into subgroups. Each unit belongs to a single stratum, for example, low, medium or high levels of conflict, and then units from those subgroups are selected (Teddlie & Yu, 2007: 79).

The target population of 1175 were registered professional quantity surveyors and candidate quantity surveyors, all members of the Association of South African Quantity Surveyors (ASAQS) and employed by a professional quantity surveying firm. From the 68 questionnaires received, only 66 duly completed questionnaires were used, representing a response rate of 5.6%.

The ASAQS was requested to upload a link to the online questionnaire to their website. After the initial upload of the survey on their website, the survey was included in the weekly ASAQS newsletter, *The Weekend Property and Construction News*, for the following five weeks. The data was retrieved and converted into a spreadsheet for analysis and interpretation.

3.4 Data analysis

The data from the online survey was converted into a Microsoft Excel spreadsheet. The categories included respondents' demographic data, causes of conflict, conflict management strategies, personality characteristics, and the effects of personality on conflict management strategies. The collected data were analysed using descriptive statistical methods, such as the mean, mode, standard deviation and skewness. The mean values for the conflict management strategies and personality characteristics identified the most predominantly used management style for dealing with conflict and the most prevailing personality trait amongst quantity surveying professionals.

According to Phiri and Smallwood (2010), the mean score (MS) was calculated for all data and the value was compared to suit the relative range. The range relative to the MS is defined as follows:

- > 4.20 ≤ 5.00 (Strongly agree)
- > 3.40 ≤ 4.20 (Agree)
- > 2.60 ≤ 3.40 (Neutral)
- > 1.80 ≤ 2.60 (Disagree)
- > 1.00 ≤ 1.80 (Strongly disagree)

Razali and Wah (2011) recommend the Shapiro-Wilk test to test normality for samples greater than 50. In addition, non-parametric tests are utilised where the p-value is below 0.05. The results of the normality tests are shown in Table 1, and all the variables show a p-value < 0.05, confirming the use of a non-parametric test to measure the relationship between the variables.

Table 1: Normality results

Variable	Shapiro-Wilk Test Statistic	Sig.
Collaborating	0,663	<0.001
Accommodating	0,834	<0.001
Avoiding	0,851	<0.001
Competing	0,878	<0.001
Compromising	0,803	<0.001
Extroversion	0,507	<0.001
Agreeable	0,255	<0.001
Conscientiousness	0,526	<0.001
Neuroticism	0,755	<0.001
Openness	0,469	<0.001

Al-Hameed (2022) relays that Spearman's rank correlation test is important for determining the relationship between variables: conflict handling styles and personality traits. Furthermore, the r-coefficient was used to indicate the degree or strength of the types of relationships between conflict management strategy styles and personality traits, where $0 < r < 1$ indicates a positive association and where $-1 < r < 0$ indicates a negative association. Also, correlations were considered statistically significant if the p-value < 0.05. According to Moore *et al.* (2013), the r- coefficient was interpreted using the following criteria for this study:

r < +/- 0.3 = Very weak relationship
+/- 0.3 < r < +/- 0.5 = Weak relationship
+/- 0.5 < r < +/- 0.7 = Moderate relationship
r > +/- 0.7 = Strong relationship

3.5 Reliability and validity of quantitative data

The extent to which the data collection techniques or analysis procedures will yield consistent findings is known as reliability (Saunders *et al*., 2009: 156). The research is considered reliable if an earlier research design can be replicated and the same results are achieved (Saunders *et al*., 2016: 202).

A widely used measure of reliability in the social and organisational sciences is Cronbach's alpha (Bonett & Wright, 2014: 1). It describes the degree to which the items that comprise a scale measure the same primary attribute and indicates the average correlation of all the items that make up the scale.

The alpha coefficient can range between 0 and 1, where 1 = perfect internal reliability and 0 = no internal reliability. However, it is generally accepted that an alpha value between 0.70 and 0.95 indicates high data reliability. The Cronbach alpha test was used to determine the reliability of the data obtained from this study. The Cronbach alpha values for the conflict-handling styles and personality traits are illustrated below in Tables 2 and 3, respectively.

Table 2: Cronbach alpha values for conflict-handling styles

Conflict-Handling Style	Cronbach Alpha Value
Collaborating style	0.73
Accommodating style	0.83
Competing style	0.79
Avoiding style	0.80
Compromising style	0.76

Table 3: Cronbach alpha values for personality traits

Personality Trait	Cronbach Alpha Value
Conscientiousness	0.82
Openness	0.70
Neuroticism	0.84
Agreeableness	0.79
Extroversion	0.84

The use of the Cronbach alpha test adds to the study's methodological rigour and demonstrates that the scales used are consistent and reliable. A further notable strength of the methodology is a well- structured questionnaire that covers demographic information, conflict causes and handling styles, and personality traits, providing a comprehensive view of the research project. Using Likert-scale questions further adds to the precision of the data collection.

4. Results

4.1 Demographics

The majority of respondents were male (85%; n=66), older than 60 years of age (35%; n=66), with a Quantity Surveying Honours degree (62%; n=66), and between 21 and 25 years of work experience as a quantity surveyor (45%; n=66).

4.2 Conflict-handling style

The questionnaire included questions from Rahim's attitudinal survey. Using a five-point Likert scale, the survey respondents had to indicate whether they agreed or disagreed with each statement and to what extent. Table 4 shows the expanded analysis of conflict-handling styles to the degree to which the client's quantity surveyors employ a particular conflict-handling style when resolving conflicts with the contractors' quantity surveyors. Figure 3 indicates the predominantly conflict-handling style used by the client's quantity surveyors. The results were evaluated according to their mean scores.

Table 4: Expanded analysis of conflict-handling styles

Conflict handling styles	Statement	Mean	Interpretation
Collaborating	"I exchange accurate information with X to solve a problem together."	4.45	Strongly Agree
Collaborating	"I try to bring all our concerns to light so that the issue can be resolved in the best possible way."	4.29	Strongly Agree
Collaborating	"I try to work with X for a proper understanding of a problem."	4.14	Agree
Collaborating	"I try to investigate an issue with X to find the best solution acceptable to us."	4.14	Agree
Collaborating	"I collaborate with X to come up with decisions acceptable to us."	4.08	Agree
Collaborating	"I try to work with X to find solutions to problems that satisfy our expectations."	4.05	Agree
Collaborating	"I try to integrate my ideas with X to come up with a decision jointly."	3.97	Agree
Compromising	"I negotiate with X so that a compromise can be reached."	3.91	Agree
Competing	"I am generally firm in pursuing my side of the issue."	3.88	Agree
Compromising	"I try to find a middle ground to resolve a problem."	3.83	Agree
Compromising	"I usually propose a middle ground for breaking deadlocks."	3.59	Agree
Compromising	"I use 'give and take' so that a compromise can be made."	3.41	Agree
Competing	"I use my expertise to make a decision in my favour."	3.15	Neutral
Avoiding	"I try to keep my conflict with X to myself."	3.05	Neutral
Competing	"I sometimes use my power to win a competitive situation."	2.89	Neutral
Accommodating	"I usually allow concessions to X."	2.86	Neutral
Competing	"I use my influence to get my ideas accepted."	2.83	Neutral
Accommodating	"I generally try to satisfy the needs of X."	2.80	Neutral
Avoiding	"I try to avoid unpleasant exchanges with X."	2.76	Neutral
Avoiding	"I try to avoid disagreements with X."	2.71	Neutral
Accommodating	"I try to satisfy the expectations of X."	2.67	Neutral
Avoiding	"I try to keep my disagreement with X to myself in order to avoid hard feelings."	2.65	Neutral
Avoiding	"I usually avoid open discussion of my differences with X."	2.59	Disagree
Accommodating	"I often go along with the suggestions with X."	2.52	Disagree
Accommodating	"I usually accommodate the wishes of X."	2.35	Disagree
Competing	"I use my authority to make a decision in my favour."	2.33	Disagree
Avoiding	"I avoid an encounter with X."	2.21	Disagree
Accommodating	"I give in to the wishes of X."	1.80	Disagree

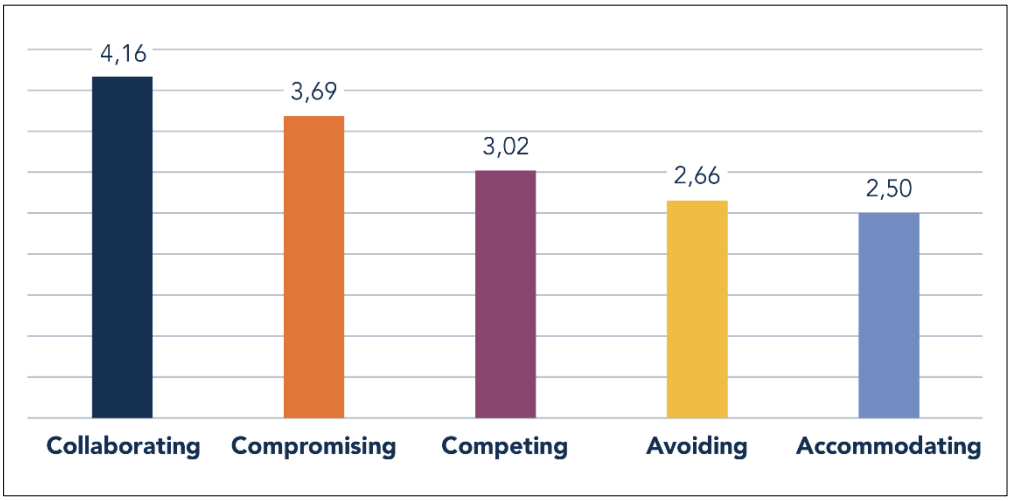

Figure 3: Predominant conflict-handling style used by the clients' Quantity Surveyor

The results revealed that the three famous conflict-handling styles of client quantity surveyors are the collaborating, compromising, and competing styles, with respective average mean values of 4.16, 3.69, and 3.02. Therefore, this study found that the client's quantity surveyors prefer collaborating to manage conflict with contractors' quantity surveyors. The collaborating style had a mean score of 4.16, which is high considering the compromising style's next highest score of 3.69.

This is an acceptable result, as the collaborating conflict-handling style is intended to minimise the pressure for both parties, thereby strengthening their mutual commitment, enriching the quality of their relationship and ensuring satisfactory project performance (Lu & Wang, 2017: 1485). This style is also the most beneficial for the construction industry as it demonstrates a mutual commitment to openly exchanging information and addressing differences constructively. This makes this style of handling conflicts suitable for more difficult situations (Özkalp *et al*., 2009: 423).

4.3 Personality traits

Questions from the Big Five personality test were included in the questionnaire. Using a five-point Likert scale, the survey respondents had to indicate the extent to which they agreed or disagreed with each of the statements. Table 5 shows the expanded analysis of the personality traits of the client's quantity surveyors, and Figure 4 indicates the most prevailing personality traits amongst quantity surveying professionals. The results were evaluated according to their mean scores.

The results showed that quantity surveyors' top three personality traits are Conscientiousness, openness and Extroversion, with respective mean values of 3.19, 3.15, and 3.11. This result indicates that quantity surveyors' most dominant personality trait is Conscientiousness, with an average mean score of 3.19. Quantity surveyors need to possess this trait as Conscientiousness characterises someone with impulse control, task orientation, and responsibility. Such a quantity surveyor could also be expected to be self-disciplined, dutiful, and accomplishment-oriented (Ome, 2013: 5514).

Openness followed closely after Conscientiousness, with an average mean score of 3.15. The personality trait of openness is associated with being imaginative and non-conformist and having a direct, provocative attitude towards conflict, which could be useful in resolving conflict (McCrae & Costa, 1997: 512). This trait relates to the varying degrees of people's range of interests, imagination, creativity and willingness to consider new ideas (Ome, 2013: 5514). Openness is beneficial for quantity surveyors, and it will assist them in proactively and creatively managing conflict while keeping an open mind to consider new ideas.

4.4 Relationships between conflict-handling styles and personality traits

Table 6 shows the relationships between the conflict-handling styles and personality traits. While all other relationships were not significant, it is clear from the results that there is a significant relationship, where $p < 0.05$, between collaborating and Neuroticism ($p= 0.019$), between accommodating and agreeable ($p =0.010$), and avoiding and Neuroticism ($p= 0.044$). The results further indicate that where a collaboration handling style is prominent, low Neuroticism is experienced as a personal trait. It further shows that in the case of an accommodating handling style, Agreeableness would be experienced as a strong personal trait, and with a prominent avoiding handling style, Neuroticism would be encountered as a strong personal trait.

The collaboration conflict-handling style that supports improved project performance (Lu & Wang, 2017) reasonably does not relate to professionals who are emotionally unstable and promote negative relationships (Anwar *et al.,* 2012). This combination is disastrous for successful project delivery. Quantity surveyors must effectively manage their traits by seeking intervention where negative traits have been observed—the accommodating conflict-handling style augers well with Agreeableness. Highly cooperative professionals (Ozkal *et al.,* 2009) contribute to agreements amicably (Ome, 2013).

Table 5: Expanded analysis of personality traits

Personality traits	Statement	Mean	Interpretation
Conscientiousness	"I pay attention to details."	4.32	Strongly Agree
Conscientiousness	"I like order."	4.20	Strongly Agree
Conscientiousness	"I am always prepared."	4.05	Agree
Openness	"I am quick to understand things."	4.03	Agree
Extraversion	"I feel comfortable around people."	3.95	Agree
Conscientiousness	"I follow a schedule"	3.89	Agree
Conscientiousness	"I get tasks done right away."	3.80	Agree
Agreeableness	"I am interested in people."	3.80	Agree
Openness	"I spend time reflecting on things."	3.79	Agree
Agreeableness	"I sympathise with others' feelings."	3.79	Agree
Agreeableness	"I take time out for others."	3.76	Agree
Conscientiousness	"I am demanding in my work."	3.74	Agree
Agreeableness	"I make people feel at ease."	3.73	Agree
Neuroticism	"I worry about things."	3.73	Agree
Openness	"I have excellent ideas."	3.59	Agree
Agreeableness	"I feel others' emotions."	3.58	Agree
Openness	"I have a rich vocabulary."	3.56	Agree
Extraversion	"I start conversations easily."	3.56	Agree
Agreeableness	"I have a soft heart."	3.48	Agree
Openness	"I am full of ideas."	3.45	Agree
Extraversion	"I don't like to draw attention to myself."	3.45	Agree
Neuroticism	"I seldom feel blue."	3.36	Neutral
Neuroticism	"I am relaxed most of the time."	3.29	Neutral
Extraversion	"I am quiet around strangers."	3.26	Neutral
Openness	"I have a vivid imagination."	3.24	Neutral
Extraversion	"I talk to a lot of different people at events."	3.17	Neutral
Extraversion	"I don't talk a lot."	3.03	Neutral
Neuroticism	"I get irritated easily."	3.03	Neutral
Extraversion	"I don't mind being the centre of attention."	2.92	Neutral
Neuroticism	"I get stressed out easily."	2.86	Neutral
Openness	"I use difficult words."	2.85	Neutral
Extraversion	"I tend to keep in the background."	2.79	Neutral
Neuroticism	"I get upset easily."	2.79	Neutral
Neuroticism	"I am easily disturbed."	2.65	Neutral
Extraversion	"I am the life of the party."	2.53	Disagree
Openness	"I am not interested in abstract ideas."	2.44	Disagree
Openness	"I do not have a good imagination."	2.42	Disagree
Extraversion	"I have little to say."	2.42	Disagree
Neuroticism	"I often feel blue"	2.36	Disagree
Agreeableness	"I am not interested in other people's problems."	2.35	Neutral
Neuroticism	"I change my mood a lot."	2.35	Disagree
Conscientiousness	"I often forget to put things back in their proper place."	2.32	Disagree
Agreeableness	"I am not really interested in others."	2.26	Disagree
Conscientiousness	"I leave my belongings around."	2.23	Disagree
Agreeableness	"I feel little concern for others."	2.20	Disagree
Neuroticism	"I have frequent mood swings."	2.18	Disagree
Openness	"I have difficulty understanding abstract ideas."	2.17	Disagree
Agreeableness	"I insult people."	1.86	Disagree
Conscientiousness	"I make a mess of things."	1.71	Strongly Disagree
Conscientiousness	"I neglect my duties."	1.64	Strongly Disagree

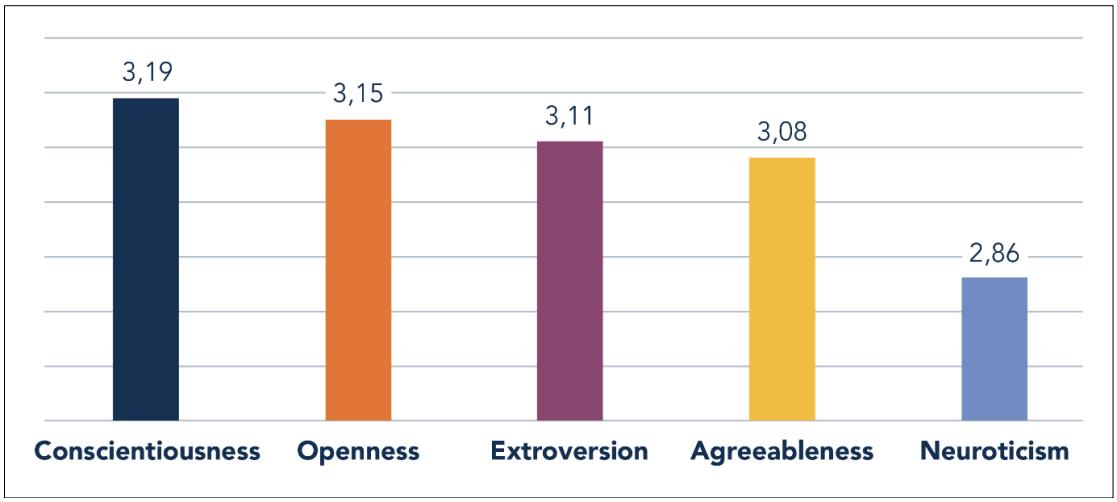

Figure 4: Personality traits

Table 6: Spearman's rank correlation results

Conflict-handing styles vs. Personality traits		Extroversion	Agreeableness	Conscientiousness	Neuroticism	Openness
Collaboration	Correlation Coefficient	-0,004	0,057	-0,026	-0,288*	-0,146
	Sig. (2-tailed)	0,977	0,651	0,834	0,019	0,243
Accommodating	Correlation Coefficient	-0,006	0,317*	0,124	-0,069	0,220
	Sig. (2-tailed)	0,962	0,010	0,320	0,580	0,076
Avoiding	Correlation Coefficient	0,139	0,141	0,137	0,248*	0,216
	Sig. (2-tailed)	0,267	0,259	0,274	0,044	0,081
Competing	Correlation Coefficient	-0,010	-0,007	0,019	0,197	-0,013
	Sig. (2-tailed)	0,935	0,955	0,878	0,112	0,916
Compromising	Correlation Coefficient	0,125	0,053	0,104	-0,088	-0,034
	Sig. (2-tailed)	0,315	0,673	0,405	0,482	0,787

It is imperative to reach a timely consensus on construction project conflicts, as delays may be detrimental to achieving set objectives. The avoiding conflict-handling style expectedly augers well professionals that have negative affectivity (McCrea & Costa, 1987). Avoiding conflict situations, unfortunately, leads to detrimental outcomes. Professionals who exude neuroticist personality traits must be identified, and interventions may be implemented to alleviate their negativity.

The results contradict the findings of an earlier study conducted by Ejaz *et al*. (2012), which shows that collaborating and accommodating conflict-handling strategies were correlated to openness, Agreeableness, and Conscientiousness. Also, the compromising and competing conflict management strategies were associated with being open and having extroverted personality traits. Cumulatively, the results show weak relationships and may need a larger sample size to confirm stronger relationships. However, the findings reveal some relationship concerns that need interventions at a broader scale within the construction industry.

5. Conclusions And Recommendations

The study's objectives were to determine the predominantly used conflict-handling style by quantity surveyors and their most dominant personality trait. Subsequently, the significant relationships between their personality characteristics and conflict management styles were analysed. The research determined that quantity surveyors predominantly employ a collaborating conflict-handling style when managing conflicts. In addition, quantity surveyors' most prominent personality trait was Conscientiousness. Furthermore, the findings indicated that a few personality traits weakly influence the client's quantity surveyors' conflict handling style. This outcome suggests that quantity surveying firms can capitalise on this information about their employees' conflict-handling styles and personalities by training professionals on utilising their personalities in conjunction with the right conflict-handling style to manage conflict successfully. Consequently, quantity surveyors with the right personality will be able to understand conflict better, recognise it more timeously,

and address differences more constructively to create a solution that will be acceptable to both parties.
Subsequently, the following recommendations are suggested:

- With most quantity surveyors implementing a collaborative conflict-handling style, it is advised that other professionals in the built environment also complement the collaborative style, resulting in mutually beneficial solutions and less conflict occurring in the future.
- Tertiary institutions should ensure the inclusion of conflict-handling approaches in the quantity surveying curriculum, preparing students concerning methods of managing conflict.
- Quantity surveying firms must implement effective human resources management to identify personality trait variances for timeous interventions.

6. Limitations And Further Research

Limited studies were conducted on conflict management styles used in the quantity surveying profession. A further limitation of the study is that the study only focused on professional quantity surveyors. Including other professionals in the built environment might yield more comprehensive results about the industry's conflict-handling styles and personality traits. Further research is thus recommended on conflict management styles used by contractors' quantity surveyors that can contribute to improving project outcomes and relationships with other professionals. Further research could also be conducted on how conflict resolution approaches can be integrated into existing built environment curricula.

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Technical and Organisational Change in UK Construction

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Abstract

This study examines the broad technological and organisational change trends in the UK construction sector. This uses the information from the input-output balances to track the key inputs to construction from the production and services sectors, along with self-input from construction.The inputs to the UK construction sector from 1997 through to 2020, based on the current supply and use tables, form the basis for the analysis. Changes in the inputs from the key commodity groups for materials and services are presented as a time series. Regression analysis is used to evaluate the relationship of the input coefficients against time to see if the slope is significantly different from zero. The changes in the material and service sector inputs are also discussed. The results demonstrate that most of the twelve material groups showed downward trends over the period studied, while most of the five service groups showed increases. This shows that materials provide a declining share of inputs to construction while most services sector inputs, along with self-input from construction, absorb higher shares. This is used to throw some light on changing trends in construction technology and organisational change in areas such as subcontracting, off-site prefabrication, and plant hire. The approach is limited because it can only identify changes between the various broad groups used in the supply and use tables. The analysis confirms certain of the well-documented technological changes in construction. These include the ongoing replacement of traditional brick-build structures with timber-framed technology. It does confirm the continued expansion of the use of subcontracting in construction. It also shows increased inputs from technology and information services and architectural and consultancy services. More surprisingly it does not indicate any rise in off-site prefabrication.

Keywords: Construction economics, input-output analysis, organisational change, technical change.

1. Introduction

The UK construction sector has long been known for conservatism and resistance to change. This was demonstrated in the nineteenth century when the UK lagged behind the USA in adopting steel-framed construction and was way behind Germany and France in adopting reinforced concrete technology (Bowley, 1966). These trends continued into the twentieth century, with the industry slow to pick on innovative materials (Lowe, 1996) unless forced to by governments. Mainly, innovations in building materials were the product of state policy, usually during after-wars or in situations of pressure on housing provision.

This included using new materials in council house building in the 1920s, prefabricated housing in the 1940s, and system building in the 1960s. It is possible to add the use of timber-framed technology in the 1980s. The latter was the exception to the rule in that it was introduced by private sector speculative builders rather than being promoted by central or local government. The fragmentation between design and construction has also been cited as a factor inhibiting innovation (Ive & Gruneberg, 2000).

The paper is intended to identify the extent of the spread of technical and organisational change in the UK construction sector over recent years. This focus is on broad technical changes (innovations in building materials and construction techniques) and organisational initiatives in areas such as provision of finance, design issues, real estate management, and use of plant hire. The objective is to track changes in key inputs to construction over time towards measuring the extent of technical and organisational change. This will focus on selected material and service sector inputs and construction self-inputs. This is compared with the total value added and the shares received by labour and capital.

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2. Literature review

Technological change stems from three distinct but complementary stages: invention, innovation, and diffusion. Freeman (1974) described invention as developing an idea, sketch or model for a device, product or process. Innovation can be seen as the commercial exploitation of that idea, sometimes coming several decades or longer after the invention. Diffusion will be the spread of that innovation to the broader economy.

Innovation can be seen as either process or product innovation (Coombs et al., 1987). The first involves the more efficient production of the existing products, while the latter will be concerned with developing completely new products or processes. Clark (1985) cites the sometimes very long delays along the process of invention and innovation through to diffusion. The spread or diffusion of such innovations throughout the economy will be key. They are likely to change or adapt as they spread through the economy (Rosenburg, 1976), and such developments may have a more significant impact than the initial innovation.

The issues with invention and innovation are that they are impossible or not easy to quantify. Invention can be measured by the number of patents applied for (Schmookler, 1966), but there will be no distinction between financially viable patents and those unlikely to ever be used commercially. Innovation can sometimes be a misleading indicator of technical change. Certain technical developments may initially appear to gain ground before being eclipsed by better-marketed or cheaper alternatives. It is not unknown for technically superior innovations to fail to survive against less advanced competitors. The case of the Betamax v VHS conflict in video recording systems (Wielage & Woodcock, 2003) gives this example. Only diffusion offers any realistic prospect of a quantifiable measure of technological change. See (Comin & Mestieri 2014) for a review of this area of measurement of technical innovation.

The development of input-output analysis (Leontief, 1936) provides an excellent approach to measuring the spread of innovations into the economy. The assumption behind Leontief's input-output approach was that the technical coefficients, representing inter-industry flows, would be relatively stable over time. Hence, input-output tables have been published infrequently, usually corresponding to a production census. When such coefficients change significantly, this will indicate technical changes in the economy (Gregori, 2009). Input-output analysis has the advantage that the data is readily available for most advanced economies worldwide.

3. Research method

The objective of the study is to identify and analyse technical and organisational change in the UK construction sector over a 24-year period from 1997 through 2020 using statistical analysis.

Simple linear regression analysis is used on the coefficients of the inputs of various production and service groupings and the primary inputs to construction against time. This used an ordinary least squares regression model with the input coefficients as the dependent variable and time as the independent variable. If the inputs from a given group to construction increase over time, this will show a positive slope coefficient in the regression model. Similarly, if the input coefficients decline over time, this will produce a negative slope coefficient. The slope coefficients are evaluated to see if they differ significantly from zero.

The paper examines the three main groups in the economy that supply construction. This involves production (mining and extraction, manufacturing, and utilities), construction (self-inputs), and services. In addition, value added (labour and capital) are considered. Twelve sub-groups of production and five sub-groups from services will also be analysed. Agriculture, forestry, and fishing are not included in the analysis as they supply few direct inputs to construction. Similarly, food and drinks and several service sector industries are omitted because they provide minimal or zero inputs to construction.

3.1 Intermediate input coefficients

The intermediate inputs from the selected product groups and sub-groups are divided by the total output to give coefficients. These coefficients represent the direct inputs needed to produce £1 of construction output. The analysis is focussed on the key sectors providing significant inputs to construction.

There are twelve commodity sub-groups from the production sector of the economy responsible for inputs to construction. The self-inputs to construction to itself constitute a second category. These, along with inputs from the five service sector sub-groups, are listed in Table 1. The selected sub-groups are those that supply the most inputs to construction. Between them, they account for over 97% of the total inputs to the industry.

3.2 Assumptions Underpinning input-output data

The implicit assumption of input-output analysis was always relative stability in the coefficients, at least in the short term. Hence, the UK IOT tables were produced at intervals of around five years, usually corresponding with the production census.

Where the coefficients change over time, this is assumed to be indicative of technical or organisational developments within the sector in question. Thus, the direction and magnitude of any changes to the coefficients can be used to estimate the impact of technical and organisational changes to inputs to construction from 1997 to 2020.

Table 1: Industrial sub-groups used in the analysis (1997-2020)

No	Industry Group	SIC Categories	Share of inputs
1.	Mining, quarrying and oil production	B05 − B09	1.5%
2.	Textiles and textile products	C13 − C15	0.2%
3.	Wood and paper products	C16 − C18	2.2%
4.	Paint and chemical products	C19 − C21	1.5%
5.	Rubber and plastic products	C22	2.0%
6.	Cement, lime, plaster, and concrete	C23.5	3.8%
7.	Glass, bricks, and ceramics	C23.1-4, C23.6-7	2.2%
8.	Metals and metal products	C24 − C25	3.6%
9.	Computers and electrical products	C26 − C27	2.3%
10.	Mechanical products	C28 − C29	1.1%
11.	Furniture and other manufacture	C30 − C31	0.4%
12.	Gas, electricity, and water	D35 − E39	0.7%
13.	Construction (self-input)	F41 − F43	30.2%
14.	Communications and IT services	J61 − K63	0.9%
15.	Finance and management services	K64 − K66	1.7%
16.	Real estate services	L68	0.4%
17.	Architectural and engineering consultancy	M71	1.4%
18.	Hiring and leasing services	N77	1.7%
1-18.	Selected industrial groups		57.8%
VA	Value added for selected industrial groups		39.4%
All	**Total for selected industrial groups**		**97.2%**

3.3 Sources of data

From the above, an obvious source of data is input-output tables (IOTs). They have been produced in detail for the UK since 1963. These IOTs are currently presented 105 x 105 in a commodity-by-commodity format (Gregori, 2009). The problem is that they have been published infrequently in the UK (usually every four to five years) and typically up to four years in arrears. There was a ten-year gap between the tables published for 1995 and the next from 2005. While the IOTs have been published annually since 2013, this does not help for a medium to long-term analysis.If changes in the standard industrial classification (SIC) are added, it makes comparison quite difficult. The last thirty years have seen the use of four different SICs (1992, 1997, 2003 and 2007). Thus, making a medium to long-term analysis using IOTs is not easy.

An alternative approach is to use supply and use tables (SUTs) produced annually in the UK over the past thirty years in an industry-by-commodity format. The first SUTs for 1989 were published in Economic Trends (Central Statistical Office, 1992). Similar tables with more detail were published in 1990 and 1991 and in Economic Trends (Central Statistical Office, 1993, 1994). SUTs were later produced from 1992 to 2004 as a continuous series (Office for National Statistics, 2006). A change in the SIC (Office for National Statistics, 2007) led to a new series. The 2020 SUTs were backdated to give consistent results from 1997 (Office for National Statistics, 2022) using the current 2007 SIC.

The SUTs have two distinct advantages over IOTs: they have been produced annually since 1989 and are published with only a two-year delay compared to around four years for IOTs. While the SUTs are not symmetrical, this should not be a significant problem for the requirements of this analysis. This gives three partially overlapping but internally consistent data series covering the 32 years from 1989 to 2020. The first ran from 1989 (or 1990 for some commodities) to 1992. The second series covers 1993 through to 2004. The third series includes fully compatible data from 1997 to 2020.

The fundamental changes to the SIC (Office for National Statistics, 2007) and the incompatibility of the earlier data with the new series from 1997 to 2020 make it impossible to get a consistent data set throughout the whole period. Thus, a meaningful analysis across the 1992-2004 and the 1997-2020 SUTs is impossible, let alone including the SUTs from 1989 or 1990-91. Hence, the analysis is restricted to the period from the current SUTs and only covers data from 1997, with a single series across the whole period.

4. Analysis

4.1 Research framework

The analysis will involve comparing the three groups: production (sub-groups 1-12), construction (sub-group 13), and services (sub-groups 14-18), as well as examining all of the eighteen industrial sub-groups named. The first test is to look at the direction of any movements in the coefficients and then to examine the significance of any changes found. In addition, the changes in wages and profits within value added will be analysed. Each of the above four groups and the various sub-groups were considered separately in the analysis. The test intended to find the coefficient of determination (R^2) for each group and sub-group, along with the direction of the slope. The change of each sub-group within their group, weighted by share, is presented along with the magnitude and direction of change. These results and the statistical significance (95% confidence) were used as the basis for the above analysis. The results are illustrated in Table 1 and in Figures 1 to 4.

Table 2: Regression analysis of the groups and subgroups

No	Commodities	Trend	R^2	Change	Significant
1.	Mining and quarrying	Negative	84%	−13%	Yes
2.	Textile products	Negative	17%	− 0%	Yes
3.	Wood and paper products	Negative	7%	−2%	No
4.	Paint and chemical products	Negative	13%	− 2%	No
5.	Rubber and plastic products	Negative	94%	−18%	Yes
6.	Cement, lime, and plaster	Negative	48%	−18%	Yes
7.	Glass, clay, and bricks	Negative	96%	− 21%	Yes
8.	Metal products	Positive	2%	1%	No
9.	Computer and electricals	Negative	31%	− 7%	Yes
10.	Mechanical products	Positive	55%	6%	Yes
11.	Furniture and other manufacture	Positive	27%	1%	Yes
12.	Gas, electricity, and water	Negative	36%	− 3%	Yes
1-12.	**Production**	Negative	76%	− 76%	Yes
13.	**Construction**	Positive	89%	89%	Yes
14.	Telecoms and information	Positive	55%	17%	Yes
15.	Banking and financial services	Positive	33%	19%	Yes
16.	Real estate services	Positive	21%	3%	Yes
17.	Architecture and consultancy	Positive	82%	40%	Yes
18.	Rental and leasing services	Negative	7%	− 4%	No
14-18.	**Services**	Positive	75%	75%	Yes
19.	Wages	Negative	80%	− 51%	Yes
20.	Profit	Positive	8%	5%	No
19-20.	**Value added**	Negative	45%	− 45%	Yes

4.2 Production

The production group, overall, has an obvious negative slope with an R^2 value of 76%. That suggests that over three-quarters of the change in contributions from the production group to construction can be explained by time and the technical changes introduced over the period. Of the twelve production sub-groups, nine have a negative slope. The clearest is the production of glass, clay, bricks, and stone, with an R^2 value of 96%. This was closely followed by rubber and plastic products at 94% and mining and quarrying at 84%. The latter sub-group involves the production of aggregates and stone. The results for computers and electrical installations (R^2 = 31%) and utilities (gas, electricity, and water supply), with R^2 at 36%.

The sub-groups with clear positive slopes are mechanical products (R^2 = 55%), furniture and other manufacturing (R^2 = 27%), and textile products (R^2 = 17%). Wood and paper products (R^2 = 7%), paint and chemical products (R^2 = 13%), and metal products (R^2 = 2%) straddle the divide between negative and positive slopes. All three have non-significant results with 95% confidence.

4.3 Construction

The self-input from construction consists of two components. The first involves repair and maintenance work on buildings owned by firms classified as construction. That would be restricted to the head, regional, and local offices and yards for contractors. This is comparatively small as most construction activities are carried out on-site.

The vast majority of this area comes from the subcontracting. This inevitably involves a degree of double counting as the work by subcontractors is included and output by main contractors, which will incorporate the subcontractors' inputs. Indeed, by convention, the early input-output tables had zeros along the leading diagonal and disregarded self-inputs. Later, the self-input was displayed in brackets but not in the row and column totals. Subsequently, the industrial self-inputs were fully incorporated into the tables despite the double-counting involved. Including industrial self-input has a far more significant impact on construction than on any other commodity.

The self-input from construction has been rising throughout the period studied. This has an R^2 value of 89% over the period studied and is undoubtedly statistically significant. The results for construction self-input are illustrated in Figure 7 by comparison with the inputs to construction from the production and services groups. This demonstrates the steady increase in subcontracting over the period studied. There was a fall after 2010, possibly reflecting the delayed impact of the world recession and a further small drop after 2015. Both

of these dips were soon reversed amid the steady increases.

4.4 Services

Overall, the contributions from the service group have risen over the period in question, with a statistically significant R^2 of 75%. That demonstrates an apparent increase in the importance of services to construction output. All but one of the sub-groups displayed rises in their contributions to construction. The most evident result is for architectural and professional services with a strong relationship, giving an R2 value of 82%.

Telecommunications and information services also have a positive relationship for inputs to construction (R2 of 55%). Banking and financial services (R2 of 33%) were remarkably erratic prior to 2010. Real estate services (R2 of 21%) also display a positive coefficient. The rental and leasing services sub-group covering plant hire is the exception and has a very shallow negative slope (R2 of 7%) but is statistically insignificant at 95% confidence. The service groups are shown in Figures 5 and 6. This illustrates that all sub-groups examined show significant positive results over time, besides rental and leasing services, which gives negative but inconclusive results.

4.5 Value Added

The value added for construction has a negative slope with an R^2 of 45% over the period studied. However, the share of the profits element continued to rise marginally (R^2 of 8%), while the proportion of wages fell sharply as a percentage of value added (R^2 of 80%).

Thus, the slight rise in profits over this period is not statistically significant at 95% confidence. However, the reduction in the share of value-added absorbed by wages is certainly significant at 95% confidence, as is the significant fall in value added. This is illustrated in Figure 7.

4.6 Summary of Results

The precise pattern of the results is that construction, in common with many other industries, the UK is becoming less dependent on inputs from the production industries. Mechanical products and furniture & other manufacturing are the only sectors to show statistically significant increases. The services sector inputs to construction also follow the rest of the economy and show increases in inputs apart from hiring and leasing of plant that gives inconclusive results for the period studied after substantial increases prior to 1997.

The most significant result is the rise in construction self-input from under a quarter to a third of total inputs to construction between 1997 and 2020. Given the double-counting implicit in the figure, this increase could distort shares of other material and services inputs to construction.

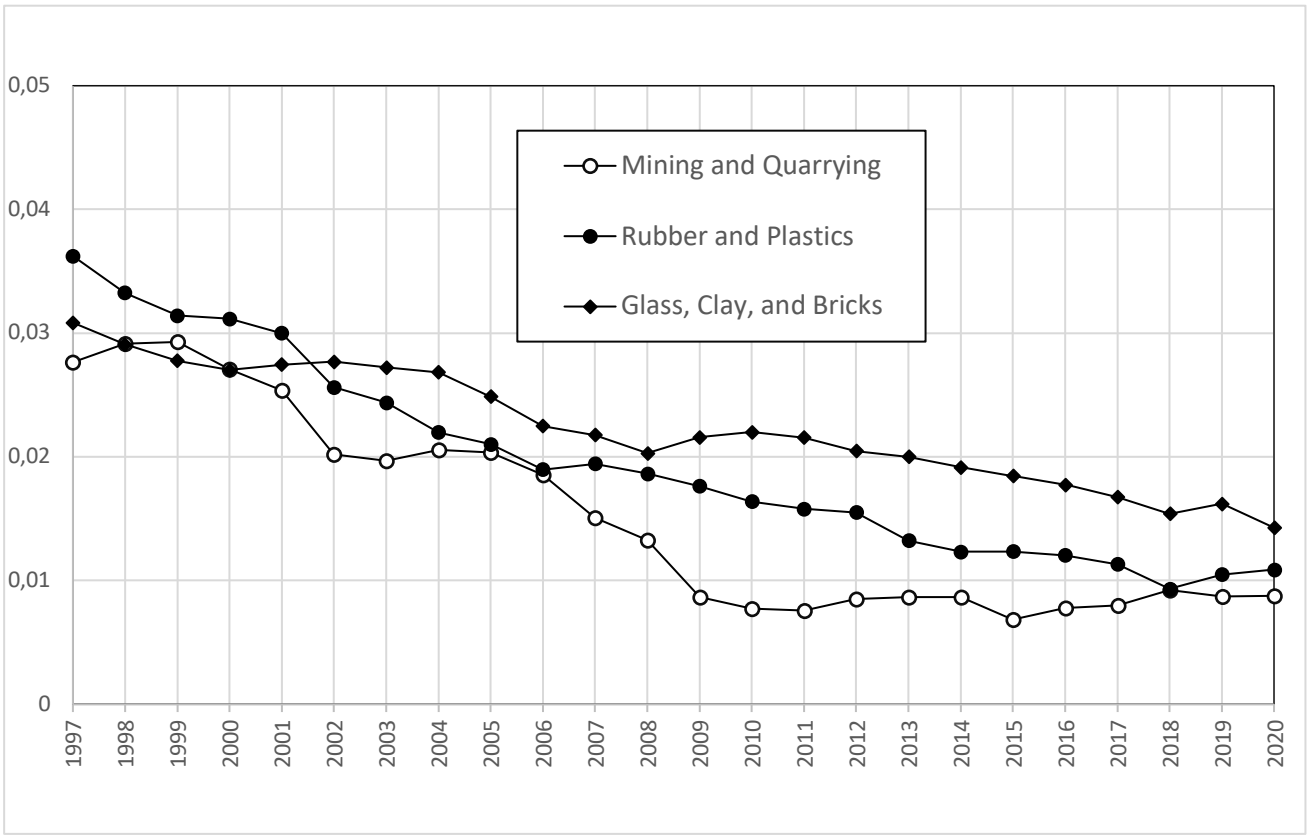

Figure 1: Inputs to Construction from Mining & Quarrying, Rubber & Plastics and Glass and Clay Products

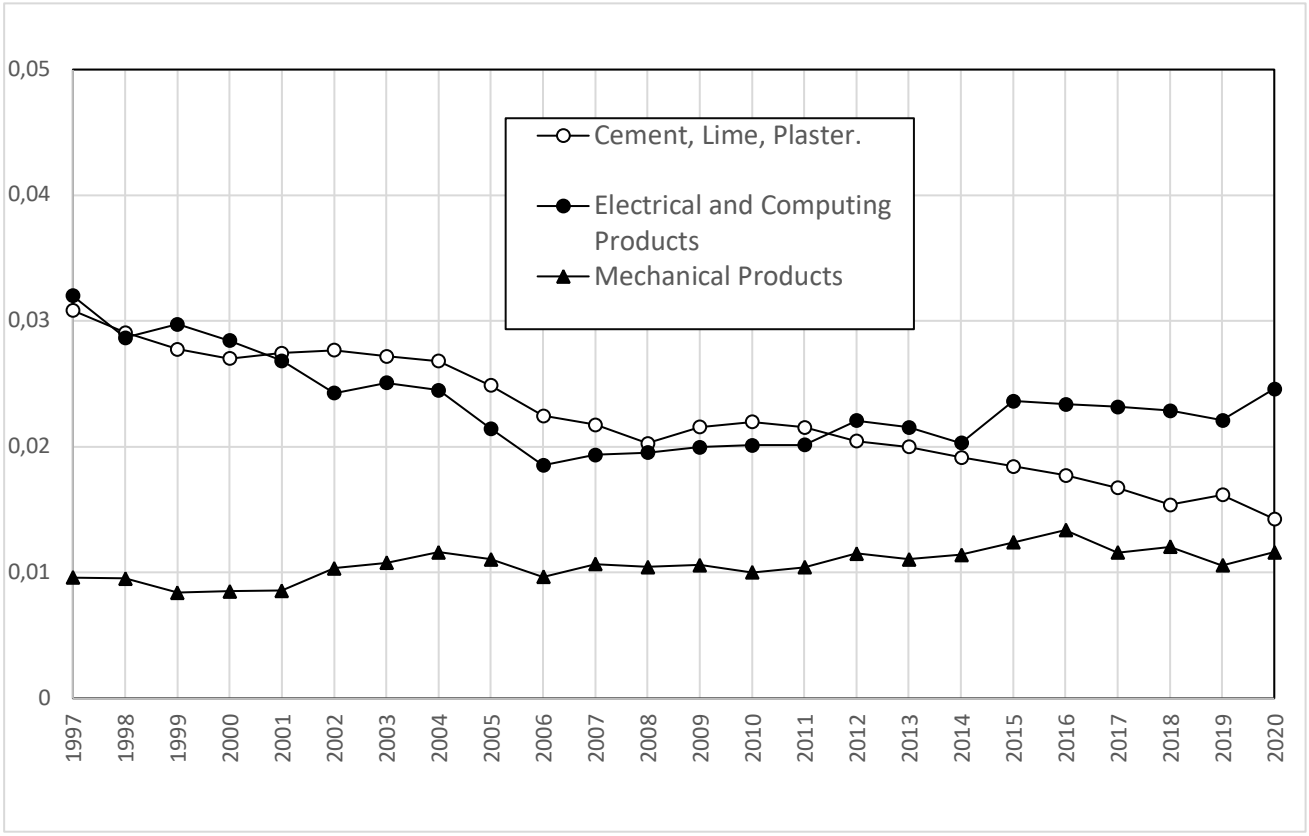

Figure 2: Inputs to Construction from Cement, Lime & Plaster, plus Electrical and Mechanical Products

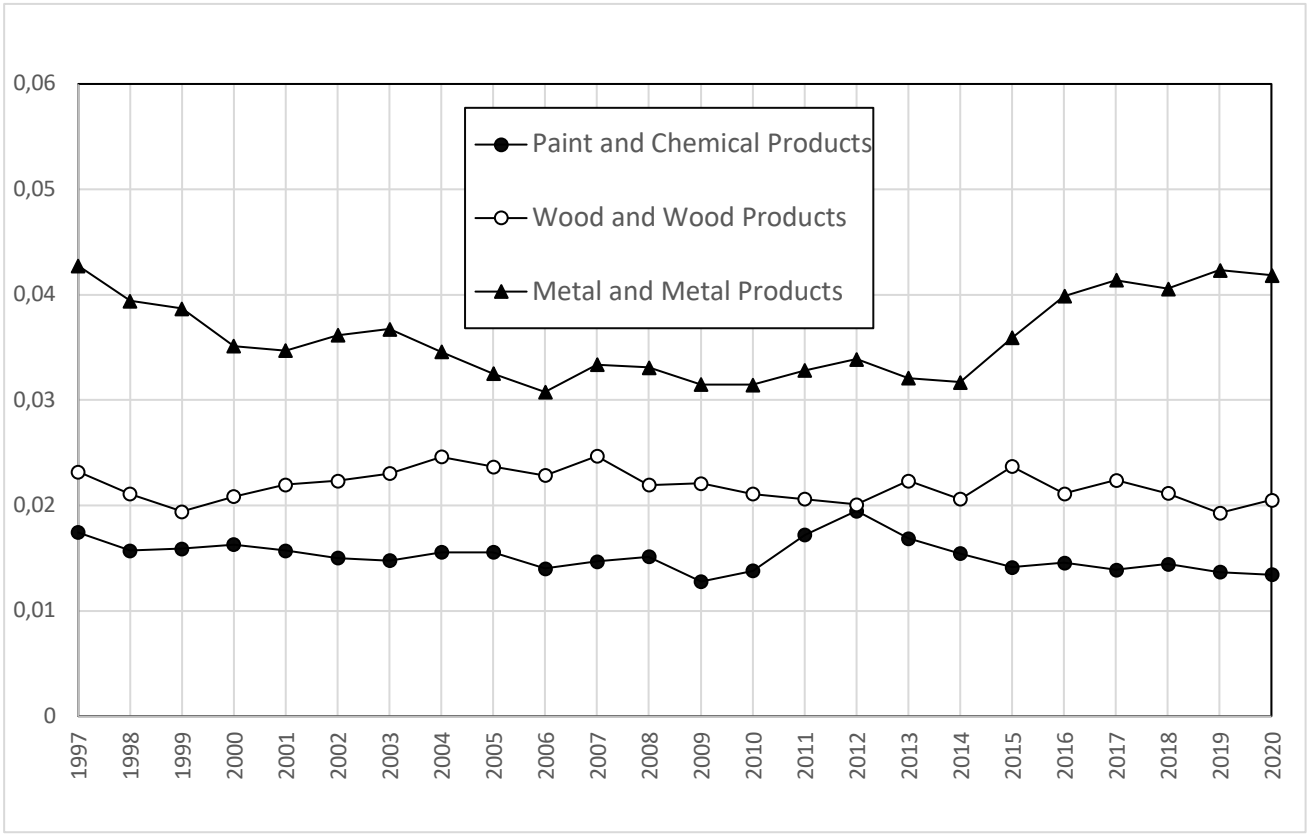

Figure 3: Inputs to Construction from Paint & Chemicals, Wood Products, and Metal Products

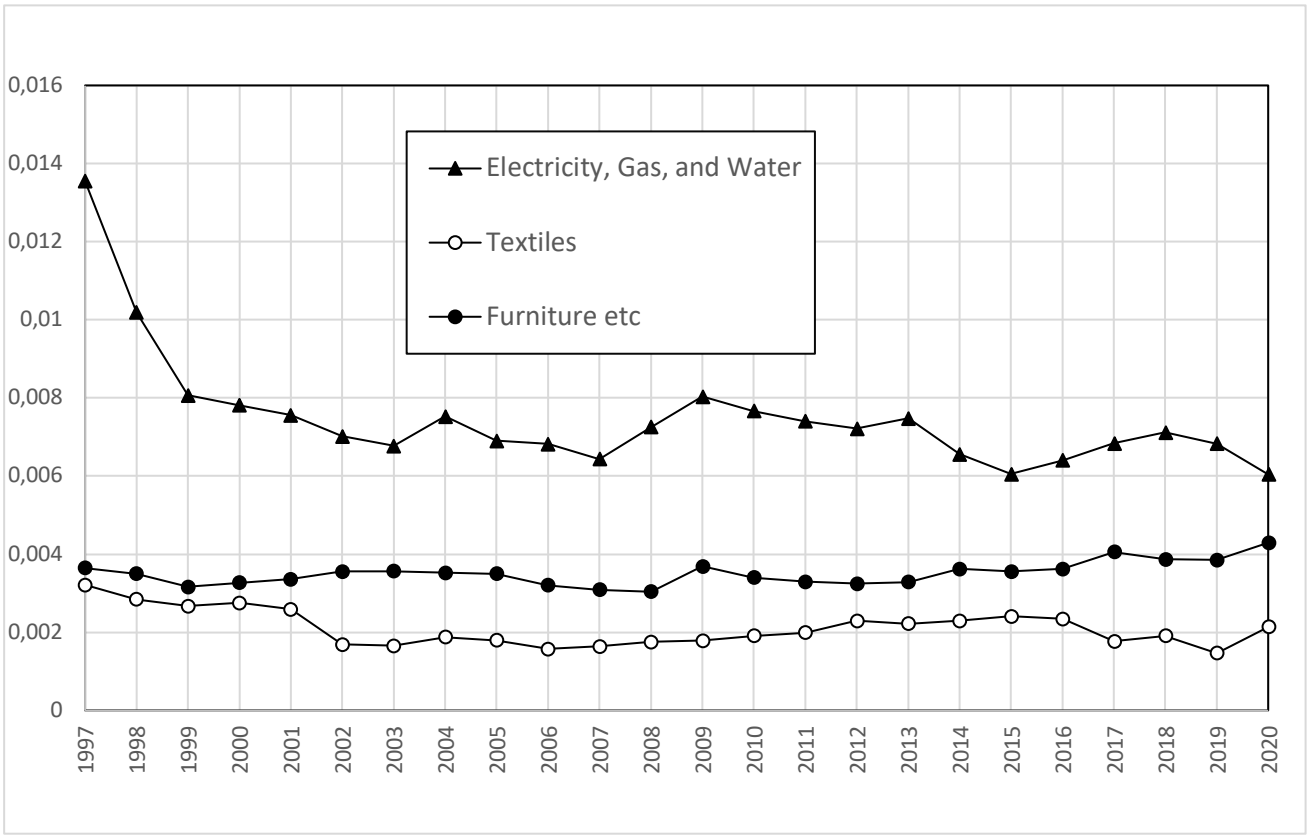

Figure 4: Inputs to Construction from Electricity, Gas, Water, Textiles and Furniture

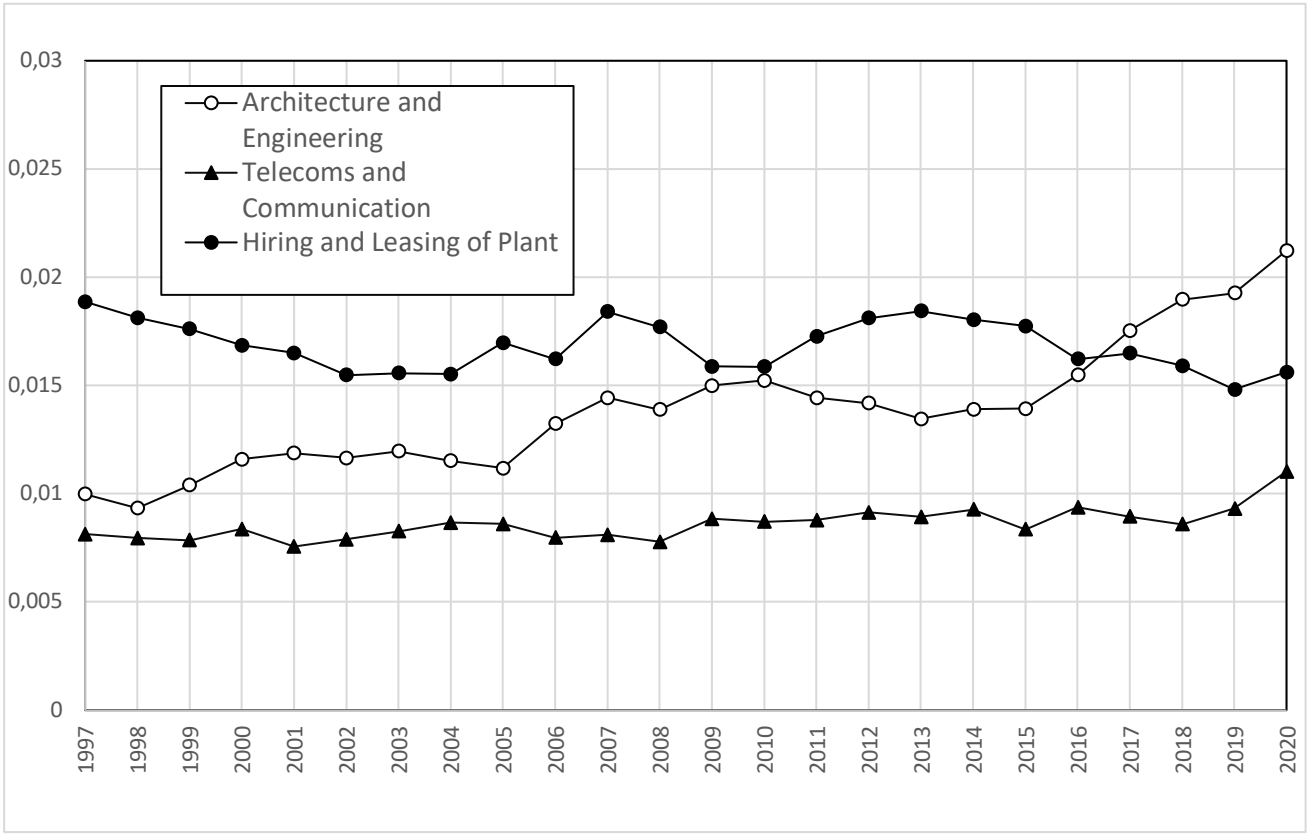

Figure 5: Inputs to Construction from Architecture, Telecoms, and Hiring and Leasing of Plant

Figure 6: Inputs to Construction from Banking and Financial Services and Real Estate Services

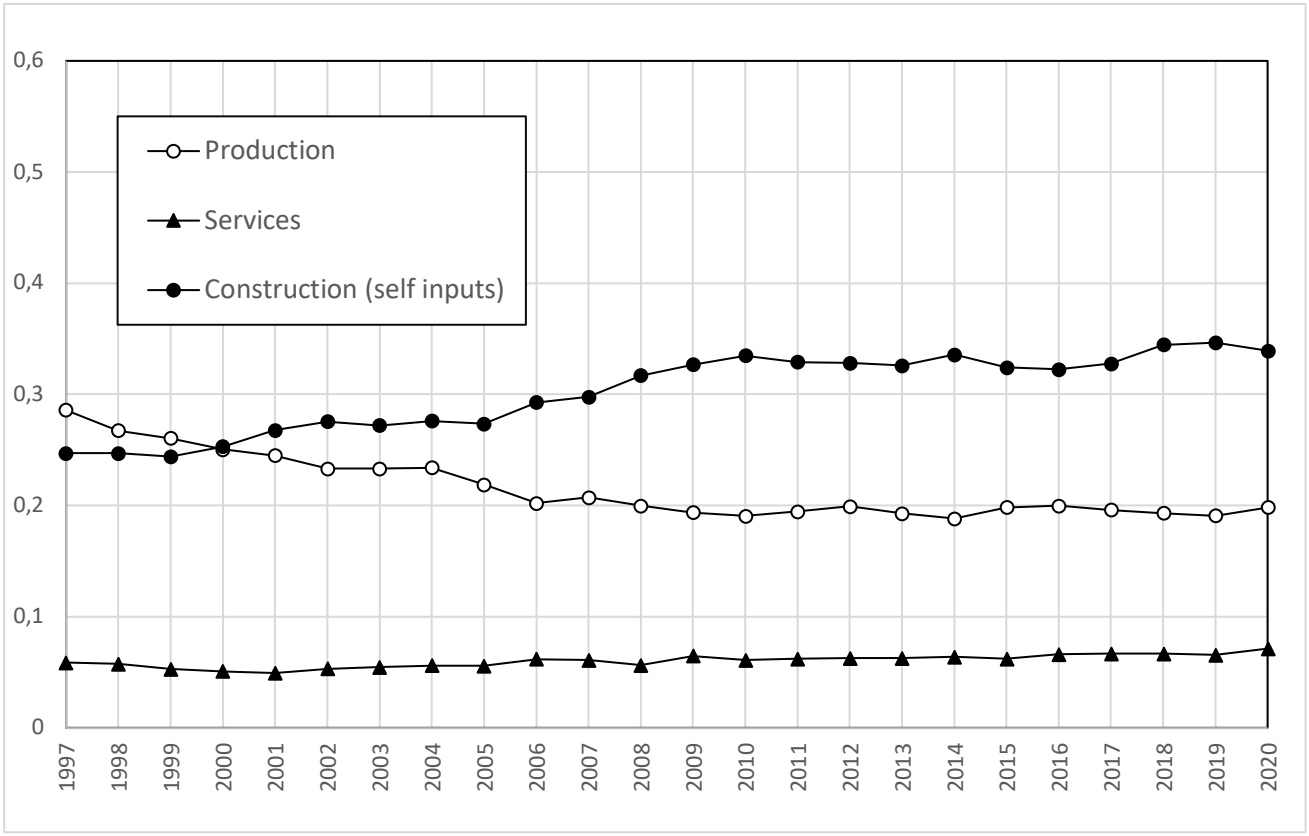

Figure 7: Inputs to Construction from Production, Self-inputs, and Services

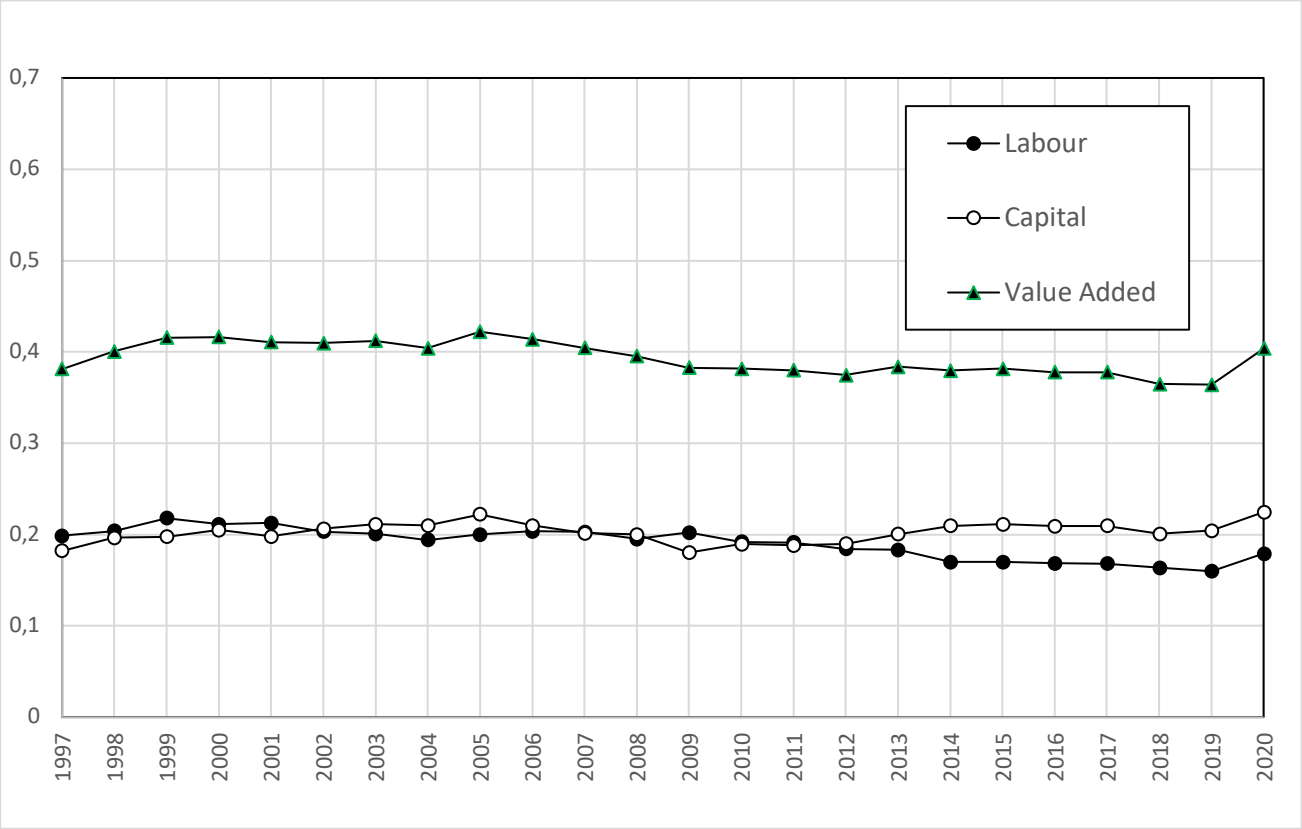

Figure 8: Inputs to Construction from Labour, Capital, and Value Added

5. Technical Change

5.1 Approach

This area is focussed on the changes within the production and construction groups. The areas of technical change include the extent of switching between different material inputs, any changes in the extent of off-site prefabrication, and changes in site mechanisation. The analysis is rather 'broad brushed' as it can only detect shifts between the various commodity sub-groups named and will not show changes within sub-groups. For example, a change from using internal block walls to stud partitions will be indicated. However, the statistics will not show a switch from brick partitions to lightweight blocks.

5.2 Material Switching

Most of the 12 selected production sub-groups are showing apparent absolute declines. This is indicative of a fall in spending on building materials. However, certain materials, mainly wood and wood products, experienced slower declines. Other sectors, including mechanical products, furniture and other manufacturing, showed increased shares. This points to a limited amount of switching of material inputs, in relative terms, as timber products replaced traditional building materials such as bricks, blocks and concrete. So, while the spending was declining in absolute terms, it was increasing in relative terms. It should be added that the timber-framed revolution in house building was well underway many years before the start of the period of study (Cullen, 1981).

The analysis will be unable to detect specific material changes, for example, the shifts from insitu plaster to plasterboard, as they form part of the same sub-group. There was also an earlier move from the use of fletton bricks to concrete or breeze blocks for the inner skin of cavity walls that certainly fell outside the scope of the time limit of this analysis

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5.3 Offsite Prefacation

An increase in the use of off-site prefabrication has been much vamped over recent years. If this were happening to any great extent, it would suggest that there would be an increase in intermediate inputs, particularly for wood, concrete and metal products. Most of the above indicators are on a downward path in absolute terms.

Value added for construction also appears to be on the decline, but this fall is not statistically significant. The increasing use of off-site prefabrication would have been expected to result in a decline in value-added as it would involve replacing on-site labour with off-site labour. The latter approach would result in more labour being employed off-site and classified to the manufacturing sector rather than construction.

There are relative increases in wood and wood products and, to a greater extent, for metal products. However, on balance, it would appear that the data shows no evidence of any discernible change in the extent of use of off-site prefabrication. There were earlier attempts at large-scale off-site prefabrication over the years. Most of

these initiatives were sponsored by the UK government, including innovative material after World War One and the use of prefabricated housing after World War Two (Bowley, 1966).

System building was in full swing by the late 1960s through to the early 1970s (Ive, 1980), once more as a governmental issue. However, these trends had certainly run their course prior to this period of the analysis. Timber-framed housing, which took off in the UK in the 1980s, is more significant. It could certainly be seen as equivalent to prefabrication. It involves substituting on-site labour for off-site labour (Hill, 1980). Unlike many other technical changes, timber-framed building was a private sector initiative.

5.4 Mechanisation

There is also some evidence of increased mechanisation from a superficial examination. The relative decline in wages as a proportion of output while increasing profits indicates increased mechanisation. It seems likely that construction firms' fixed capital is declining rather than rising with the increases in plant hire. However, there is no evidence of any corresponding increase in inputs to construction from plant hire. If anything, this is flat-lining or declining from the data. That is something of a conundrum that requires further investigation.

6. Organisational Change

6.1 Approach

The changes to the service sector of the economy above may tell us a lot more about changes in the management of construction than they do about technical issues. This covers issues such as increased use of plant hire and subcontracting. There will also be some procurement issues, such as the employment of work-package type procurement, including management contracting and construction management. In addition, innovative approaches such as contractor finance and contractor design are relevant here. These issues are characterised by design, build, and public-private partnership projects (PPPs).

6.2 Leasing and Hire of Plant

Plant hire had been increasing for many years partially due to the perceived higher utilisation of hired plants (Hillebrandt, 1988). The 1992-2004 series of SUTs (Office for National Statistics, 2006) showed steady rises in hiring and leasing of plants. However, these trends appear to have been partially reversed over the studied period following changes in the method used to produce SUT data.

The current SUT (Office for National Statistics, 2022) data shows some quite dramatic backdated modifications from the 2017 SUTs onwards. This initially reduced the inputs from hiring and leasing the plant to construction throughout the series to around 70% of the earlier results and ended up at approximately 50% of the previous values from 2002 onwards. There was no explanation in the SUTs other than a scheduled update/revision.

6.3 Subcontracing

The construction sector in the UK has relied heavily on subcontracting for many years (Hillebrandt, 2000). A steady increase in construction self-input over most of the period studied suggests that subcontracting continues to rise. This could also reflect letting of work using work-package type arrangements as with management contracting and construction management. However, the trends from 2010, following the onset of the recession, appeared to be a temporary slight downward turn. In the early days of an economic downturn, a reduction in subcontracting will be expected. Contractors facing a loss of workload would likely keep more of that work in-house. As time goes on, an increase in subcontracting might be expected to follow because the main contractors would react to a continuing depressed state by downsizing their operations. Alternatively, the economy would recover and cause subcontracting to expand.

Another factor could be the partial retreat from work-package-type contracts towards traditional procurement. This is also likely to be expected during and immediately after a major recession. It will be interesting to see what happens in later years when the construction sector's recent economic recovery is fully reflected. As things stand, it will be best described as a possible rather than a probable increase over time.

6.4 Labour-only subcontracting

One factor that could impact changes in the use of labour-only subcontracting (Ball, 1988) comes in the same category as subcontracting and work packages. This first arose in the 1960s to avoid the selective employment tax in operation at the time. It continued to grow in the 1970s and 1980s. While the use of labour-only subcontracting appears to have declined by the end of the period studied, it was very significant for most of the period in question. The impact of labour-only subcontracting would undoubtedly confuse the issues. The fact that there is a steady reduction in the apparent labour inputs to construction over the period studied suggests that this could be a factor.

6.5 ContractorFinancing of Projects

This was always a factor for the speculative sector of the construction industry but gained momentum in the early 1990s via the private finance initiative (PFI), later rebadged as PPPs. The changes in inputs from banking and financial services over time are used to analyse this area.

The figures from 1997 onwards from the 2020 SUTs demonstrate a clear increase in contractor design. In the early years, PFI projects took time to get going and, in any event, were only pioneered in 1992. This approach gained ground after the change of Government in 1997. As PPP-type procurement expanded during the long boom, it took something of a hit after the 2008 downturn. This was

partially because contractor consortiums were less willing to undertake the risks involved with PPP and also because of the government's reversion to traditional contracts.

The expected growth of contractor-financed projects is undoubtedly consistent with the growth in inputs from the financial sector to construction, illustrated in Figure 4. The data relates not only to financial services but also to insurance. This would also be expected to grow along with increased contractor financing because of the need for complex documentation to satisfy the financiers. The recent figures are sufficient to indicate an overall trend of increased contractor financing over the study period.

6.6 Contractor design

There is a long history of contractor design in the UK construction sector. Initially, this was confined to speculative work, specific standardised design, and building 'package deal' projects. Design and build procurement eventually dominated the UK private sector commercial and industrial construction work by the 1980s. Later the advent of design, build, maintain and operate did much the same for the public sector by the end of the 1990s. A good deal of contractor design in such areas was traditionally in standardised or modular buildings and utilised in-house designers employed by the builders and contractors. This would not show up in an inter-industry analysis.

As contractors start to employ professional design and cost consultants rather than in-house staff, this will be reflected in increased inputs from the architectural and engineering services sector, including design consultancy. Inputs from consultants were needed for the more sophisticated levels of design needed as design and build procurement expanded from its initial limited niche market; with traditional procurement, construction clients, rather than contractors, would employ consultants. Hence, it would not appear in construction output.

The use of consultants was key in the design, build, maintain and operate contracts used for PFI/PPP projects. In addition to design and costing, consultants may be used for areas such as project and facilities management. The apparent increase in inputs to construction from professional consultancy to construction over the 1992 to 2020 period is perfectly consistent with the above points. Thus, this would confirm that contractor design of projects is increasing for the period under consideration. This could have implications for innovation if it is accepted that a unification of the design and construction processes would be more likely to encourage the spread of technical change.

6.7 Globalisation

Globalisation started to impact the UK construction sector significantly over the period studied. This could involve overseas-based contractors operating in the UK by purchasing existing UK builders. For example, traditional UK builders such as Gilbert Ash and Higgs and Hill were acquired by the Dutch contractor HGB, who later became BAM. They had taken over the civil engineering contractor, Edmund Nuttall, to form the current BAM Nuttall.

It is not obvious where this will be shown directly on the SUT figures. However, because of the technological change implicit with globalisation, the inputs from communications and information technology will be expected to increase. This would affect the design and construction processes and also the clients' briefs (Gruneberg, 2010). This impact of international ownership increased steadily over the period studied and will have impacts.

6.8 Comparison with other Countries

It is unlikely that other countries would avoid the issues listed above. The UK has a main contractual system similar to that employed in the USA, the Commonwealth, and much of the Far East. Most continental Europe, Latin America, and francophone Africa use a different trade-based contractual system. These differences will have a negligible impact on the technology used. Indeed, over the last 40 years, procurement systems such as management contracting and construction management in the UK are close to those employed in Europe.

Evidence from the USA seems to suggest that they are experiencing similar developments as those in the UK. See, for example, the input-output analysis of the US construction industry by Pietroforte et al. (2009) and the study of construction markets in the world economy (Gruneberg, 2009). The introduction of design supply and fix approaches to procurement, as highlighted, has certainly applied as numerous variants of the PPP approach were throughout many countries across the globe.

7. Conclusions

7.1 Main developments

This study sought to examine the broad technological and organisational change trends in the UK construction sector. The results from the materials sector were not very conclusive, with, at best, minimal switching of materials and limited increases in mechanisation but no evidence of significant changes in the use of off-site prefabrication. This can be seen as a continuation of the trends that have been clear throughout the post-war era (Lowe, 1996). The most conclusive result was the levelling off of the earlier increase in the use of plant hire. Positive but less conclusive results suggested the increased use of contractor finance and contractor design. Finally, the growth in subcontracting is illustrated by the increase in the extent of self-input from construction. This, along with the substantial increase in subcontracting, can also be seen as a continuation of post-war trends.

These results are consistent with contractors looking to reduce the level of risk in an era characterised by the growth of construction insolvency. This involved using subcontracting and plant hire more while displaying a degree of caution about mass moves to off-site prefabrication.

7.2 Suggestions for further Investigation

Areas from the research that have clear potential for further change that are worthy of investigation include the potential for further use of off-site prefabrication and industrial buildings. The issue of contractor funding is employed in speculative house building and in design, build, maintain, and operate projects. This is another aspect which might prove interesting.

There is the point highlighted earlier regarding the decline in the spending by contractors on plant and equipment while inputs from plant hire appear to remain static. This may be a short-term issue, but still requires investigation.

There is also the issue of the long-term impact of the COVID-19 pandemic. It had limited effects on the study apart from the lockdown in March 2020, the final year of the study period. There were undoubtedly strong effects of the resulting recession on construction output in 2020, but the long-term impacts, such as increases in home working and potential changes in retail distribution, remain unclear even at this stage.

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