

ASSESSMENT OF NIGERIA CONSTRUCTION INDUSTRY SUPPLY CHAIN RISK; FUZZY DELPHI METHOD APPROACH

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ABSTRACT

Infrastructural development is of great importance to the economic growth and development of any nation, and the construction industry has significant roles to play. Nigeria being a developing economy with lots of infrastructural deficiencies requires contributions from every sector for her development. The building and construction industry requires lot of participation from different professionals within its supply chain network but the existence of different risks in the chain can impede the smooth running of the industry activities thereby limiting the industry from achieving its full potentials. Relevance of Stakeholder theory in the construction industry supply chain risk was discussed. This study is focused on assessment of the supply chain risk factors in the Nigeria construction industry with the use of Fuzzy Delphi Method approach. Sixteen (16) risk dimensions and fifty-nine (59) risk factors were identified as of direct impact on Nigeria construction industry in particular from ninety five (95) risk factors, and evaluations of their level of relevance were determined through the Fuzzy Delphi method with the help of seventeen (17) experts' opinion. The five topmost of the fifty-nine (59) identified risk factors that are of relevance in the Nigeria construction industry are; Geo-technical, sub-standard materials, quality of work, design interpretation and delay payment. Four (4) out of the five (5) are within the technical risk dimension. Construction industry expert should make concerted effort to work round the identified risk factors in order to reduce their negative impact on project execution processes.

Keywords: - Fuzzy Delphi, Construction Industry, Supply Chain Risk, Stakeholders' Theory

1.0 Introduction

As a sector of the economy that is interconnected with every aspect of human activity, the construction industry faces many challenges that prevent it from achieving its entire purpose of delivering quality products and services to the general public within the estimated time frame and within the planned cost. The challenge is of several dimensions such as, collapse of building which can be as a result of faulty design, incompetent workmen, poor material, compromised supervision, lack of commitment on the part of the customer in some cases and several others (Ali, Awad, & Abdulsalam, 2020). Globally, infrastructural development such as; roads, bridges, drainages and buildings play vital roles in the economic development of any country, because many other growth and developmental factors depend on it (Srinivasu & Rao, 2013). That forms part of the reasons why government leaders of many developing nations lay emphasis on improvement of their existing infrastructures and the development of new ones (Aiginger & Rodrik, 2020). In Nigeria; there are inadequacies in infrastructural development such as roads and housings for her growing population. Existence of bad road networks impeding the movement of goods and services, and shortage of houses to accommodate her teeming population is of great concern. This trend must be arrested to relieve citizens and thereby facilitating growth for the nation (Rigon, Abah, Dangoji, Walker, Ogunleye & Hirst, 2015, and Mangan & Lalwani, 2016). With the campaign on sustainable development goals (SDG) programme globally, goal number 9 focuses on industry, innovations, and infrastructure, with part of its target being the development of quality, reliable, sustainable, and resilient infrastructure which includes regional and trans-border infrastructure to support economic development and human well-being with intention of making accessibility of these infrastructures affordable and equitable to everyone. Goal number 11 talks about making cities and human settlements safe, resilient, and sustainable so that come the year 2030, there

should be affordable, adequate, and safe housing and transport systems for the majority of the world population, especially in Africa (Caiado, Leal Filho, Quelhas, de Mattos Nascimento & Avila, 2018). The construction industry in Nigeria is a major contributor to the economic development of the country just as it does in other nation's world over through employment of many professionals and non-professionals, either directly engaging them on the project or as ancillary employees providing services for those working on the project. Presence of risks has negative impact on the industry performances in that, the growth expected is impeded, and posing greater challenges for the industry to achieve its potentials; the reason why this study is focused on the assessment of those risk factors that are of great impact on the industry growth through the experts' views with the aid of Fuzzy Delphi method approach to identify those risk sources and factors that has direct impact on the overall performance of the industry in Nigeria. Thus, the research questions for this study are;

- i. How many of the identified risk factors have direct impact on the Nigeria construction industry?
- ii. What level of impact does the identified risk factors has on the industry?

2.0 Theoretical Review

2.1 Stakeholder Theory

In this study, stakeholder theory is employed to x-ray the importance of supply chain risk assessment in the construction industry. The concept was first introduced at Standard Research Institute in 1963 and later developed into a theory by Edward Freeman with other scholars in the 1980s (Parmar, Freeman, Harrison, Wicks, Pumell & DeColle, 2010). The theory highlights that for a lasting growth and success to be achieved by any organization or corporation, the satisfaction of all the stakeholders must be of paramount importance to any strategic decision-making of

management team (Bal, Bryde, Fearon & Ochieng, 2013). The theory takes into consideration everyone within the supply chain and these are; employees, customers, the investors, communities, the suppliers and even the government with the focus that each of these group has to be satisfied rather than focusing on the investors alone (Waddock, `Bodwell & Leigh, 2017). With the trend in the global economy, construction industry supply chain now take critical look at commitment of stakeholder for them so as to be able to deliver their services and products in an excellent manner (Flanagan, Lu, Shen & Jewell, 2007 and Bal, Bryde, Fearon & Ochieng, 2013). Each of the stakeholders has an interest to protect in the course of project execution, and if not well managed, there is going to be conflict of interest which will eventually impact the project negatively. A well-managed stakeholder commitment in a supply chain will result in strategic management efforts to reduce its negative impacts of the project on the environment, increase return on investment to the shareholders, improved welfare for the employees, payment of adequate tax to the government, and a good relationship with the operating environment (Lau & Chen, 2021). Stakeholders involved in the construction industry supply chain are many; there is the need for synergy between all concerned to make sure every participant within the chain work together to achieve the best of result that will be beneficial to all. In the same manner, each of the identified risk sources and the risk factors in the building and construction industry supply chain must be well engaged as the negligent of one can portend a negative effect on the overall project delivery.

2.2 Conceptual Review

2.2.1 Construction Supply Chain

A typical construction supply chain begins with the client/customer's need for a project (Harris, McCaffer, Baldwin & Edum-Fotwe (2021), the client interact with other stakeholders in the industry such as a town planner to assist in the location of the right place where the project can be situated depending on the purpose of the project, then comes in the land surveyor to ascertain the

size of the land. The architect is invited to design a model based on the client's need, the structural engineers, electrical and mechanical engineers will get involved after which the designs is forwarded to relevant government agencies for approval, followed by the quantity surveyor for the bills preparation. Tender for the project will be advertised and the accepted contractors will be awarded the contract to execute. All of the process above is pre-execution stage which can also be seen as the planning stage. The execution stage will bring in many other professionals, labours and suppliers and which the project is handed over to the client and the project closed. This shows that the construction industry engages the services of many people which by implication indicating the complexity of the industry and its susceptibility to risks.

2.2.2 Construction Supply Chain Risks

There exists risk at every aspect of human endeavours on a daily basis (Hilson & Murray-Webster, 2017). It is therefore not out of place to see many scholars researching into this sector. Identifying and assessment of these risks and the level of their impact is of great importance in the construction industry, as this will assist operators to put in place necessary measures that can help to mitigate them (Jackson, 2020). There are definite goals, cost limit and time frame that any construction project is expected to achieve. These goals are usually defined at the conception and planning stages of such projects. At each stage of construction (project implementation process) there are likelihood of some issues cropping up which might affect the areas of focus (Hopkinson, 2017) such as; cost overrun or not been able to delivered within the set time. Other concerns might be a decrease in the quality of the delivered project due to constraints as a result of scope, time and cost (Sanchez, & Terlizzi, 2017).

Construction industry is full of different type of risk factors within its supply chain (Bilal, Oyedele, Qadir, Munir, Ajayi, Akinade & Pasha, 2016), and such risk factors has influenced the

performance and the end result of projects carried out in the industry (Khoshfetrat, Sarvari, Chan & Rakhshanifar, 2022). Every project life cycle in the construction industry is time bound, operates on an estimated budget and with an expected product quality (Zou, Zhang & Wang, 2007). There exist inherent risks and hazards that should be identified within the construction industry supply chain (Sugathadasa, Herath & Thibbotuwawa, 2021) such that strategic effort will be put in place to reduce the effect of those risks as much as possible so as to be able to achieve the set goals for all the stakeholders.

2.3 Empirical Reviews

Raykar & Ghadge, (2016) worked on the critical factors that contribute to time overrun and cost overrun in the construction projects. It was noticed that these two overruns are common problems bedeviling project works in the construction industry. Their findings are; poor management of site and supervision, issues with sub-contractors, inadequate planning and project scheduling, management of materials and absence of coordination within stakeholders are the major critical factors contributing to both time and cost overruns. Also, bad weather, work scope (coverage), cost of equipment and its usage, management of cash flow and decision-making policy contributes to an extent as well.

In the study carried out by Mahamid, (2016) to identify the contributing factors to the construction projects poor performance in Saudi Arabia described poor performance in construction projects as a worldwide phenomenon, and with a high rate of occurrence. This calls for attention from researchers to look into what are the likely causes of this global happening. The study made some findings; one of them is that there are so many interested stakeholders involved in construction projects, and it will require a lot of coordination between them to get things done appropriately.

The researcher employed severity index, group index and rank correlation to identify and ranked identified related factors, and concluded that top factors contributing to the poor performance of construction projects in the country are; communication between clients and project participants is very poor, others are; payment delays, planning and scheduling, labour productivity, and site management.

Fuzzy Delphi method is being engaged by many scholars to research in the construction industry such as; Chan, Chan & Yeung (2009) in the study of “fuzzy techniques” in construction management application overview, and Wang, Huang & Ko (2019) applied fuzzy Delphi technique to look at sustainability achievement and elementary campus construction needs. Application of fuzzy Delphi method to evaluate risk factors in the Nigeria construction industry is not conspicuous. The need to look at it and prioritized same to assist stakeholders in the industry in project execution to attain the objective of working within the budgeted cost, time frame and delivery of quality product that meets the need of every participant will be of great value.

3.0 Method

Cross-sectional research design was engaged to carry out this study with the use of Fuzzy Delphi (FD) technique initiated in 1985 by Murray, Pipino and Gigch, and it was later developed by Kaufman and Gupta in 1998 (Abdul Karim, Rambat, Harum, Matsuura, Rasak, Ghazali, Rashdan, Mohd Fadly, Zubir, Husyairi & Nazirah, 2017). Quantitative system of data collection was adopted in line with positivism theoretical thinking. A descriptive survey was also used by administering a FD structured questionnaire research questions which assisted the experts with a minimum of five (5) year experience in the industry to identify risk factors in the Nigeria construction industry without or with minimal level of bias and partiality. To ascertain the relevance of the each of the

risk factors in the Nigeria construction industry, the study collected and examined opinion of seventeen (17) different experts drawn from practitioners within the industry supply chain, the likes of Architects, Engineers, Quantity surveyors, contractors and developers based on their wealth of experience in diverse fields that connect with the construction industry circle with the use of Fuzzy Delphi method. The number of experts consulted in the course of this study is in line with Jones & Twiss (1978) that indicated that for Delphi study, number of experts required is between 10 to 50, and also in agreement with Adler & Ziglo (1996) which supported the view of the number of experts for the application of FD technique, that once there are between 10 to 15 experts' opinion, the study is valid.

3.1 Data Collection

With the assistance of different literatures such as; Kolhatkar and Dutta (2013), Bilal *et al.*, (2016), Jackson, (2020), Khoshfetrat, *et al*, (2022), Hilson and Murray-Webster, (2017) Martin, et al, (2018), Tessema, Alene and Wolelaw (2022), Ishaq, Abubakar, Mohammad, Lawal and Ibrahim (2021), Sugathadasa, *et al*, (2021) and experts' opinions, sixteen (16) risk factors were identified through the use of FD method and these includes; technical, financial, environmental, logistics, human capital, occupational health and safety, management and leadership, legal and acquisition, government policies, force majeure, contractors and sub-contractors, equipment, economic, materials, and clients as potential risk factors. An FD structured questionnaire was administered to seventeen (17) experts where they are requested to evaluate the importance of each of the specified risk factors and their corresponding sub-risk factors. The structured questions followed a closed-ended format where their answers made use of the Likert scale 1 - 7 (specifying “(7) absolutely significant (AS), (6) Significant (SI), (5) Fairly Significant (FS), (4) Indifferent (ID), (3) Fairly Insignificant (FI), (2) Insignificant (IS), (1) absolutely insignificant (AI)”) with the

ascribed linguistic variable as stated in table 1 by applying fuzzy triangular numbers for the estimation of the fuzzy number for each of the stated criterion. The Likert scale is stating the estimation of the likelihood of occurrence of such risk within the industry supply chain.

3.2 Data Analysis

Microsoft Excel solver was used to analyze the collected data in line with Fuzzy Delphi technique taking the following steps;

3.2.1. Identification of different supply chain risk factors in the construction industry.

3.2.2. Conversion of the collected data from the experts' opinion based on the Likert scale 1 - 7

3.2.3. Putting together experts' opinions using equations (1), (2) and (3)

$$x_j = \min\{x_{ij}\} \quad - \quad (1)$$

$$y_j = 1/n (\text{Summation } y_{ij}) \quad - \quad (2)$$

$$z_j = \max\{z_{ij}\} \quad - \quad (3)$$

where x_j is the minimum value for each j variable, y_j is the geometric mean for each j variable, and z_j is the maximum value for each j variable such that $j = 1, 2, 3, \dots, m$

3.2.4. Calculating experts' opinions by making use of equation (4) which will also assist in defuzzing the fuzzy values obtained for each of identified factors. To decide, there is a resulting threshold 'T' which can be obtained by taking the average of the defuzzification values.

$$R_j = (x_j + 4y_j + z_j) / 6 \quad - \quad (4)$$

Where $j = 1, 2, 3, \dots, m$

Decision rule positions are;

Reject R_j if $T > R_j$ for every j

Accept R_j if $T \leq R_j$ for every j

3.2.5 For the prioritisation of the risk factors, calculate the defuzzification number for each of the assessment Likert scale using equation (4).

4.0 Results

The total number of questionnaires sent out to the identified professionals was twenty (20) and seventeen (17); (check appendix 1 for details) out of them answered and returned the completed questionnaires representing 85% response. These professionals are practitioners that operate both in the private and the public sectors of the Nigerian economy for a minimum of five (5) years. All of the seventeen (17) were well completed and fitted for the analysis. Following the Fuzzy Delphi analytical procedures as discussed above, sixteen (16) sources of risk and ninety-five (95) risk factors were identified (see details in table 1) through different literature, and personal experiences of some professionals and participants in the supply chain management of construction industry. Based on the resulting threshold ($T = 0.6544$), and in line with the decision rule which states that all variables whose value is less than the threshold be rejected, while those variables with greater or equal value with the threshold be accepted (see table 1).

Table 1: Fuzzy Delphi Results for Identified Building and Construction Supply Chain Risk Factors

S/ N	Sources of Risk	SR N	Risk Factors	Min.	Max.	Geometri c Mean	Defuzzificati on	Decisio n
1	Technical (TC)	1.1	Geotechnical	0.9	1	0.9755141	0.967009	Accept
		1.2	Quality of Design	0.5	1	0.911428	0.857619	Accept
		1.3	Design Interpretation	0.7	1	0.9671746	0.928116	Accept

2		1.4	Sub-standard materials	0.9	1	0.9634968	0.958998	Accept
		1.5	Quality of Work	0.9	1	0.9516277	0.951085	Accept
		1.6	Land Topology	0	1	0	0.166667	Reject
		1.7	Scope	0	1	0	0.166667	Reject
		2.1	Credit	0	1	0	0.166667	Reject
		2.2	Interest Rate	0	1	0	0.166667	Reject
		2.3	FOREX	0	1	0	0.166667	Reject
	Financial (FI)	2.4	Receipt	0.1	1	0.7659991	0.693999	Accept
		2.5	Misappropriation	0.1	1	0.7901165	0.710078	Accept
		2.6	Contract Value	0	1	0	0.166667	Reject
		2.7	Unnecessary spending	0	1	0	0.166667	Reject
		2.8	Material Cost	0.1	1	0.7999712	0.716647	Accept
		2.9	Cost of Fuel	0.1	1	0.7764838	0.700989	Accept
3	Environment (EV)	2.10	Labour Cost	0.1	1	0.7852348	0.706823	Accept
		3.1	Windy Location	0.1	1	0.5775861	0.568391	Reject
		3.2	Noise Pollution	0	0.9	0	0.15	Reject
		3.3	Unfriendly Neighbours	0.1	1	0.5857743	0.57385	Reject
		3.4	Road Size	0.1	1	0.5747001	0.566467	Reject
		3.5	Insecured Environment	0.7	1	0.9103456	0.89023	Accept
		3.6	Land grabbers/Area boys	0.3	1	0.703493	0.685662	Accept
		3.7	Competitors	0.1	1	0.4320933	0.471396	Reject
		3.8	Political Situation	0.3	1	0.7560287	0.720686	Accept
		4	Logistics (LG)	4.1	Bad Road	0.1	1	0.6497908
4.2	Security			0.3	1	0.809188	0.756125	Accept
4.3	Vehicle			0	1	0	0.166667	Reject
4.4	Security Agents			0.1	1	0.6352376	0.606825	Reject
4.5	Drivers' Integrity			0.3	1	0.6966506	0.6811	Accept
4.6	Fuel			0.1	1	0.7382101	0.675473	Accept

5	Human Capital (HC)	4.7	Storage	0.1	1	0.6370563	0.608038	Reject
		4.8	Site Location	0.1	1	0.6439254	0.612617	Reject
		5.1	Technical Know how	0.7	1	0.918195	0.895463	Accept
		5.2	Human Health	0	1	0	0.166667	Reject
		5.3	Relationship	0	1	0	0.166667	Reject
		5.4	Skilled Labour	0	1	0.8848749	0.756583	Accept
		5.5	Supervision/Monitoring	0.7	1	0.8271218	0.834748	Accept
		5.6	Supplier Failure	0.1	1	0.6111638	0.590776	Reject
6	Occupational Health and Safety (OHS)	6.1	Education	0.1	1	0.6911831	0.644122	Reject
		6.2	Personal Protective Equipment	0.5	1	0.7874829	0.774989	Accept
		6.3	First Aid Materials	0.1	1	0.6326578	0.605105	Reject
		6.4	Insurance	0.1	1	0.6505635	0.617042	Reject
7		6.5	Noise	0	1	0	0.166667	Reject
		6.6	Dust	0.3	1	0.6043461	0.619564	Reject
		6.7	Carelessness	0.1	1	0.8267434	0.734496	Accept
		6.8	Work Area	0.3	1	0.6799036	0.669936	Accept
		6.9	Epidemic	0.1	1	0.834656	0.739771	Accept
		7.1	Corporate Planning	0.3	1	0.9296472	0.836431	Accept
	Management and Leadership (ML)	7.2	Reporting	0.5	1	0.8400538	0.810036	Accept
		7.3	Communication	0.5	1	0.8869903	0.841327	Accept
		7.4	Favouritism and Nepotism	0	1	0	0.166667	Reject
		7.5	Control system	0.3	1	0.855416	0.786944	Accept
		7.6	Team building	0.5	1	0.913607	0.859071	Accept
7.7	Company Policies	0.1	1	0.6491645	0.61611	Reject		
7.8	Decision Taking	0.1	1	0.8660851	0.760723	Accept		
7.9	Non-inclusion	0.1	1	0.7026575	0.651772	Reject		

8	Legal and Acquisitions (LA)	8.1	Law suits	0.1	1	0.6210034	0.597336	Reject
		8.2	Source of purchase	0.1	1	0.7694747	0.696316	Accept
		8.3	Family Receipts	0.1	1	0.6857585	0.640506	Reject
		8.4	Sellers' manipulation	0.1	1	0.6349244	0.606616	Reject
9	Government Policies (GP)	9.1	Bureaucracy	0.1	1	0.7746319	0.699755	Accept
		9.2	Changeability	0.1	1	0.7445753	0.679717	Accept
		9.3	C of O	0.1	1	0.5903935	0.576929	Reject
10	Government Agencies (GA)	9.4	Self-seeking	0.1	1	0.6575855	0.621724	Reject
		9.5	Tax law	0.5	1	0.7279009	0.735267	Accept
		9.6	Building Law	0.3	1	0.7702171	0.730145	Accept
		10.1	Sharp practices	0.5	1	0.7654583	0.760306	Accept
		10.2	Incompetent staffs	0.3	1	0.860734	0.790489	Accept
		10.3	Proliferation of agencies	0.7	1	0.8026662	0.818444	Accept
11	Force Majeure (FM)	11.1	Earthquake	0	1	0	0.166667	Reject
		11.2	Erosion	0.1	1	0.7102261	0.656817	Accept
		11.3	Weather	0.3	1	0.7187553	0.695837	Accept
		11.4	Site condition	0.3	1	0.7139702	0.692647	Accept
12	Contractors and Sub-contractors (CS)	12.1	Experience	0.7	1	0.8991311	0.882754	Accept
		12.2	Integrity	0.7	1	0.9068839	0.887923	Accept
		12.3	Financial	0.5	1	0.8815101	0.837673	Accept
		12.4	Staff strength	0.3	1	0.7826261	0.738417	Accept
		12.5	Time	0.5	1	0.8739742	0.832649	Accept

		12. 6	Professional Competence	0.7	1	0.937663	0.908442	Accept
13	Equipment (EQ)	13. 1	Inadequate equipment	0.5	1	0.9192868	0.862858	Accept
		13. 2	Obsolesce	0.3	1	0.7963666	0.747578	Accept
		13. 3	Maintenance	0.3	1	0.840853	0.777235	Accept
		13. 4	Replacement	0.1	1	0.607381	0.588254	Reject
		13. 5	Accessibility	0.1	1	0.7029792	0.651986	Reject
14	Economic (EC)	14. 1	Project funding	0.5	1	0.8750135	0.833342	Accept
		14. 2	Economic downturn	0.7	1	0.9434924	0.912328	Accept
15	Material (MT)	15. 1	Availability	0.5	1	0.911428	0.857619	Accept
		15. 2	Cost	0.7	1	0.8991311	0.882754	Accept
		15. 3	Location	0.5	1	0.8216353	0.797757	Accept
16	Client (CL)	16. 1	Attitude	0.1	1	0.753862	0.685908	Accept
		16. 2	Payment	0.7	1	0.949358	0.916239	Accept
		16. 3	Duration	0.3	1	0.8810851	0.804057	Accept
		16. 4	Information Distortion	0.3	1	0.8735529	0.799035	Accept
		16. 5	Inspection	0.3	1	0.8448782	0.779919	Accept
Threshold		T		0.272	0.999	0.6640001	0.654421	

Source: Authors' Analysis 2022

To answer the second question of this study, that is the level of impact of the risk factors in the industry, the risk factors in the questionnaire based on the experts' opinion were considered, and

the obtained defuzzification of the fuzzy Delphi process in table 2 matched with the seven (7) – point Likert scale defuzzification numbers as shown in table 3.

Table 2: Defuzzification numbers for a 7 – point Likert scale

Absolutely Significant (AS)	Significant (SI)	Fairly Significant (FS)	Indifferent (ID)	Fairly Insignificant (FI)	Insignificant (IS)	Absolutely Insignificant (AI)
0.9833	0.8833	0.7	0.5	0.3	0.1167	0.0167

Table 3: Risk Factors Prioritization

Risk Factors	Risk Score	Risk Priority	Level of Risk	Source of Risk
Geotechnical	0.967009	1	AS	TC
Sub-standard materials	0.958998	2	AS	TC
Quality of Work	0.951085	3	AS	TC
Design Interpretation	0.928116	4	AS	TC
Timely Payment	0.916239	5	AS	CL
Economic downturn	0.912328	6	AS	EC
Professional competence	0.908442	7	AS	CS
Technical Know how	0.895463	8	AS	HC
Insecured Environment	0.89023	9	AS	EV
Contractor's Integrity	0.887923	10	AS	CS
Contractor's Experience	0.882754	11	SI	CS
Cost of Materials	0.882754	12	SI	MT
Inadequate equipment	0.862858	13	SI	EQ
Team building	0.859071	14	SI	ML
Quality of Design	0.857619	15	SI	TC
Availability of Materials	0.857619	16	SI	MT
Communication	0.841327	17	SI	ML
Contractor's Financial Capability	0.837673	18	SI	CS
Corporate Planning	0.836431	19	SI	ML
Supervision/Monitoring	0.834748	20	SI	HC
Project funding	0.833342	21	SI	EC
Contractor's Time Management	0.832649	22	SI	CS

Proliferation of Agencies	0.818444	23	SI	GA
Reporting Process	0.810036	24	SI	ML
Duration Time of Project	0.804057	25	SI	CL
Information Distortion	0.799035	26	SI	CL
Location of Materials	0.797757	27	SI	MT
Incompetent staffs	0.790489	28	SI	GA
Control system	0.786944	29	SI	ML
Inspection	0.779919	30	SI	CL
Maintenance	0.777235	31	SI	EQ
Personal Protective Equipment	0.774989	32	SI	OHS
Decision Taking	0.760723	33	SI	ML
Sharp practices	0.760306	34	SI	GA
Skilled Labour	0.756583	35	SI	HC
Security	0.756125	36	SI	LG
Obsolesce	0.747578	37	SI	EQ
Epidemic	0.739771	38	SI	OHS
Staff strength	0.738417	39	SI	CS
Tax law	0.735267	40	SI	GP
Carelessness	0.734496	41	SI	OHS
Building Law	0.730145	42	SI	GP
Political Situation	0.720686	43	SI	EV
Material Cost	0.716647	44	SI	FI
Misappropriation	0.710078	45	SI	FI
Labour Cost	0.706823	46	SI	FI
Cost of Fuel	0.700989	47	SI	FI
Bureaucracy	0.699755	48	FS	GP
Source of purchase	0.696316	49	FS	LA
Weather	0.695837	50	FS	FM
Receipt	0.693999	51	FS	FI
Site condition	0.692647	52	FS	FM
Attitude	0.685908	53	FS	CL
Land grabbers/Area boys	0.685662	54	FS	EV
Drivers' Integrity	0.6811	55	FS	LG
Changeability	0.679717	56	FS	GP
Fuel Availability	0.675473	57	FS	LG
Work Area	0.669936	58	FS	OHS
Erosion	0.656817	59	FS	FM

Source: Authors' Analysis 2022

5.0 Discussion

After the analysis of the experts' opinion, following the fuzzy Delphi procedure, the threshold ($T = 0.6544$) was arrived at. It was discovered that all the sixteen (16) identified dimension of risk are relevance in the Nigeria building and construction industry and the number of the risk factors were reduced to fifty-nine (59) as against the ninety-five (95) gotten from different literatures and experts' opinions.

It is imperative to note that the technical risk source is of great relevance in the Nigeria environment, and the identified risk factors by the experts' opinion such as sub-standard materials, quality of works, design quality and design interpretation are in support of the findings by Martins *et al*, (2017). Furthermore, the timely payment by the clients to the contractors and sub-contractors for jobs is of relevance as well and this is in conformity with the work of Raykar & Ghadge, (2016). Communication which involves the dissemination of the required information and information distortion are also of great relevance to Nigeria system and these also follow the study carried out by Mahamid, (2016).

Looking at table 1, technical is considered to be the highest risk source in the industry and geotechnical risk factor as the most relevant, it can be seen that other risk factors within the technical group that fall into this category are, sub-standard materials, quality of work, design interpretation. Also, from table 3 geotechnical falls into the absolute significant in the level of risk. Others in that category are; sub-standard materials, quality of work, design interpretation, timely payment, economic downtown, professional competence, technical know-how, secured environment and contractors' integrity. All of these are absolutely significant risk factors in the industry. The risk sources of these ten (10) absolute significant risks factors are; Technical,

Economic, Human Capital, Environment, and Contractors and Sub-contractors (table 3). Understanding the relevance of all identified risk dimensions and their corresponding risk factors will assist practitioners in the industry to look out for ways of militating against them as they carry out their activities. This will increase efficiency and impact on the level of satisfaction to all stakeholders within the supply chain.

6.0 Conclusion

Risk assessment involves identification of the risk factors and the evaluation of their level of relevance. Carrying out assessment of Nigeria building and construction supply chain risk is of paramount importance to the generality of Nigeria space because of its impact on the infrastructural development of the nation. Fuzzy Delphi procedure is a veritable tool for solving the challenge of identification and evaluation of the level of relevance of the risk factors in the Nigeria construction industry and the result has a good level of precision. This research work offers the outcomes of identification and evaluation of supply chain risks in the industry through the application of Fuzzy Delphi method, and it has contributed in identifying sixteen (16) potential risk sources and fifty-nine (59) likely risk factors that were ranked according to the level of their significance based on the opinion of experts consulted through Fuzzy Delphi procedure. From the ranking table (table 3), it can be seen that geotechnical with the criterion value of 0.967 which has to do with the stability of the point where a project will be erected has the highest risk potential indicating that it shouldn't be taken for granted to avoid failures, followed by sub-standard materials with 0.959, quality of work 0.951 and design. So also, are the other fifty-six (56) risk factors; Even erosion risk factor that has the lowest value of 0.657 is still of great importance because it is fairly significant, meaning its occurrence can impact negatively on the project. Identification and

evaluation of each of the risk factors should be of help to the practitioners to take the necessary precautions in the course of carrying out their daily activities.

In conclusion, it is noteworthy to assert that Fuzzy Delphi method is of value in identifying and evaluating the level of relevance of supply chain risk factors affecting the Nigeria construction industry.

7.0 Limitation and Suggestion for Future Research

This study focuses on identification and evaluation of level of relevance of supply chain risk factors in the Nigeria building and construction industry. Future research work can look at the level of influence and interaction between each of the identified risk factors and how to militate against them.

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Appendix 1

List of Professionals

ITEM NO.	HIGHEST QUALIFICATION	PROFESSION	EXPERIENCE
1	Master's Degree	Civil Engineering	More than 30 years
2	Bachelor's Degree	Civil Engineering	More than 30 years
3	Master's Degree	Architecture	10 years
4	Master's Degree	Mechanical Engineering	12 years
5	HND	Quantity Surveyor	10 years
6	Master's Degree	Architecture	15 years
7	HND	Civil Engineering	5 years
8	Bachelor's Degree	Geology	15 years
9	HND	Quantity Surveyor	12 years
10	HND	Architecture	10 years
11	Master's Degree	Civil Engineering	18 years
12	OND	Architecture	13 years
13	OND	Electrical Engineering	19 years

14	Master's Degree	Project Management	10 years
15	Bachelor's Degree	Civil Engineering	20 years
16	HND	Civil Engineering	15 years
17	Master's Degree	Civil / Structural Engineering	More than 30 years