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Assessing maintenance budget elements for building maintenance management in Nigerian built environment: a Delphi study

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Abstract

Purpose – A maintenance budget is an element of maintenance management (MM) that deals with financial planning for maintenance operations and execution within a maintenance organisation. Developed countries have standardised MM structures which guides maintenance activities. This, however, cannot be said of developing countries, as there are few or no MM standards adopted. Given this contextual setting, the study aims to validate the relevance of maintenance budget (MB) elements utilised in developed countries for developing countries – using Nigeria as a case study exemplar. Also, the study further examines the effectiveness of the validated maintenance budget elements.

Design/methodology/approach – The research adopts qualitative techniques and employs the Delphi survey to collect and analyse primary data from an operational perception through structured questionnaires to solicit views from panellists on the subject being assessed. A relative importance index (RII) was used in measuring consensus for the Delphi study outcomes, while a Cronbach Alpha test was carried out on all the MB elements to determine their level of reliability.

Findings – The key finding from the study reveals that of the 21 elements that influence the implementation of MB, 10 elements have a very high influence on the MM of buildings (VHI: 9.00–10.00), 5 elements had a high influence (HI: 7.00–8.99) and 6 other elements scored medium impact (MI: 5.00–6.99). The elements of MB that recorded very high influence on prompt MM effectiveness include MB implementation, corruption-free maintenance process, reduction in maintenance expenditure, maintenance financial plan, cost implication of maintained asset, cash flow indexing, prioritisation of maintenance financing, maintenance funding, incorporation of financial indicators and audit of operational maintenance cost.

Practical implications – On a practical note, these elements will guide the built environment professionals in organising maintenance activities to best use limited resources.

Originality/value – Cumulatively, the research presented shows that these elements are similar to those of other countries. Effective MM of buildings is assured when these elements are integral to developing a MB.

Keywords Built environment, Maintenance management, Maintenance budget, Nigeria

Paper type Research paper

Introduction

Maintenance is an action carried out to restore or retain a structure to an acceptable standard through combining all management, technical and administration in the maintenance process

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and operations (EN 13306, 2001). Regardless of the required budget for maintenance operations, it cannot be abandoned (Ogunbayo and Aigbavboa, 2019). According to Mohd-Noor *et al.* (2011), budgeting for successful MM operations is a key factor of progression in maintenance organisations. Like other key performance indicators of MM, budgeting supports all maintenance operations and processes (Ahzahar *et al.*, 2011; Omar *et al.*, 2017). Omar *et al.* (2017) observed that the success of maintenance operations could be affected by lack of budget. Srivastava *et al.* (2020) stated that a proper budget is crucial for maintenance organisations to sustain operational effectiveness. In this study, MM is proxies by several variables – namely organisational maintenance policy, human resources management, personnel training, monitoring and supervision, task planning and scheduling, maintenance information system, maintenance approach, spare part management, outsourcing strategy and continuous improvement benchmarks against maintenance (Pantzartzis *et al.*, 2016; Srivastava *et al.*, 2020).

MB, according to Srivastava *et al.* (2020), is a driver for maintenance operations and processes. It is an estimate for maintenance operations in advance of the period which it applies (Srivastava *et al.*, 2020). As one of the core elements of MM, MB guides required estimates for manpower, spare parts, consumables and other operations expenses towards bringing efficiency and economy in the maintenance operations (Hastings, 2015; Arumsari and Rarasati, 2017). In this study, MB encapsulates the prioritisation of maintenance financing, valuation of maintenance operation budget, maintenance operation financing and other activities undertaken by the maintenance department of the public organisation that deals with financial planning for maintenance operations and execution.

According to Alsyouf (2006), an adequate MB will impact the building maintenance process. Srivastava *et al.* (2020) postulated that a well-defined MB ensures optimal maintenance operation and process towards efficient productivity and profitability. It is worthy of note that there were fewer studies carried out focussing on the scope of MB elements for the MM of buildings in developing countries, including Nigeria (Alsyouf, 2006, Ling and Formoso, 2014; Hastings, 2015). Hence, this study aims to affirm whether the elements of MB found in other countries (developed) that influence MM of buildings are significant in the maintenance of buildings within the developing countries using the Nigerian Built Environment (NBE) as a case study. It is important to note that MB elements are industry, organisational and country context. Therefore, depending on the laws, economic, political factors and organisational system, different information procedures might or might not be relevant in MB development in a particular country. Equally, depending on the elements of MB that impacted maintenance of buildings, assuming some industries, organisations and national settings to be in the same direction with the NBE will be a great distortion. However, some developed countries' organisations and industries still share a resemblance with developing countries' context. As a result, it is essential to empirically ascertain the elements of the MB that influence the MM of buildings in developing countries. Therefore, the main objective of this study is to identify elements of the MB that influence MM of buildings in developing countries and determine the extent to which each element influences building MM using the NBE as a case study.

Literature review

MB attributes: a relevant survey of existing literature

In the maintenance process, different MB types are prepared by organisations for different maintenance activities. One major aim of MB is that it is prepared to bring about economic relief and efficiency in the maintenance activities (Odent and Berthellemy, 2002). Further, some difficulties might exist in determining what to budget in maintenance activities because maintenance is not an exact science and deterioration patterns cannot be

forecasted accurately (Odent and Berthellemy, 2002). Nevertheless, Mohd-Noora *et al.* (2011) stated that researchers define MB in several ways, from different perspectives, due to the importance of running proper maintenance activities. One important aspect of MB maintenance is that it is a key factor of progression that influences the financial planning of maintenance operation in a maintenance organisation (Wireman, 2005; Ahzahar *et al.*, 2011). Although researchers have identified different elements for MB, maintenance organisations in the built industry explore every prospect to improve MB towards profitability and achieve cost savings for their organisation. Researchers have expressed diverse views regarding the explicit elements that constitute MB since the inception of MB studies. Omar *et al.* (2017) noted that these depend on maintenance funding, optimisation of business profitability financial planning, annual budget, maintenance operation system improvement, corruption-free maintenance process, maintenance materials assessment and incorporation of financial indicators. The early studies on maintenance by Campbell (1995) and Wireman (2005) and affirmed by Pukīte and Geipele (2017) more recently show that elements of MB contain cost control for labour, cost of monitoring the contractor and market and financial terms of operations. Ismail (2014) and Pukīte and Geipele (2017) postulated that MB elements also include prioritisation of maintenance financing, valuation of maintenance operation budget, maintenance operation financing, optimising maintenance resources and MB implementation. Ahzahar *et al.* (2011) emphasised that in designing MB for maintenance activities, there is a need to consider elements based on the factors as follows: better asset replacement planning, certainties in yearly MBs and financial plans. Also, in designing MB elements, Ahzahar *et al.* (2011) stated that annual MB planning, reduction in organisation maintenance expenditure and optimisation of maintenance financing outsourcing should be considered. Karia *et al.* (2014) identified the following elements as important in the MB development: maintenance operation system improvement, corruption-free maintenance process, maintenance materials assessment, maintenance funding, better asset replacement planning, certainties in yearly MBs, and operational maintenance auditing. Marquez and Gupta (2006) identified the cost of lost production, labour costs, cost of spare parts, cost of providing information systems, cost of human resources to support the programme and equipment/line/plant production lost cost as the core element of MB. Of recent, the study of Srivastava *et al.* (2020) indicated that the MB is one of the basic parts of the MM function and includes elements such as analysis of damage cost, maintenance operation system improvement, corruption-free maintenance process, and maintenance materials assessment. Mekasha (2018) identified the cost of an asset for its entire life span, failure rate cost, cost of spares, personnel cost, repair times, and components costs as an important element of the MB.

Moreover, Mohd-Noor *et al.* (2011) proclaimed that for effective and cost efficiency elements of MB will include audit of operational maintenance cost, yearly MBs certainties, cash flow indexing, planning for future asset replacement, the cost implication of maintained asset, reduction in maintenance expenditure and maintenance financial plan. Flores-Colen and Jorge (2010) postulated that MB elements would include maintenance operation system improvement, incorporation of financial indicators and optimisation of business profitability. Flores-Colen and Jorge (2010) stated that the MB elements would also contain maintenance funding, maintenance materials assessment, corruption-free maintenance process, prioritisation of maintenance financing and valuation of maintenance operation budget. The elements submitted by Pinjala *et al.* (2006) include market and financial terms of operations, MB implementation, assets maintenance prioritisation, cash flow indexing and planning for future asset replacement and cost implication of maintained asset. Also, Spedding (1987), Hamid *et al.* (2007) and Mohd-Noor *et al.* (2011) stated that elements of MB should be determined based on the type and implementation strategy of maintenance activities guided by the maintenance policy of the organisation.

Theoretical background

In explaining the elements of the MB, both the input-output model (Visser, 1998) and the decision-making model (Pintelon and Gelders, 1992) were engaged. Visser (1998)'s input-output maintenance model showed that an adequate MB is derived for maintenance activities as shown in Figure 1 and highlighted below through:

(1) MB planning (input);

(2) Organisation efficiency (process) and

(3) Maintenance operation effectiveness (output).

As noted by Visser (1998), the input-output maintenance model showed that budget within a maintenance system of an organisation is a transformation process encapsulated in an enterprise system based on input and output processes (see Figure 1). The inputs process includes material, labour, spares, information, tools, money and external services needed to achieve the desired level of effective MM. At the same time, the expected output (maintenance operation effectiveness) from the planning includes maintainability, profits, availability, safety and result-oriented output. Moreover, in achieving the expected output, there is a need for organisation efficiency through efficient production and maintenance system. Visser (1998) maintains the need for external resources to prepare the MB (see Figure 1). The input-output model detailed how maintenance activities will influence the MB for the cost of work, quality of work, availability of the facility and safety of the maintenance operation (Visser, 1998). Through this process, the profitability of the maintenance organisation would conveniently be guided (Visser, 1998; Tang, 2002).

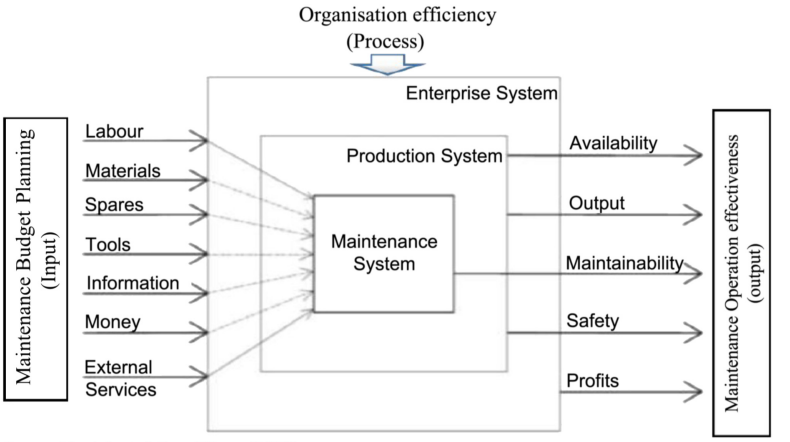
Likewise, the decision-making model, as advanced by Pintelon and Gelders (1992), showed that an adequate MB is derived for maintenance activities as shown in Figure 2 through:

(1) design effective management system;

(2) capacity for financial decision-making and

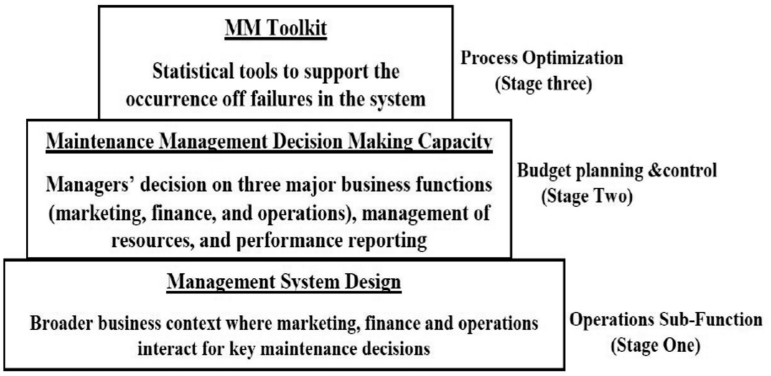
(3) provision of toolkit to support failure (techniques/actions/policies).

Further, Pintelon and Gelders (1992) suggested that the decision-making MM model consists of three stages: maintenance system design, MM decision-making capacity and MM toolkit.



Source(s): Adapted from Visser (1998)

Figure 1.
Input-output maintenance management model



Source(s): Adapted from Pintelon and Gelders (1992)

Figure 2.
Decision-making-based maintenance management model

The first stage of the model underlined the need for key decisions on MB to be guided by broader business context through a better interaction system among the maintenance organisation's marketing, finance and operation units. The second stage of the model emphasised the importance of budget planning and control that guide the decision of maintenance managers on major business functions (finance, operation and marketing), resources management and performance output. The third stage, which is the final stage, showed the need for statistical tools to support the occurrence of failures in the MB planning and control statistically. It also highlights the need for other tools to help optimise maintenance actions and policies.

As shown in Figures 1 and 2, a fair MB derived based on both models will nurture maintenance organisation to a strategical position in developing a MB suitable for executing maintenance operations and processes (Marquez and Gupta, 2006; Marquez, 2007; Alzaben, 2015; Mekasha, 2018). The built environment as a whole, particularly building and facility management organisations in Nigeria, is no exemption. Moreover, the combined model strength defines the maintenance planning, organisation efficiency and capacity for financial decision-making towards the development of MB for maintenance activities within the maintenance organisation (Marquez and Gupta, 2006; Marquez, 2007; Alzaben, 2015; Mekasha, 2018). However, it could be deduced from the above literature reviewed that MB influences building MM (Lind and Muyingo, 2012; Puķīte and Gelders, 2017; Pintelon and Muchiri, 2009). Nonetheless, in researchers' opinion on the specific elements that constitute MB, there seem to be varying views.

Consequently, to guide this study, a synthesis in the current study of the views developed by the various authors provides a more holistic framework. Hence, detailed in Table 1 were the elements of the MB theoretical concept that guided the current study. These elements, as seen in the literature reviewed, represent the views different studies have advocated predominantly.

Methodology

In assessing the elements of MB for the MM of buildings in Nigeria's built environment, this study adopted the Delphi survey technique (Aigbavboa, 2014; Ameyaw *et al.*, 2016). According to Linstone and Turoff (1975), the Delphi method is a structured communication method developed as a systematic, interactive forecasting method that depends on a panel of experts. Rowe and Wright (2001) postulated that the Delphi method believes that forecasts

Elements	Author(s)	Countries
Prioritisation of maintenance finance	Pintelon and Gelders (1992)	Belgium
	Visser (1998)	Australia
	Campbell (1995)	Canada
	Flores-Colen and de Brito (2010)	Portugal
	Wireman (2005)	The USA
Valuation of maintenance operation budget	Pintelon and Gelders (1992)	Belgium
	Visser (1998)	Australia
	Flores-Colen and de Brito (2010)	Portugal
	Ahzahar *et al.* (2011)	Malaysia
Maintenance operation financing	Pintelon and Gelders (1992)	Belgium
	Visser (1998)	Australia
	Campbell (1995)	Canada
	Wireman (2005)	The USA
	Puķīte and Geipele (2017)	Latvia
Optimising maintenance resources	Pintelon and Gelders (1992)	Belgium
	Visser (1998)	Australia
	Campbell (1995)	Canada
	Wireman (2005)	The USA
	Puķīte and Geipele (2017)	Latvia
Market and financing terms of operations	Campbell (1995)	Canada
	Wireman (2005)	The USA
	Pinjala *et al.* (2006)	Belgium
	Puķīte and Geipele (2017)	Latvia
Maintenance budget implementation	Campbell (1995)	Canada
	Wireman (2005)	The USA
	Pinjala *et al.* (2006)	Belgium
	Puķīte and Geipele (2017)	Latvia
Asset maintenance prioritisation	Pintelon and Gelders (1992)	Latvia
	Visser (1998)	Australia
	Marquez and Gupta (2006)	Spain
	Pinjala *et al.* (2006)	Belgium
Optimisation of finance outsourcing	Visser (1998)	Australia
	Ahzahar *et al.* (2011)	Malaysia
	Mekasha (2018)	Ethiopia
Audit of maintenance operational cost	Karia *et al.* (2014)	Malaysia
	Srivastava *et al.* (2020)	India
Yearly maintenance budget certainties	Karia *et al.* (2014)	Malaysia
	Ahzahar *et al.* (2011)	Malaysia
	Omar *et al.* (2017)	Malaysia
	Mohd-Noor *et al.* (2011)	Malaysia
Cash flow index	Marquez and Gupta (2006)	Spain
	Pinjala *et al.* (2006)	Belgium
	Mohd-Noor *et al.* (2011)	Malaysia
Planning for future asset replacement	Pintelon and Gelders (1992)	Belgium
	Karia *et al.* (2014)	Malaysia
	Ahzahar *et al.* (2011)	Malaysia
	Mohd-Noor *et al.* (2011)	Malaysia
	Mekasha (2018)	Ethiopia

Table 1.
Elements of maintenance budget

(*continued*)

Elements	Author(s)	Countries
Cost implication of maintained asset	Marquez and Gupta (2006)	Spain
	Pinjala *et al.* (2006)	Belgium
	Mohd-Noor *et al.* (2011)	Malaysia
	Mekasha (2018)	Ethiopia
Reduction in maintenance expenditure	Visser (1998)	Australia
	Ahzahar *et al.* (2011)	Malaysia
	Mohd-Noor *et al.* (2011)	Malaysia
Maintenance financial plan	Ahzahar *et al.* (2011)	Malaysia
	Omar *et al.* (2017)	Malaysia
	Mekasha (2018)	Ethiopia
	Mohd-Noor *et al.* (2011)	Malaysia
Maintenance operation system improvement	Flores-Colen and de Brito (2010)	Portugal
	Karia *et al.* (2014)	Malaysia
	Omar *et al.* (2017)	Malaysia
	Srivastava *et al.* (2020)	India
Incorporation of financial indicators	Flores-Colen and de Brito (2010)	Portugal
	Omar *et al.* (2017)	Malaysia
	Mekasha (2018)	Ethiopia
Optimisation of business profitability	Visser (1998)	Belgium
	Flores-Colen and de Brito (2010)	Portugal
	Omar *et al.* (2017)	Malaysia
	Mekasha (2018)	Ethiopia
Maintenance funding × (suggested by experts)		
Maintenance materials assessment × (suggest by experts)		
Corruption-free × maintenance process (suggest by experts)		

Source(s): Researchers' literature survey (2021)

Table 1.

from a structured group are more accurate than those from unstructured groups. Ameyaw *et al.* (2016) believed that Delphi's group judgement output is more accurate than individual judgements. Tilakasiri (2015) recommended the Delphi technique for the development of concepts, standards, frameworks or models for a study. With contemporary construction management literature, this method has been used extensively within the built environment studies, for instance, by Aghimien *et al.* (2021) to assess challenges applicable to the South Africa construction industry; Aliu *et al.* (2021a) examine undergraduate courses relevant to the built environment in the Fourth Industrial Revolution (4IR) era and Aliu *et al.* (2021b) used it to examine the 21st-century employability skill improvement framework for the construction industry. As demonstrated by the body of knowledge, the Delphi survey techniques adopted for this study provide a robust epistemology approach and consist of a more accurate group judgement output than individual judgements. However, the study employed the Delphi technique to collect and analyse primary data from an operational perception. As affirmed by Rowe and Wright (2001) and Fletcher and Marchildon (2014) and Somiah *et al.* (2020), Delphi is useable for both qualitative and quantitative studies and includes the use of structured questionnaires to solicit views from panellists. According to Leung (2001), this will be achieved through iterative rounds until saturation occurs, at which point participants converge on the correct (most exact) response. Also, Aigbavboa (2014) asserted that Delphi survey usage is effective, robust and suitable tool for capturing vital data in qualitative studies. Hence, this qualitative study adapted and employed the Delphi process as described in Figure 3.

The first step of the Delphi in this study was reviewing the relevant literature, through which relevant MB elements that influenced MM of buildings were identified. For Delphi's

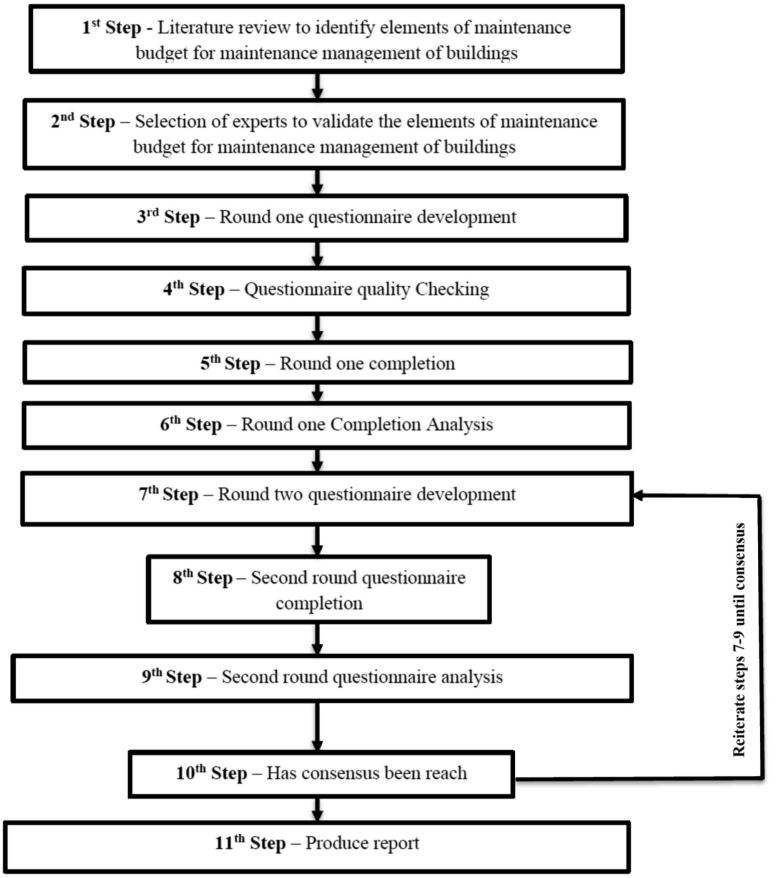


Figure 3.
Delphi process diagram

Source(s): Adapted from Aigbavboa (2014)

survey of this study, the second step was the expert selection. The experts were prudently selected based on recommendations of (Loo, 2002; Somiah *et al.*, 2020), and their opinion represents a broad spectrum on the subject being assessed. Thus, for this study, experts were mainly drawn from both industry and academia. Also, the selection criteria of experts for this study were based on Aigbavboa (2014) suggestion, which detailed that experts' practical experience and theoretical knowledge are significant in their selection. At the beginning of the study, 30 experts freely responded to be part of the Delphi study through emails. These emails were gotten through their related professional bodies and online academic profiles. However, 15 experts could not continue with the study due to their busy schedules and other personal commitments. This was written in their response to the author during round one of the Delphi study. In all, for both rounds one and two of the Delphi study, only 15 experts partook. Nonetheless, the Delphi process ended after round two when a strong consensus was achieved. In the Delphi study, according to Hsu and Sandford (2007), the sample size as a representation of a population is not reliant on a statistical sample but on bringing together experts to share their knowledge and experience in the study area. Therefore, as guided by previous studies within the subject under study (Hsu and Sandford, 2007; Aigbavboa, 2014), a

sample size of 15 experts was used for this study due to the heterogeneous nature of the selected panellists. Delbecq *et al.* (1975) noted that expert panellists of between 10 and 15 are adequate for a Delphi study provided the background of the expert panellists is homogeneous. Subsequently, for rounds one and two of the Delphi survey, instructions and questionnaires were sent to the 15 expert panellists selected. Table 2 showed clearly that the demographic profile of the expert in relation to MB development for MM of buildings had the required essential knowledge and experience.

Also, a checklist was developed for the study, and this helped in creating a benchmark for the panel of experts' selection for the Delphi study (see Appendix). Through the checklist designed, an expert panel member for the study must obtain a minimum of five points to qualify to join the Delphi study. However, all the selected 15 panels of experts obtained the minimum requirement of five points required for this study, and they were considered fit for the study. Additionally, in developing the questionnaire for the Delphi study, a rigorous literature review was carried out. Moreover, the questionnaire quality (clarity, transparency and completion period amongst others) was tested through a pilot study.

Similarly, feedbacks gotten from the pilot study was incorporated before the final questionnaire was produced. As postulated by Pallant (2007) and Rehbinder (2011), in order to create a reliable construct of multiple variables, a scale with a Cronbach's alpha higher than 0.7 is required; hence, a Cronbach alpha test was carried out on all the MB elements to determine their level of reliability. The Cronbach's alpha value for all the MB elements was 0.719. This shows that the data collection instrument is reliable, and the responses obtained

Respondents' demographic profile	Frequency (n = 15)	Percentage (%)
Highest qualification		
Doctor of Philosophy (PhD)	7	46.67
Master's degree	4	26.67
Bachelor's degree	3	20.00
Higher national diploma	1	6.67
Total	15	100
Designation		
Lecturer	6	40.00
Maintenance manager of in-use buildings	4	26.67
Facility manager	3	20.00
Research institution of buildings	2	13.33
Total	15	100
Years of experience		
0–5	1	6.67
6–10	2	13.33
11–20	5	33.33
21–30	3	20.00
Over 31 years	4	26.67
Total	15	100
Professional affiliation		
Nigerian Institute of Building	3	20.00
Nigeria Institute of Quantity Surveyors	3	20.00
Nigeria Institute of Architects	2	13.33
Nigeria Society of Engineers	1	6.67
Nigeria Institute of Estate Surveyors and Valuer	2	13.33
Real Estate Developers Association of Nigeria	4	26.67
Total	15	100

Table 2. Demographic profile of respondents'

from it can be relied upon to be valid (Pallant, 2007). Likewise, the use of a combination of the mean (M), median ($\bar{x}$), interquartile deviation (IQD) and standard deviation (σx) based on RII earlier used in similar studies such as Aigbavboa (2014) and Somiah *et al.* (2020) were employed in the analysis and determining consensus in responses of experts. Therefore, the consensus for the study was measured as detailed in Table 3.

As shown in Table 3, the consensus for the Delphi study was based on 10-points impact scale where 1 to 2 signify no influence; 3 to 4 signify low influence; 5 to 6 signify medium influence; 7 to 8 signify high impact and 10 signify very high impact. In addressing the issue of generalisation, reliability and validation of results, the Delphi findings for this study are all-encompassing theoretical reasoning and rigorousness of the data collection process (Sarantakos, 2005; Somiah *et al.*, 2020). As shown in Figure 4, the methodological structure this study adopted was underpinned by the input-output MM model (Visser, 1998) and the decision-making MM model (Pintelon and Gelders, 1992). Similarly, through the chance provided for the experts to maintain or freely effect changes to their response based on good reasons for the latter, and through tenacious individual communication with experts, internal validity for the study was asserted. Further, as theorised by Ameyaw *et al.* (2016), structured questionnaires were used in soliciting data from the panellist for this study. Also, through the use of IQD, mean, median and σx for the study was calculated and analysed for each Delphi survey round based on the estimated statistical view of the expert panellist. In line with the ethical consideration for the study, throughout the Delphi study process, the experts' identity was kept confidential.

Results

Delphi study round one result

The round one Delphi survey for this study is intended to affirm the MB elements that influence the MM of buildings in the NBE. As shown in Figure 4, eighteen (18) elements of MB during round one of the surveys identified through a literature review were validated by panellists to have influenced the MM of buildings in the NBE. Similarly, expert panellists were given opportunities to suggest new elements that may influence MB that the questionnaire might not include. Further, out of the 18 elements identified, 8 elements, namely *MB implementation, reduction in maintenance expenditure, maintenance financial plan, the cost implication of maintained asset, cash flow indexing, prioritisation of maintenance financing, incorporation of financial indicators and audit of operational maintenance cost* had a very high influence (VHI: 9.00–10.00) on MM of buildings, 5 elements, namely *yearly MBs certainties, valuation of maintenance operation budget, maintenance operation financing, market and financial terms of operations and optimisation of finance outsourcing* had a high influence (HI: 7.00–8.99), while other 5 elements, namely *optimisation of business profitability, asset maintenance prioritisation, maintenance operation system improvement, optimising maintenance resources and planning for future asset replacement* have medium influence (MI: 5:00–6.99). The experts' panellist suggested three new elements, which have been marked by the * sign during the round one survey (see Table 4). As suggested by the panellist, the new elements were *maintenance funding, maintenance materials assessment and a corruption-free*

Table 3. Relative importance index for measuring consensus in Delphi study outcomes

S/n	Consensus	Median (M)	Relative impact index (RII)	Interquartile deviation (IQD)
1	Strong consensus	9–10	0.80–1.00	≤1
2	Good consensus	7–8.99	0.60–0.79	≥1, 1 ≤ 2
3	Weak consensus	≤6.99	≤0.59	≥2, 1 ≤ 3

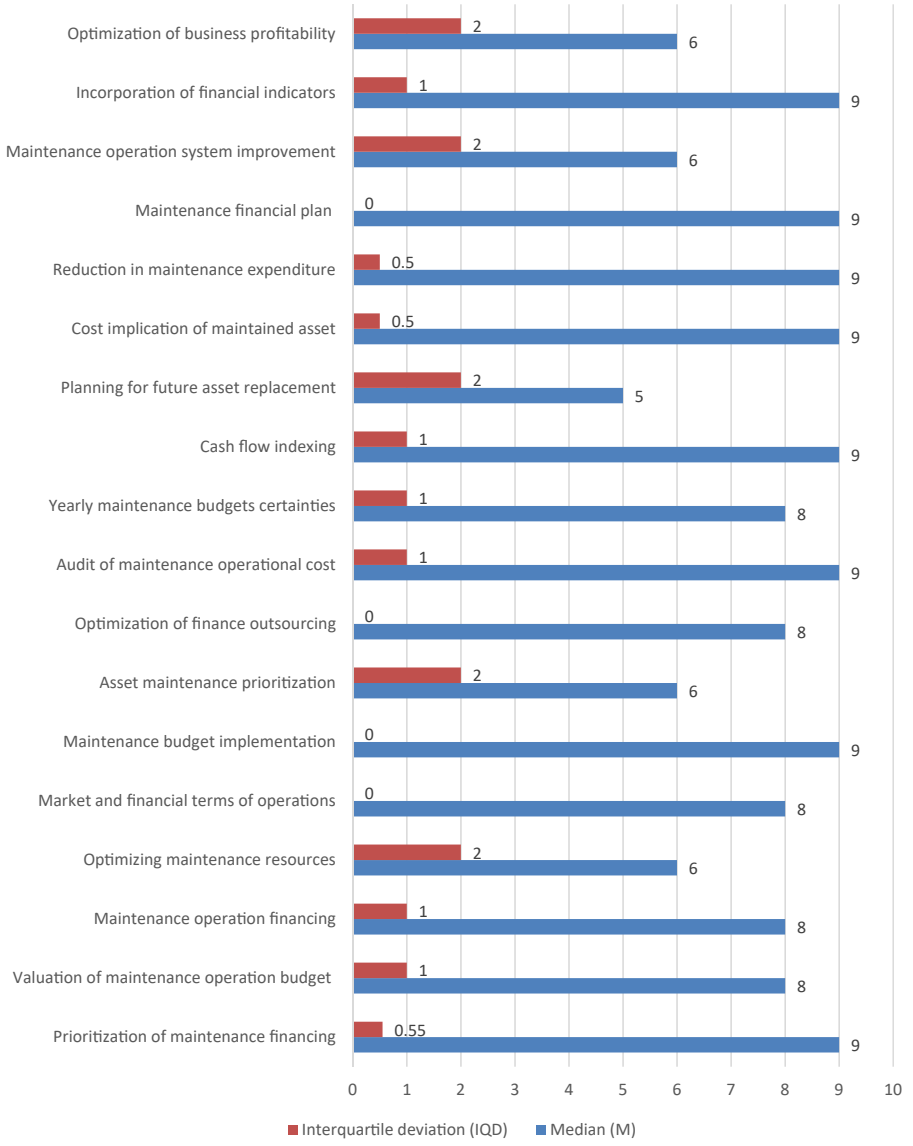


Figure 4.
Delphi study round one results – elements of maintenance budget maintenance for maintenance management of buildings in the Nigerian built environment industry

maintenance process. These new elements were included for assessment as suggested by the experts in the second round (see Table 4).

Round two results of Delphi study

In round two of the Delphi study, a total of 21 elements constituted the elements of MB of building in the NBE. Out of the 21 elements, 15 elements have good consensus. Ten of the elements that recorded (VHI: 9.00–10.00) were *MB implementation* with mean ($\bar{x}$) score of

Sub-attributes of maintenance budget	Median (M)	Mean ($\bar{x}$)	Standard deviation (σx)	Interquartile deviation (IQD)	Mean scores ranking (R)
Prioritization of maintenance financing	9	8.73	0.44	0.55	7
Valuation of maintenance operation budget	8	8.20	0.83	1.00	12
Maintenance operation financing	8	8.20	0.65	1.00	12
Optimizing maintenance resources	6	5.90	1.46	2.00	20
Market and financial terms of operations	8	8.00	0.52	0.00	14
Maintenance budget implementation	9	9.14	0.34	0.00	1
Asset maintenance prioritization	6	6.01	1.16	2.00	18
Optimization of finance outsourcing	8	7.99	0.52	0.00	15
Audit of maintenance operational cost	9	8.38	0.72	1.00	10
Yearly maintenance budgets certainties	8	8.26	0.85	1.00	11
Cash flow indexing	9	8.81	0.75	1.00	6
Planning for future asset replacement	5	5.60	1.59	2.00	21
Cost implication of maintained asset	9	8.87	0.64	0.50	5
Reduction in maintenance expenditure	9	8.93	0.70	0.50	3
Maintenance financial plan	9	8.93	0.59	0.00	3
Maintenance operation system improvement	6	6.00	1.25	2.00	19
Incorporation of financial indicators	9	8.47	0.83	1.00	9
Optimization of business profitability	6	6.40	1.30	2.00	16
Maintenance funding*	9	8.67	0.62	0.50	8
Maintenance materials assessment*	6	6.33	1.40	2.00	17
Corruption-free maintenance process*	9	9.13	0.74	1.00	2

Note(s): *Values connotes variables suggested by expert pannelists

Table 4.
Round two Delphi study results – elements of maintenance budget for maintenance management of buildings in Nigerian built environment

(9.14) emerge first, *corruption-free maintenance process* with $\bar{x}$ value of (9.13) emerge second. Similarly, *reduction in maintenance expenditure and maintenance financial plan* with $\bar{x}$ value of (8.93) jointly ranked third, *cost implication of maintained asset* with $\bar{x}$ value of (8.87) emerge fifth, *cash flow indexing* with $\bar{x}$ value of (8.81) ranked sixth, *prioritisation of maintenance financing* with $\bar{x}$ value of (8.73) ranked seventh, *maintenance funding* with $\bar{x}$ value of (8.67) ranked eighth, *incorporation of financial indicators* with $\bar{x}$ value of (8.47) ranked ninth and *audit of operational maintenance* cost with $\bar{x}$ value of (8.38) ranked tenth in MM of buildings in the NBE (see Table 4). Whereas 5 elements that recorded (HI: 7.00–8.99) were *yearly MBs certainties* with $\bar{x}$ value of (8.26) ranked 11th, *valuation of maintenance operation budget and maintenance operation financing* both jointly ranked 12th with $\bar{x}$ value of (8.20), *market and*

financial terms of operations with $\bar{x}$ value of (8.00) ranked 14th and *optimisation of finance outsourcing* with $\bar{x}$ value of (7.99) ranked 15th. The last 6 elements with a medium influence value (MI: 5.00–6.99) were *the optimisation of business profitability* with $\bar{x}$ value of (6.40) ranked 16th, *maintenance materials assessment* with $\bar{x}$ value of (6.33) ranked 17th, *asset maintenance prioritisation* with $\bar{x}$ value of (6.01) ranked 18th, *maintenance operation system improvement* with $\bar{x}$ value of (6.00) ranked 19th, *optimising maintenance resources* with $\bar{x}$ value of (5.90) ranked 20th and *planning for future asset replacement* with $\bar{x}$ value of (5.60) ranked 21st. As detailed in Table 4, the IQD scores used in determining the consensus levels varied among the elements, while the σx scores amongst 15 of the elements show a very strong consistency level and little variability in the panellist responses. Moreover, the Cronbach's alpha value of the 10 elements that recorded IQD score VHI: 9.00–10.00 and the other 5 elements that recorded IQD score HI: 7.00–8.99 were found to be 0.719. This shows that the data collection instrument is reliable, and the responses obtained from it can be relied upon to be valid.

Discussions

The study aimed to establish whether the elements of the MB found in other countries that influence the MM relevant to the maintenance of buildings in the NBE. In total, 21 elements of the MB were found to influence the MM of buildings in NBE. Though the level of consensus amongst the elements varies, the IQD scores indicated consensus for 15 of the elements, with the 1QD being ≤ 1 or ≥ 1, $1 \leq 2$, respectively. Similarly, (σx) of the 15 elements indicated consistency in the experts' responses, as their σx values were at most 1.

Of the top ten elements that recorded (VHI: 9.00–10.00), six elements are similar to findings of the studies by Visser (1998) and Pinjala *et al.* (2006). These include MB implementation, *corruption-free maintenance process, maintenance financial plan, maintenance funding, cash flow index and the prioritisation of maintenance financing*. These were the elements of the MB that influence the effectiveness of MM of buildings. The findings are also in line with the study of (Omar *et al.*, 2017). Equally, the other four elements, namely *reduction in maintenance expenditure, cost implication for maintained asset maintenance funding, incorporation of financial indicators and audit for the operational maintenance cost* aligns with the studies by Ahzahar *et al.* (2011) and also affirmed by the study of Mohd-Noor *et al.* (2011) who highlighted the elements for MB. The study's finding based on the RII for measuring consensus in the Delphi study outcomes showed that strong consensus was achieved for all the ten elements. Their median (M) score is between 9 and 10 and RII is between 0.80 and 1.0, with IQD ≤ 1. Comparatively, of the five elements that recorded (HI: 7.00–8.99), three of the elements were consistent with the studies by Campbell (1995) and Wireman (2005) that focussed on *yearly MBs certainties, optimisation of finance outsourcing and valuation of MB* as elements of the MB that influence the effectiveness of MM of buildings. The findings are comparable with Flores-Colen and de Brito (2010) study, which listed the various MB elements influencing MM of buildings. The other two elements, namely *market and financial terms of operations and maintenance operation financing* aligns with the study of Pintelon and Gelders (1992) and Puķīte and Geipele (2017) on various MB elements for the effectiveness of MM of buildings. Based on the RII for measuring consensus in the Delphi study outcomes, the study's finding showed that good consensus was achieved for all five elements. As their M scores are between 7 and 8.99, RII scores are between 0.60 and 0.79, with IQD ≥ 1, $1 \leq 2$.

The 15 elements' respective scores indicate consistency in the expert panellists' response as their σx values were between 0.00 and 1.00. Additionally, the Cronbach's alpha value for the 15 elements was 0.719. This agreed with Pallant (2007) and Rehbinder (2011) that a scale with a Cronbach's alpha higher than 0.7 is required to create a reliable construct of multiple

variables. Thus, in this study, a Cronbach's alpha value of 0.7 and above is considered reliable and indicative of internal consistency amongst the variables of MB elements.

Lastly, the remaining six elements, namely *the optimisation of business profitability*, *maintenance materials assessment*, *asset maintenance prioritisation*, *maintenance operation system improvement*, *optimising maintenance resources* and *planning for future asset replacement* based on the study findings, all recorded weak consensus. The RII for measuring consensus in the Delphi study outcomes showed that weak consensus was achieved for all the six elements as their M scores is ≤ 6.99 and RII scores is ≤ 0.59, with IQD $\geq 2, 1 \leq 3$. Also, the 6 elements' respective scores for standard σx indicate inconsistency and variability in the expert panellists' response as their σx values were above 1. Moreover, the Cronbach's alpha value for the six elements with the IQD of $\geq 2, 1 \leq 3$ were found to be 0.719, which is within the acceptable 0.7 required to create a reliable construct of multiple variables. However, with the low IQD score, it is thus considered that the elements were unindicative of internal consistency. This indicates that the six elements cannot be incorporated into MB standards for maintenance operations in developing countries. Thus, they do not influence MB for MM of buildings within the NBE.

Practical and theoretical implications of this work

The critical outcome of this study shows it has theoretical, practical and policy implementations. Empirically, the study affirms that elements of MB are required for effective MM of buildings in the NBE. The identified elements of MB will assist maintenance organisations in the NBE in preparing an accurate maintenance cost and estimate for maintenance activities. The study theoretically advances that MB for MM of buildings represents 15 essential elements. Amongst these vital elements were MB implementation and corruption-free maintenance process, indicating that MB is the key to effective maintenance and corruption-free maintenance. On a practical note, the study establishes the relative influence of each validated element to guide stakeholders in the built environment in preparing an operational estimate for required consumables, spare parts, human resources and other expenses. It ought to guide the stakeholders in the planning and controlling the use of available resources towards achieving the maintenance set objectives.

Similarly, in preparing an operational estimate, the findings of this study will assist built environment professionals in designing a good MB for preventive maintenance with a better MB recording. It will also help to develop a financial plan when considering seasonal maintenance need. Moreover, the findings of this study will assist built environment professionals in guiding against inaccurate financial planning for maintenance operations. Finally, the findings of this study will help the built environment professionals reduce wastage, improve the maintenance process and increase productivity amongst maintenance personnel.

Conclusions and recommendations

This study was carried out to establish whether the element of MB found in other countries that influence MM of buildings are relevant in the maintenance of buildings in the NBE. The expert panellists appraised a total of 21 MB elements that were perceived to have influenced MM. However, out of the total elements validated, 15 elements of the MB were found to have influenced MM of buildings in NBE industry. Moreover, these elements were consistent with MB elements that have been identified by earlier studies in some international and national contexts.

In conclusion, the study's findings indicated that 15 out of the identified elements of MB from developed countries are valid for developing countries and are effective for MM in the

NBE. These elements will help the built environment in organising maintenance activities in such a way as to make the best use of limited resources by providing an objective basis for decisions such as which components should be encompassed in maintenance activities. Therefore, the objectives of the study were achieved. Based on the study's findings, it is thus recommended that in preparing MB for MM of buildings in the NBE, the validated elements of MB should be sought since these elements are vital to the built environment industry toward MM of buildings.

The study also recommends that the MB elements identified from this study should guide industry practitioners in the maintenance practice. However, due to time constraints, the study was limited to build environment professionals within Southwestern Nigeria, which interprets to show that the findings cannot be entirely generalised for the NBE. However, it is pertinent to know that professionals in Southwestern Nigeria used for this study account for the significant professional activities in the NBE. Conversely, future studies can be carried out to test the MB elements in practice to ensure the study's findings apply to the built environment practically. This can be done by incorporating all built environment practitioners who have first-hand experience with day-to-day maintenance activities.

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Appendix

Table A1. Criteria/checklist for constituting the panel of experts for the Delphi study

Questionnaire items	Marks possible	Expected maximum marks	Expected minimum marks	Obtained minimum marks
Q1. Please indicate your highest level of education				
Higher diploma	1 point		1 point	1 point
Bachelor's degree	2 points			
Master's degree	3 points			
Doctoral degree	4 points	4 points		
Q2. Are you a member of any professional body in Nigeria?				
Yes	3 points	3 points		3 points
No	1 point		1 point	
Q3 Please indicate your years of experience in the Nigerian built environment industry				
0–5 years	1 point		1 point	1 point
6–11 years	2 points			
11–20 years	3 points			
21–30 years	4 points			
Over 31 years	5 points	5 points		
Total		12 points	3 points	5 points

Note(s): Minimum obtained marks of 5 points qualified an expert to be part of the Delphi panel

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