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Original Article

Supply Chain Model for Construction Projects in Developing Countries

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Abstract *- Rapid changes occurring in the world impact construction project planning, leading to an increase in cost and duration. Owing to the high number of uncertainties in construction projects, businesses struggle to adhere to established work schedules. Consequently, enterprises cannot monitor purchase orders for raw materials, leading to an increase in raw material prices and waste. This research devolved a model to deal with supply chains in Developing Countries, starting from the initial planning stage through the demand for raw materials to their storage on-site. The benefit of this model is that each change to the project (quantities of items - new items - canceling things - modifying raw materials pricing - etc.) will have its effect on the raw materials request calculated. The model validity was checked by entering data from an actual field project, and adjustments were made to the design, supply conditions, and material requirements.*

Keywords *- Supply Chain Management, Construction management, Material management, Construction project, Construction in developing countries.*

1. Introduction

During the financial crisis, several challenges were highlighted, including difficulty obtaining financing, increased costs of materials and labor, a shrinking construction market, slim profit margins, and tough competition. The wildly changing pricing of building materials has long been a problem for the construction industry in developing countries. In the construction and engineering industry, the importance of materials cannot be overstated [1]. Because as mentioned by [2], construction materials constitute around half of the total project cost and, when assembled properly, serve as the basis for any structure. According to studies by [3], and [4], the cost of construction materials may make up as much as 65% of the entire cost of a building project.

Owing to factors such as fluctuating building material pricing, inept project management, dishonest contractors, and political favoritism, public construction projects in developing countries often encounter cost overruns, delays, and even abandonment [5]. It is the same story in countries such as Ethiopia, where [6] says that varied pricing for construction materials hinders the completion of projects. [7] highlight the factors that lead to the increasing cost of construction projects in developing countries. A construction project's timely completion depends on the timely availability and equitable distribution of building supplies [8]. Nonetheless, this has hampered attempts by public and private investors to engage in expanding the area's infrastructure to support its sustained growth and development [9]. According to [10], clients, consultants, and builders in the construction business often encounter the issue of price volatility among building supplies.

1.1. Construction Projects

As an important element of most countries' GDP, construction projects have been hit hard by the COVID-19 pandemic. Maintaining an efficient Supply Chain Management (SCM) procedure ensures building supplies are delivered on time throughout construction. However, this is necessary in order to manage the unforeseen disruption risks to supply chains that may arise as a result of a wide variety of natural or man-made disasters, such as a tsunami, earthquakes, terrorist activity, war, economic upheaval, political, and other social and organizational events, such as government shutdowns. [11]

Stronger SCM is needed to withstand shocks like policy shifts, work stoppages, and other disruptions. Although the likelihood of such a supply chain disruption is limited, its potential influence on a project's success should not be underestimated. If you can improve your supply chain management, it could be possible to reduce the time, money, and energy wasted fixing bad-quality work on your projects [12]. Having a well-managed supply network has been proven to provide businesses an edge by allowing them to recover from interruptions [13] quickly.

Successful completion of a construction project within the specified time schedule, budget, and quality standards is universally acknowledged as the single most essential and often used performance indicator. As a result, studies on the connections between SCM skills and project outcomes in the building industry are warranted. Although there is a paper trail connecting SCM knowledge to improved business performance, there is very little in the way of figures demonstrating how SCM processes affect construction projects' end outcomes [14].

1.2. Supply Chain Management

Supply Chain Management (SCM) examines and coordinates the activities of all participants in the manufacturing and distributing of goods and services, from gathering raw materials to the end user [15]. The supply chain is the system of individuals and organizations responsible for the production and distribution of a product. The manufacturers of raw materials serve as the first link in the chain, and the last connection occurs when the finished product is delivered to the consumer by van [16]. According to [17], the basic goal of SCM is to maximize productivity and profit, or the overall value produced throughout all supply chain stages (financial, informational, product/material). The strategic alignment between customer expectations and SC performance is crucial to a supply chain's success in a highly competitive market [18]. Strategic fit, as defined by [19], is the degree to which an organization's internal resources and skills match its external environment (the needs or expectations of its clients or consumers).

1.3. Construction Supply Chain

The significance of the construction industry to the global economy is reflected in the longevity of research on Construction Supply Chains (CSCs), which dates back to at least the 1980s [20]. CSCs differ from industrial supply chains due to the wide variety of projects they support and the complexity of the underlying contractual relationships [21]. Short-term contractual arrangements and the project-based nature of CSCs make them especially susceptible to commitment swings and uncertainty [22]. The reliability of project delivery, the speed of material flow, the quality of communication, and the efficiency of project management are all things that might suffer when CSCs are poorly managed [23].

While the construction industry has undergone significant transformation over the last several decades as a result of advances in both technology and culture, CSCs themselves seem to have altered little. CSC has several difficulties. The major issues in the CSC emerge at the points of contact between distinct actors or phases, see Figure 1. Critical issues in the CSC manifest at the interaction points between different actors and stages. The CSC's autonomous and short-sighted control is to blame for the issues. Construction supply chain performance challenges are caused by several factors, including change orders, poor communication, a lack of coordination and integration within functional disciplines, and a lack of overall integration. These issues cause the project plan to be in a constant state of change. [24]

1.4. Construction Supply Chain Challenges in Developing Countries

Using [25], and [26] as examples of illustrious works, it is evident that the vast bulk of CSC management-related research has been undertaken in developed nations. However, most models and frameworks produced in the developed world advocate for certain structures that would be impractical in less developed nations. For instance, in the UK, [25] used simulation platforms to establish a construction supply chain (CSC) architecture. In the United Kingdom, an integrated information framework by [25]. Even if the results of this research have led to better SCM in the construction sector, there are several obstacles in the way of their transferability to nations with weaker economies. [26], for instance, found that the lack of a model enabling the deployment of Radio frequency identification (RFID) in developing nations meant that the technology was not given the attention it deserved. Therefore, it is reasonable to assume that the success of CSC management in underdeveloped nations has been hampered by the absence of a model able to demonstrate the use of technologies like RFID.

The most formidable obstacle in attempting to transplant a model created for use in the developed world onto the developing world is the large difference that exists between their respective construction industries. In the UK construction industry, [27] devised a maturity model for supply chain (SC) connections, illustrating four maturity stages and 24 assessment criteria. This structure was based on the research and benchmarks developed by Egan and Latham. In developing countries, there is no consistent standard by which to evaluate the success of CSCM. Meanwhile, [28] Australia employs a CSCM architecture based on mobile internet communication. The Australian building industry deemed the framework adequate because of its emphasis on regulation and oversight for cybersecurity and internet-based information access.

The approach helped enhance CSC management in Australia. Mobile internet has the potential to revolutionize industries, but there has not been a successful example in a poor country yet. There is a need for a CSCM model designed to meet the needs of developing nations since existing frameworks and models for CSCM in rich countries fall short. On the other hand, studies of CSCM in developing nations focus on Supply Chain Management (SCM) structures in the building sector, including lean, agile, green, and many others. Studies in developing countries have not produced a comprehensive framework for modelling SCM in the construction sector.

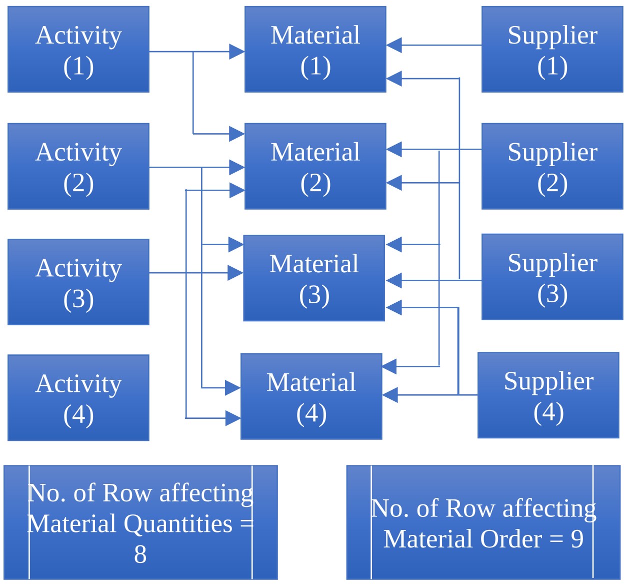

Fig. 1 Material in construction supply chains

2. Problem Statement

Changes in the cost of manufacturing inputs and continuing changes made to project needs are constant challenges for developing countries, which often face shortages of both vital resources and skilled laborers. Therefore, contracting companies may struggle to determine the optimum way to go through the supply chain to finish a project at the lowest feasible cost and according to the ideal set of criteria within the specified time period. The implementation of the works is delayed, the budget grows, and the quality worsens as a result of the overlapping of so many components in the execution of the supply chain in construction projects. Therefore, contracting companies must analyse the supply chain thoroughly to eliminate the bottleneck. The complexity of the construction industry's supply chain arises from the fact that more than two main elements—the quantity of material in each activity and the conditions of the supplier for the supply of this material—control the purchase orders for raw materials. It is common practice in construction projects for a single material to be utilized in executing many activities and procured from multiple vendors (as needed). Changes in project requirements and the economic difficulties faced by developing nations mean that costs must be adjusted, and certain activities may be scrapped entirely or replaced with others while others may be added.

Particularly in projects with a high activity count, the supply chain struggles to keep up with these changes. So, suppose we assume a project with four activities, as shown in Figure 1. In that case, the required quantity of a material like material 2 is calculated from activities 1, 2, and 3 and supplied from suppliers 2, 3, and 4. Any change in the quantities of activities 1, 2, and 3 affects the supply of this material 2. As a result, we can identify six influence scenarios on the substance. If the project requires numerous distinct activities and, by extension, a wide variety of raw materials and service providers, the number of factors involved may quickly grow beyond control, and potential conflicts may arise. As a result, it has become more difficult for construction companies to keep costs under control and pinpoint the optimal scenario for the supply chain of raw materials.

3. Methodology

This study's methodology is grounded in a review of existing literature on supply chain management in construction projects, followed by a thorough analysis of existing practices that make optimal use of the resources in developing countries' construction projects. From the contractor's perspective, the supply chain information flows in two directions: the first involves the exchange of specifications and needs, while the second involves the exchange of project terms and schedule details. Until the project is finished, traffic in both directions follows a closed loop determined by the general contractor (as shown in Figure 1).

Contractors may break down the implementation of each given project component into three distinct phases: Phase one is looking at the project components and figuring out how much of everything is needed. Simply said, this is the "planning" phase. At this point in time, the consultant and the person in charge of planning are in constant communication with one another.

This is the second stage, sometimes known as the supplier selection stage or just the supplier's stage. The procurement officer's and suppliers' working relationship is in its current phase. The third and final step, also known as the inventory stage, is when the necessary quantities of raw materials are determined based on implementation and storage at the site.

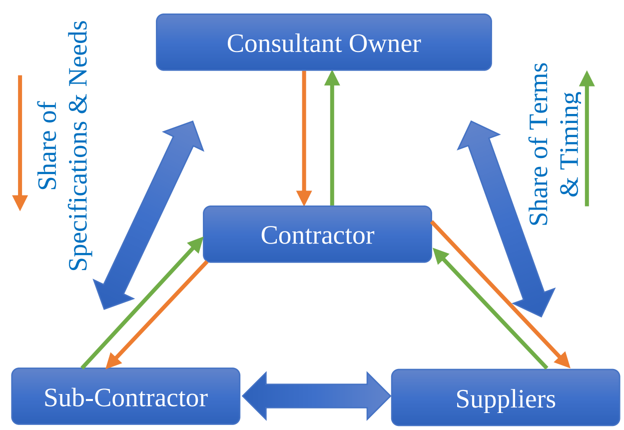

Fig. 2 Construction supply chain in developing countries

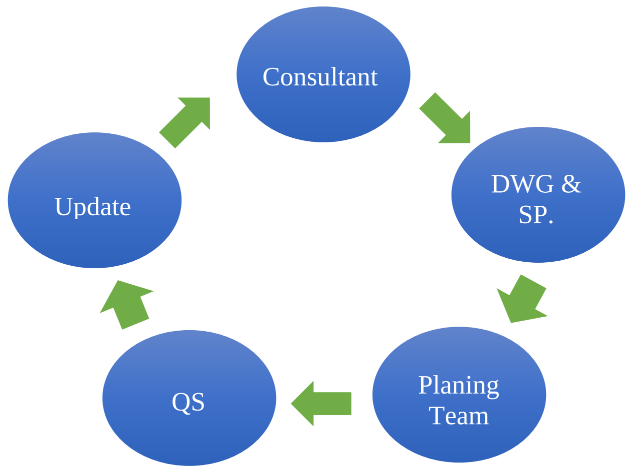

Fig. 3 Planning phase

Throughout the process, the consultant and the contractor operate as intermediaries, each using the knowledge in their own way. At first – as shown in figure 2-, the consultant creates the panels and specifications (SP.); secondly, the contractor's planning team calculates the components of the items (quantities surveying QS); finally, the consultant approves the items; and this cycle repeats itself until the item is executed or no changes are made.

The supplier stage presents a more difficult challenge due to the overlapping responsibilities – as shown in Figure 3- of the planning stage (responsible for determining quantities and timings), the procurement department (responsible for collecting supplier offers), the store (responsible for the timings of ordering quantities), and the consultant (responsible for approving the supplier). They are interconnected, and there is no direct friction between their elements, which leads to several problems, such as the purchase of raw materials in insufficient quantities or at inconvenient times, the consultant's rejection of those materials, the storage of those materials in a way that leaves them open to destruction, the selection of an insufficient financial supplier, and so on.

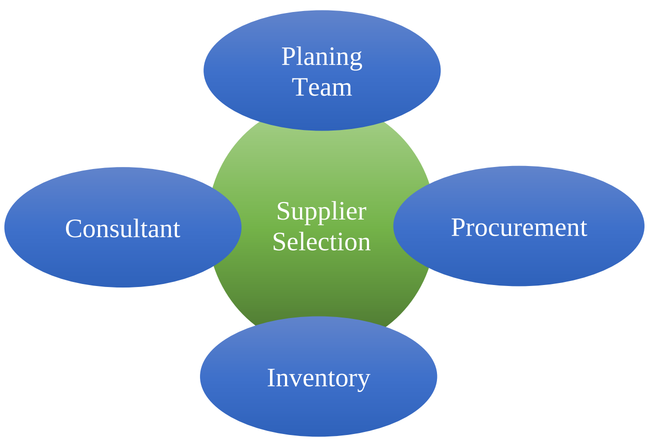

Fig. 4 Supplier phase

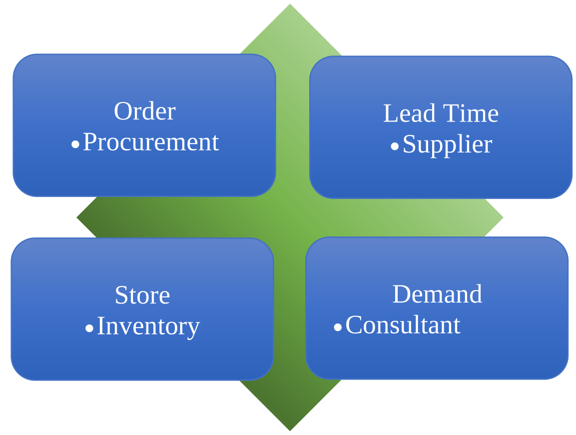

Fig. 5 Inventory phase

Each phase of the project has a connection to another part, with demand relating to purchasing management, delivery relating to the supplier, and storage relating to the management of stores and demand. The final phase – as shown in Figure 4- is the inventory phase, in which the supply chain is the request for raw materials, and the timing of the request is related to the supplier's ability to provide the raw material, then store the raw material, and consume the raw material.

4. Model Development

It is hoped that the model would facilitate communication between the departments working on the project. The model's intention is also to facilitate easy modification. Reduce the time spent on information sharing by doing away with wasteful methods. The model's objective required the creation of three major divisions to accomplish: planning, procurement, and storage. The Planning Team must input the project timeline and identify the resources needed for each task. It is also in charge of checking in with the project consultant and making any necessary adjustments to the timetable or activity requirements. The bids, conditions, and any changes to the bids from vendors are entered by the Supplier Selection Division. The inventory division is in charge of recording the available stock of each raw material and keeping a close watch on that information during the project's execution.

The General Administration – as shown in Figures 6 and 7- establishes users on behalf of each department, splitting them up into a manager and their staff for simplified service delivery. While the manager has access to the program's complete features for management purposes, the manager sets certain of the employee's responsibilities. Each manager inputs the unit and activity names, raw materials, and supplier names he will use in the software separately to avoid any duplication of data entry. The company's interest in its investment and the relative weight of the factors used to choose the best proposals presented by suppliers are both established by the General Administration, which also names a manager for each department.

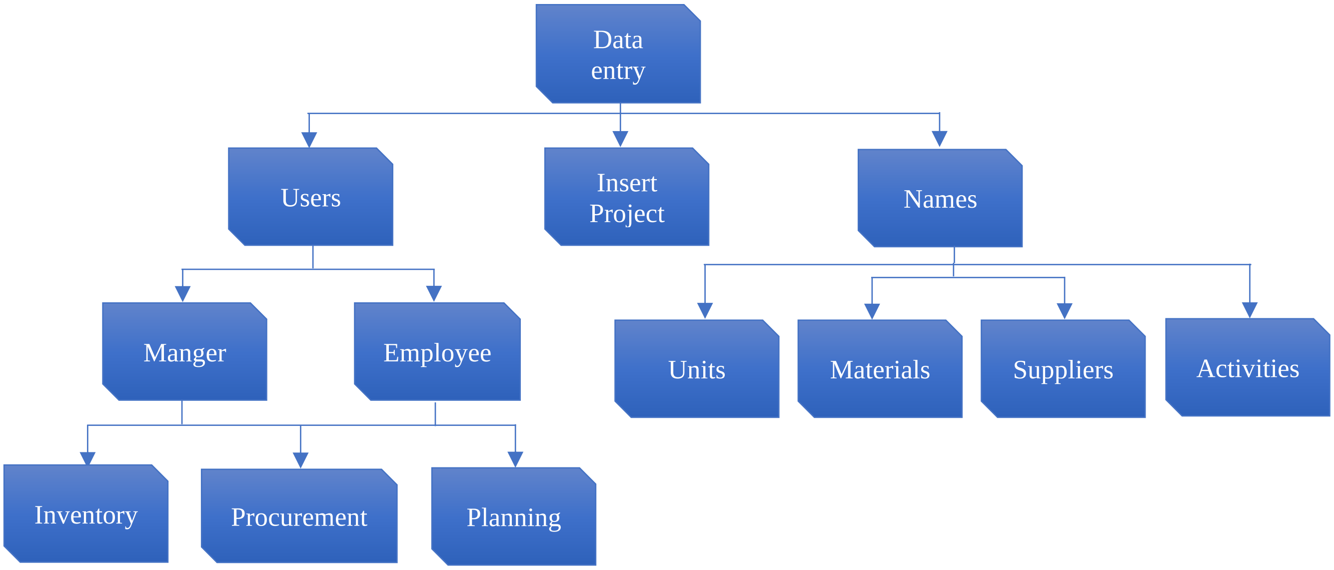

Fig. 6 Model data entry

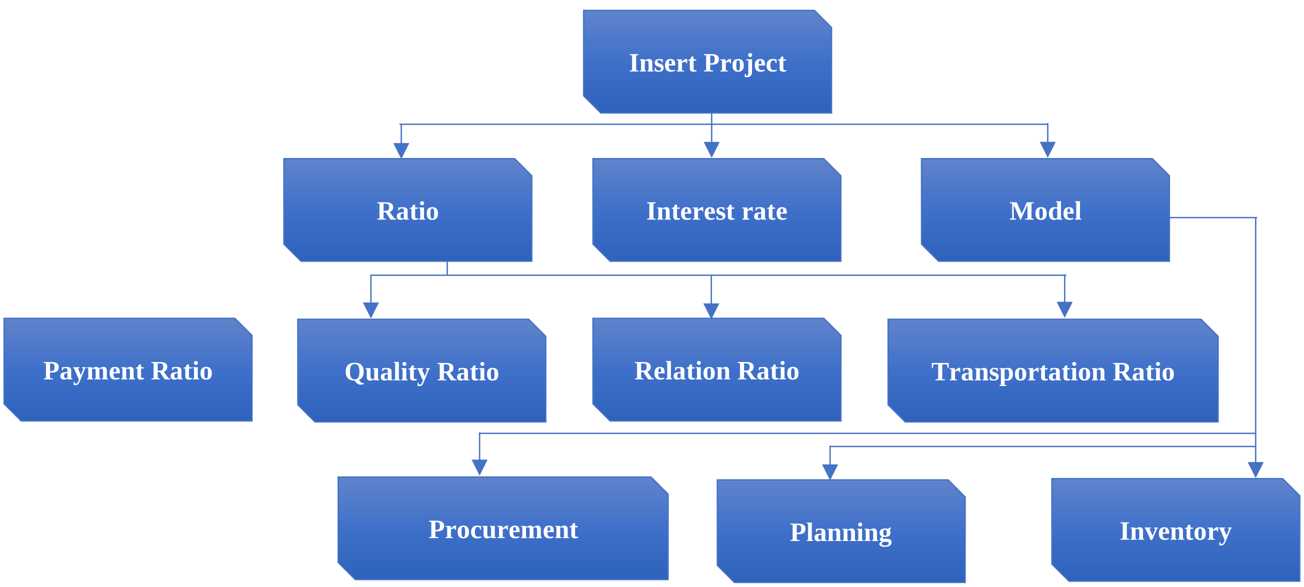

Fig. 7 Project data entry

The program's work is broken down into three phases of implementation: data entry, data analysis, and output. First, the model generates a schedule for the project based on data entered by the project management (more on this below). It calculates the quantities of raw materials needed for the project by determining the required raw materials and their relationship to the project items. Finally, the first stage concludes with determining the quantities needed for each material distributed weekly throughout the duration of the project's implementation. The next step is to choose the most advantageous bids offered by Suppliers to provide the necessary raw materials. The model examines the information submitted by the Procurement Department (more on this later), selects the most reliable suppliers, and revises the schedule every week to reflect the new names of the most reliable suppliers as providers. Finally, the model examines the information entered by the warehouse department (to be explained later) to calculate the amount of time needed for the order to be fulfilled before the materials arrive on the scheduled dates and to update the schedule to include the dates of orders for the materials according to the suppliers.

In the same way, as in Figure 8, integration happens throughout all project departments thanks to a unidirectional flow of information, and the software recalculates for each stage individually in the event of any changes to the input data. The model has been broken down into a series of loops that function independently and accept adjustments to avoid dealing with big data collection. In this way, the model will update the data whenever any changes are made and play the loop that caused the change and the loop that followed it. For instance, if any values are changed, the model will execute the first loop, the second, etc, producing different results each time. If the change is made to the terms of suppliers, the model will only perform the third and fourth loops. The time required to extract relevant information is reduced as a result.

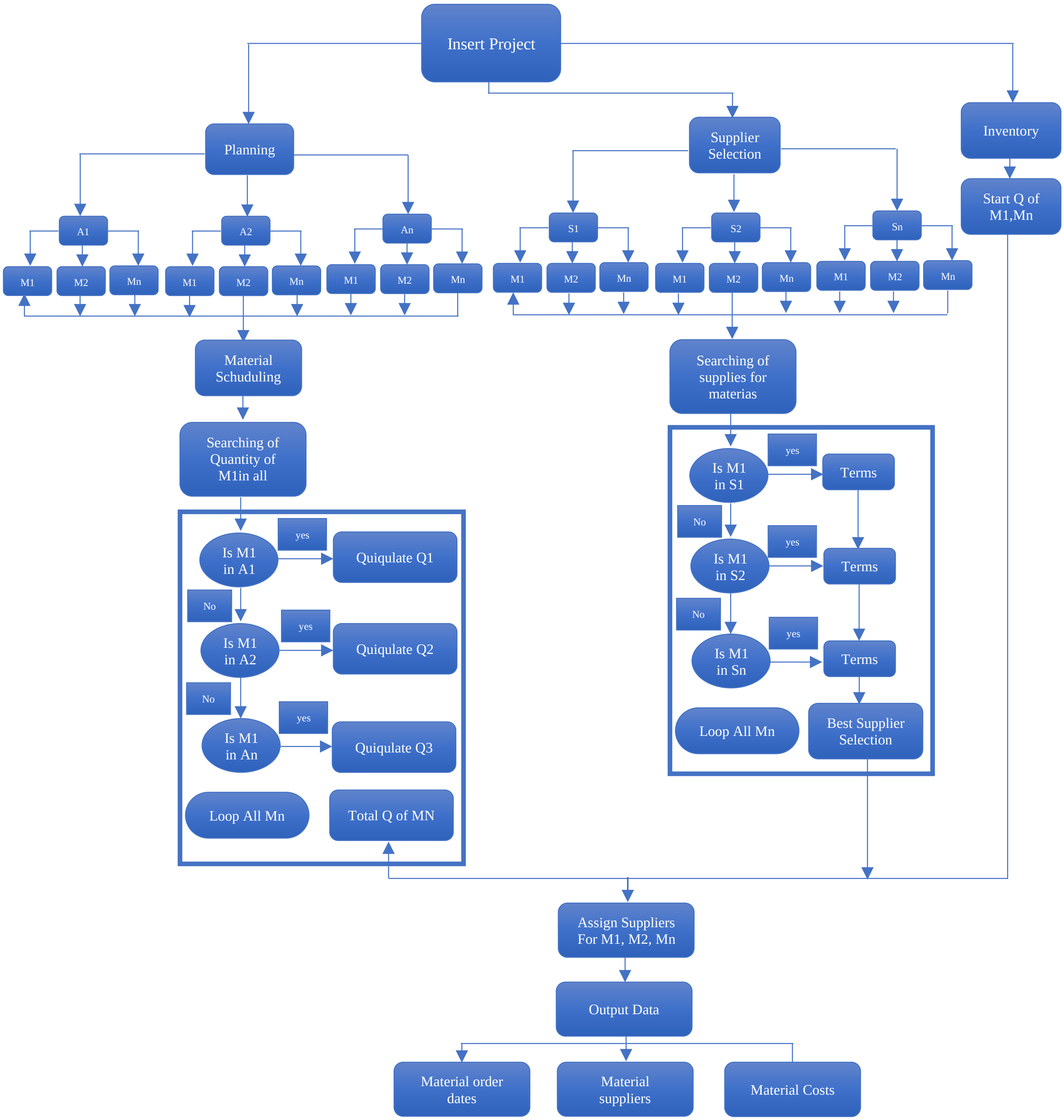

Fig. 8 Model flow chart

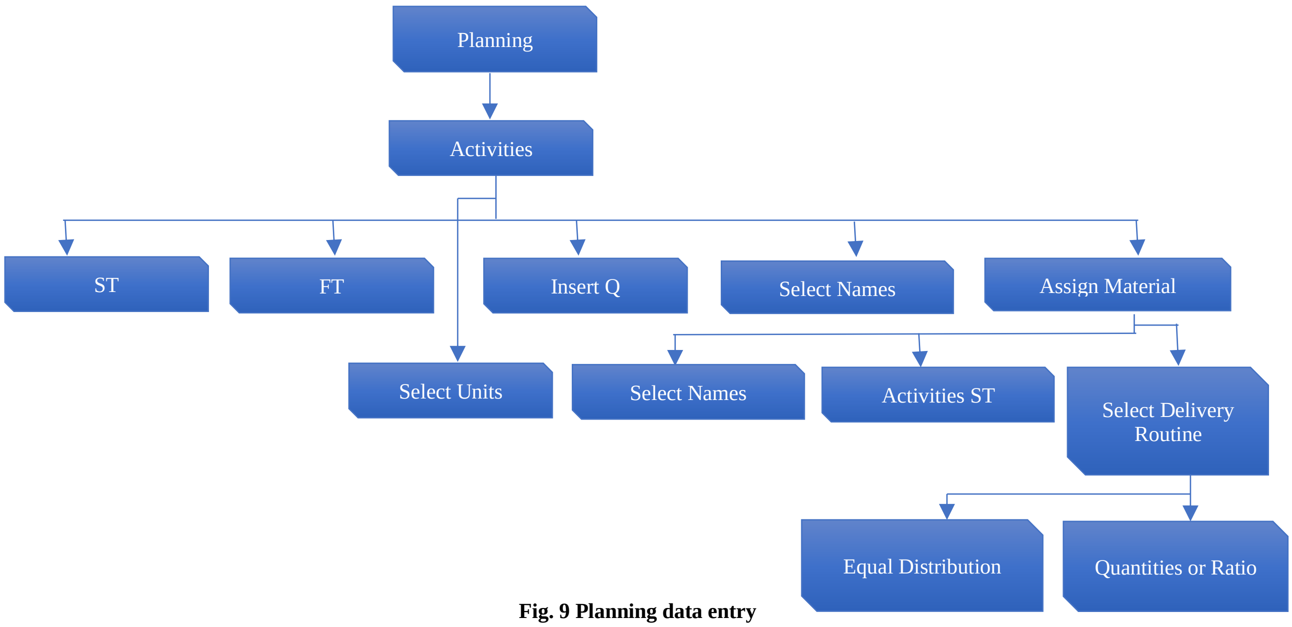

Fig. 9 Planning data entry

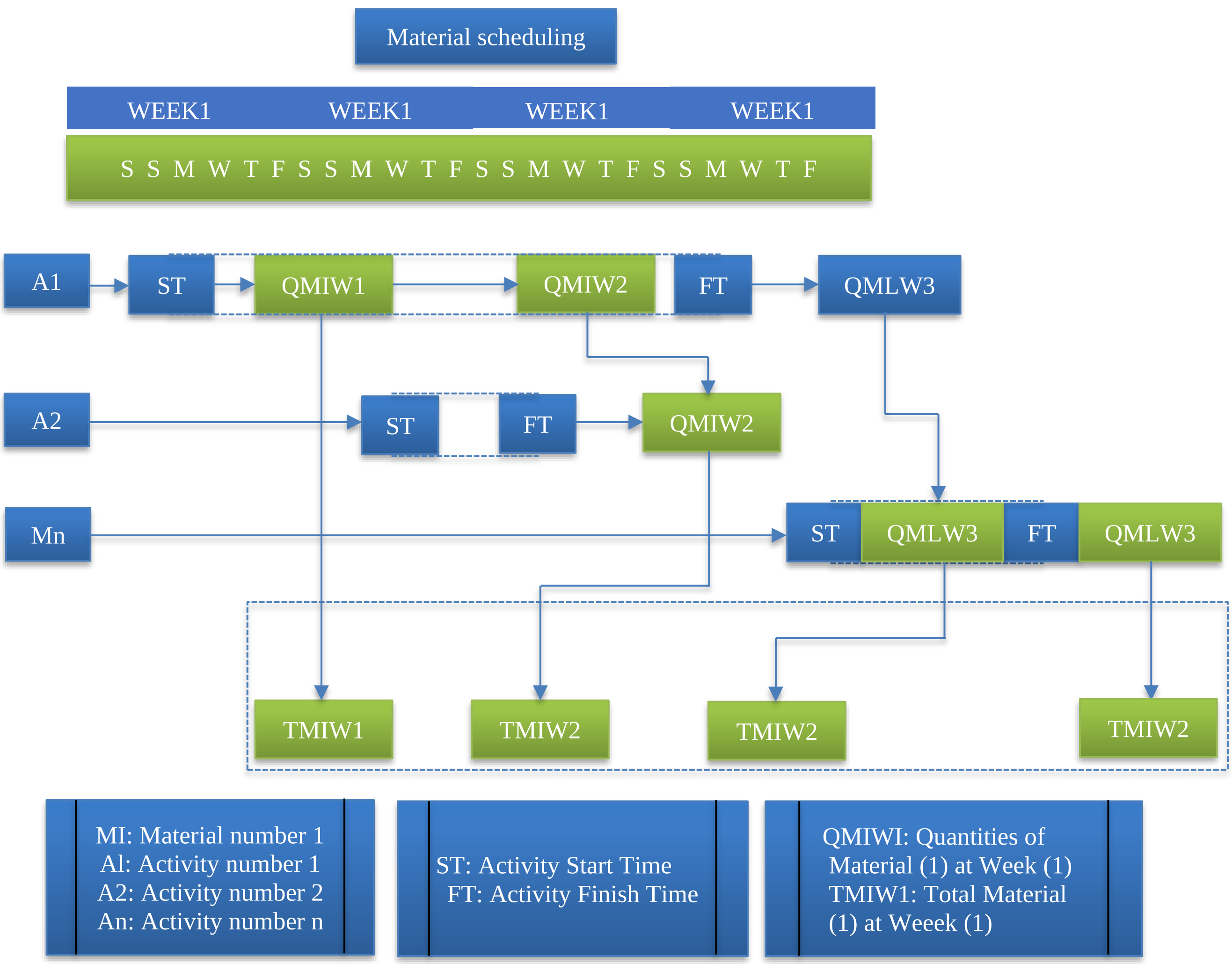

Fig. 10 Material scheduling

5. Planning Phase

In the planning stage, the model lays out a timeline for the project and calculates how much of each raw material will be needed each week. To do this, the model splits the data into the scheduling loop and the raw material amount calculation loop. The Planning Department must update the information about the project's activities (the name of the activity, the time of the start of the activity ST, the time of the finish of the activity FT, the quantity of the activity Q) in the scheduling loop as the situation changes, as shown in figure 9. The model then generates a timetable for the project and assigns tasks in accordance with the inputted information.

The Planning Department assign the raw materials – as shown in Figure 9 - used in each activity, establishes their relationship to the amount of activity (is it a percentage of the quantity of activity or fixed quantity), and establishes the method of using the quantities of raw materials on the duration of the activity's implementation through the cycle of calculating the raw material quantities (is it at the beginning of the activity or is it distributed weekly over the duration of the activity). As shown in Figure 10, The model looks for the names of all raw materials included in the project, calculates how much of each material will be consumed in each activity each week, and then stores this information for all activities. At last, the model compiles a table describing the weekly demand for each item. This data table is then used during the supplier phase.

5.1. Supplier Phase

The model's current objective is to identify the most suitable providers of each material in accordance with the requirements of the contract. Multiple materials for a single supplier and their respective terms of supply may be selected in this model (from a list of materials input during the planning stage). Procurement is in charge of entering information (as shown in Figure 11), such as names of suppliers, raw materials supplied by each supplier, and contract terms for each material (price, supply time, quality, determining the degree of the supplier's relationship with the company, the minimum quantity of supply, the volume of packaging of the order, and the maximum weekly supply quantity).

Then, the model plan and organize orders from suppliers for each material. To do this, as shown in figure 12, the model searches all the data given into it to find providers of a target material. The search is conducted in loops, with each loop beginning with the identification of a material's name and searching in the storage of each material's suppliers in a table. The outcome is an updated version of the materials tables taken from the planning phase, with the names of possible suppliers added to each entry.

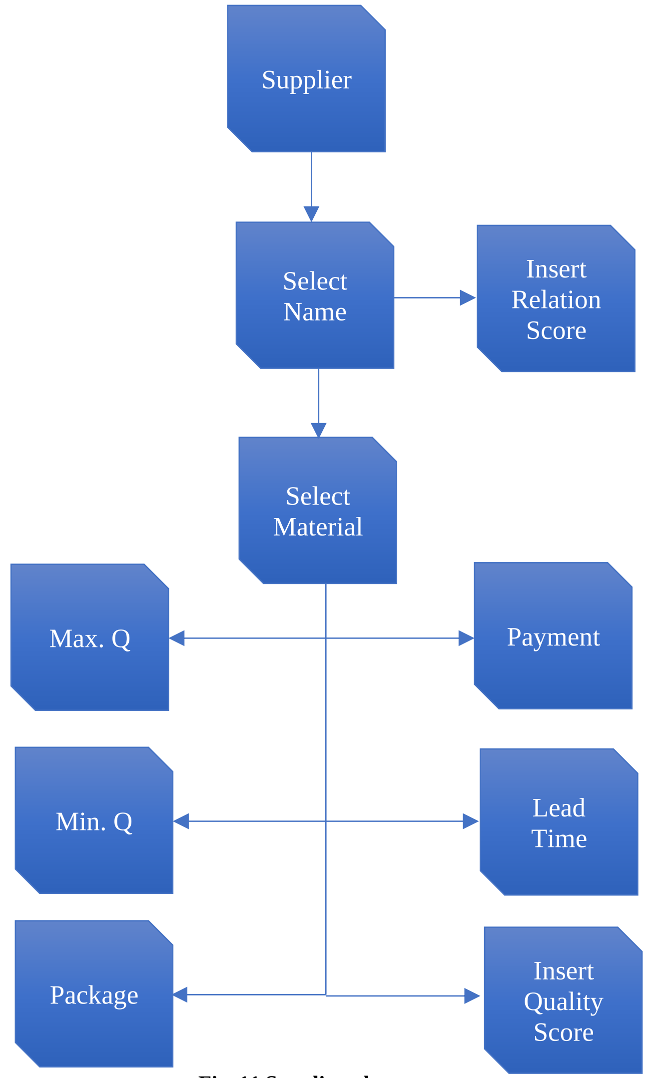

Fig. 11 Suppliers data entry

The model analyses the providers' situations in two stages: first, it makes comparisons between the different suppliers, and second, it considers the limits on supply volumes. Relative function, as we'll see in more detail below, is achieved by evaluating the supplier using the following four criteria established by the cost-effective vendors who supply a given material: Before anything else, the company's current partnership with the supplier. 2. The expense of supplying the materials.

The third consideration is the quality of the materials. Finally, the required supply timeframe. Calculators of supply levels compare the quantity needed to fulfil weekly material orders with the supplier's maximum weekly supply level. Through the scenario that the requirement is not met, the model will order the absolute necessities from the supplier with the highest rating and the remaining amount from the supplier with the next highest rating, and so on.

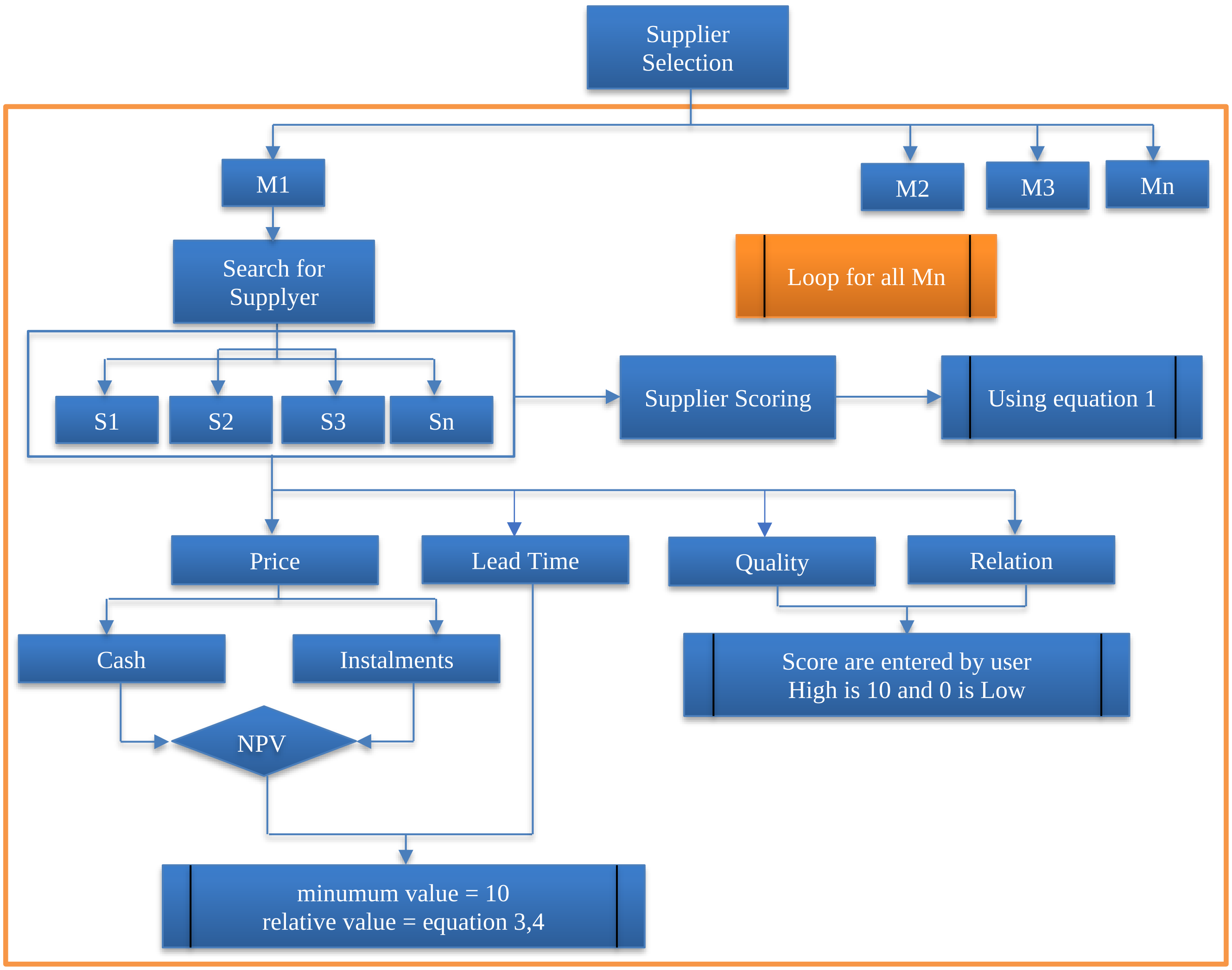

Fig. 12 Supplier selection

Price, quality, relationship, and lead time with the contractor are the metrics that may be compared between vendors. These phrases have a critical index that users may modify from one project to another. According to these four parameters, the model ranks the alternative supplier of one material. The ordering procedure may be calculated from Eq. (1).

$$S_S = S.L.*I.L. + S.R.*I.R. + S.Q.*I.Q. + S.C.*I.C. \qquad (1)$$

Where,

Score = Score of Supplier S,
S.L. = Score of Lead time,
I.L. = Importance of Lead time,
S.R. = Score of Relation to the contractor,
I.R. = Importance of Relation to the contractor,
S.Q. = Score of Quality,
I.Q. = Importance of Quality,
S_C = Score of Cost,
I_C = Importance of Cost.

Suppliers are ranked using the model's four criteria (costs, quality, relationship, and lead time). Ratings of quality and relationship range from 0 to 10. The greater value indicates a competitive advantage. The user then chooses whether to pay in full or instalments by inputting the cost terms. If the price is to be paid in instalments, the model may assess the rank by calculating the price's net present value (N.P.V.) using Eq. (2).

$$N.P.V. = (P_{w1} / (1 + i/52)1) + (P_{w2} / (1 + i/52)2 + \ldots\ldots + (P_{wn} / (1 + i)\ n \qquad (2)$$

Where,

N.P.V. = Net Present Value,
P_{w1} = Payment per week 1,
P_{w2} = Payment per week 2,
P_{wn} = Payment per week n,
i = interest rate, and
n = the number of the payment,

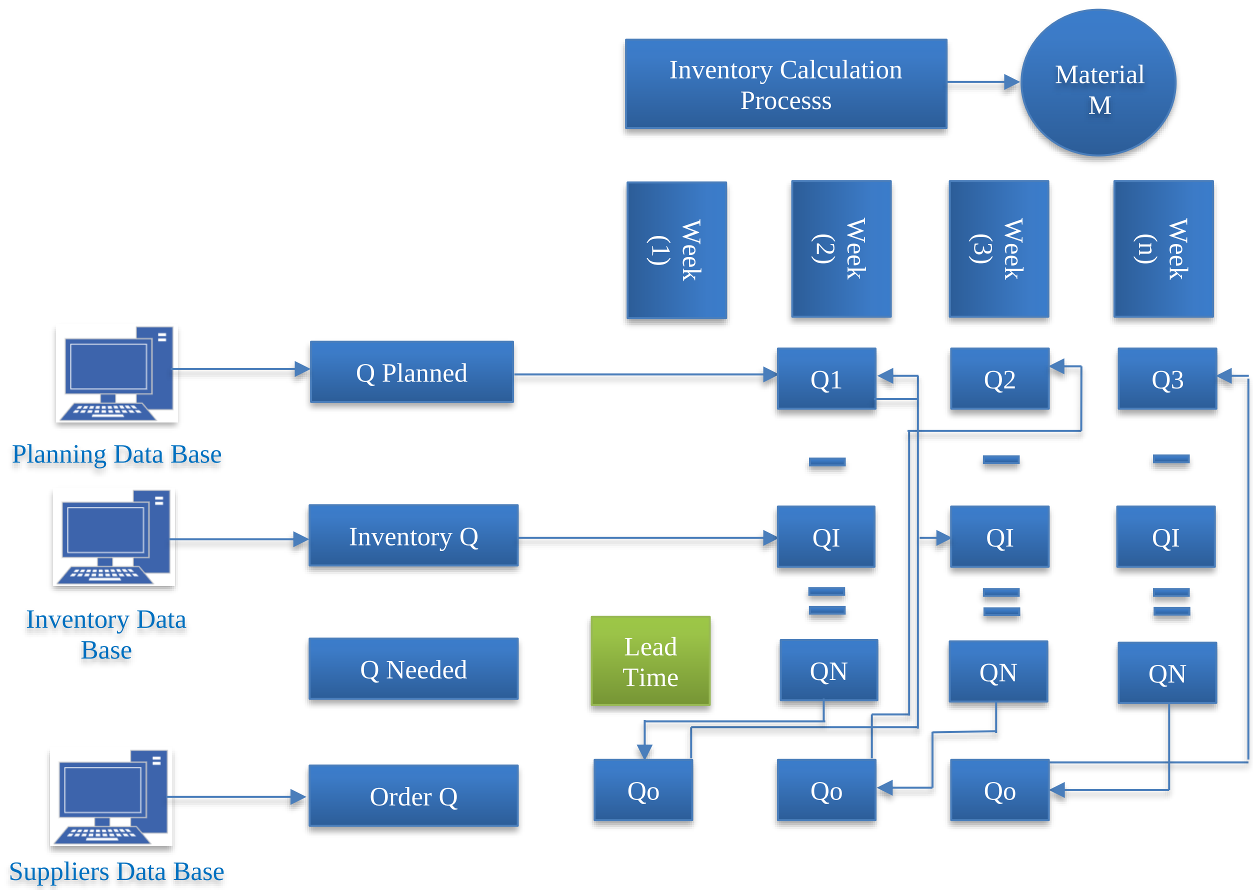

Fig. 13 Inventory calculation

After assigning a value of 10 to the provider with the lowest N.P.V., the model would next use Eq. (3) to determine the score for the other suppliers.

$$S.C._n = (\text{Min } C / C_n) * 10 \quad (3)$$

Where,

$S.C._n$ = Score of Supplier n cost,

Min C = Minimum Cost of the Supplier, and

C_n = Cost of Supplier n.

Finally, the model ranks all suppliers from best to worst according to their lead time scores ranging from 0 to 10. Eq. (4) was used to determine the rankings of the remaining suppliers, with 10 being the best option.

$$S.L._n = (\text{Min } L / L_n) * 10 \quad (4)$$

Where,

$S.L._n$ = Score of Supplier n lead time,

Min L = Minimum Lead time of suppliers, and

Ln = Lead time of supplier n.

5.2. Inventory Phase

At this point, the model has collected all available information and analyzed it in consideration of the constantly updated data that has been fed into it about the amounts of currently available resources at each given time period of the project. Inventory management is responsible for collecting data on material stocks. As a result, the computer evaluates the weekly material needs, the current stock of materials, the time between placing the order and receiving the shipment, and the projected order date, then modify the materials tables accordingly. So, the project's inventory management includes a full record of all the times items were ordered throughout the duration of the project.

6. Model Validation

It's possible that new initiatives will be produced to validate the model. The project data input – as shown in Figure 14 - includes the following fields: Name of Project (Test Project), Interest Rate (Benefit from Investment = 22%), Priority of Transport (10%), Priority of Quality (20%), Priority of Cost (60%), Priority of Supplier Relationship (10%), ST (1/4/2023), and FT (1/12/2023). These fields may be found in Figure 14. This project is comprised of a total of ten items, which are as follows: PC Footing, RC Footing, Column G, Slab G, Column S1, Slab S1, Column S2, Slab S2, Masonry, and Plastering after it comes for each item's quantity, the ST and the FT.

Modify the project

Test Project	: project name
22	Investment :benefit
10	:Transport priority
20	:Quality priority
60	Installment :priority
10	Supplier relationship :primacy
04/01/2023	: Start Date
12/01/2023	: Expiry date

Fig. 14 The project data input

Expiry date	Start Date	Quantity	Item name
2023-04-15	2023-04-01	m3 1000	PC Footing
2023-05-06	2023-04-15	m3 1000	RC Footing
2023-05-13	2023-05-06	m3 100	columnG
2023-06-03	2023-05-13	m2 500	SlabG
2023-06-10	2023-06-03	m2 70	column S1
2023-07-01	2023-06-10	m3 500	Slab S1
2023-07-08	2023-07-01	m2 65	column S2
2023-07-29	2023-07-08	m3 500	Slab S2
2023-09-02	2023-07-29	m2 20000	Masonary
2023-11-30	2023-09-02	m2 50,000	plastering

Fig. 15 Project scheduling

Material details

cement

The store	supplied quantities	Suppliers	The date of application	Required quantity	the date
0				1668	2023-04-06
0				1666	2023-04-13
0				3416	2023-04-20
0				1750	2023-04-27
0				1750	2023-05-04
0				2100	2023-05-11
0				1225	2023-05-18

Fig. 16 Material order plan

Figure 15 depicts the scheduling table generated by the model. The materials are then allotted to their respective products. These things are cemented into existence. RC footing in this project requires 5 bags of cement per m3. Cement usage in the following m3 volumes is 7 bags per unit: RC footing; Column G; Slab G; Column S1; Slab S1; Column S2; and S2. Cement requirements in Masonry are 0.125 bags per m2. In Plastering, the cement ratio is 0.0175 bags of cement for every square meter.

As can be seen in Figure 16, the model generates a cement ordering plan.

The next move is to settle on a supplier. The cement suppliers' terms were entered by the procurement department at this stage. Each of the three sellers is denoted by a S. For the purpose of the company's supplier relationship, the following terms shall apply S1=10, S2=8, and S3=5. The values for quality are thus S1 = 8, S2 = 10, and S3 = 7. Bags of S1 and S2 cost 100 L.E. each, while bags of S3 cost 90 L.E. S1 has an LT of 2 weeks, S2 of 1 week, and S3 of 1 week. Payment terms are as follows: S1 = instalments ($20 per week for 1–5 weeks), S2 = cash, and S3 = cash. Quantities (Qmax) are capped in 2000 in S1, 2000 in S2, and 6000 in S3. The barest minimums are 200 of S1, 200 of S2, and 1200 of S3 (Qmin). The last three shipments, S1, S2, and S3, each contain 1,200 units. As shown in Figure 17, the material order plan is then revised.

Quantities of stock on hand must be entered as the final step. Cement stock levels are to be recorded by the inventory team. Figure 18 depicts how the orders will shift if the warehouse stocks 2000 bags of cement. As shown in Figure 18, the material order plan is then revised.

Material details

cement

The store	supplied quantities	Suppliers	The date of application	Required quantity	the date
32	1668	S1	2023-04-02	1668	2023-04-06
66	1634	S1	2023-04-09	1666	2023-04-13
1050	2000 1350	S1 S3	2023-04-16 2023-04-19	3416	2023-04-20
0	700	S1	2023-04-23	1750	2023-04-27
50	1750	S1	2023-04-30	1750	2023-05-04
1150	2000 1200	S1 S3	2023-05-07 2023-05-10	2100	2023-05-11
125	200	S1	2023-05-14	1225	2023-05-18

Fig. 17 Updated material order plan

Material details

cement

The store	supplied quantities	Suppliers	The date of application	Required quantity	the date
332	store reimbursement	store reimbursement	store reimbursement	1668	2023-04-06
66	1334	S1	2023-04-09	1666	2023-04-13
1050	2000 1350	S1 S3	2023-04-16 2023-04-19	3416	2023-04-20
0	700	S1	2023-04-23	1750	2023-04-27
50	1750	S1	2023-04-30	1750	2023-05-04
1150	2000 1200	S1 S3	2023-05-07 2023-05-10	2100	2023-05-11
125	200	S1	2023-05-14	1225	2023-05-18

Fig. 18 Updated material order plan after reviewing store stocks

Material details

cement

The store	supplied quantities	Suppliers	The date of application	Required quantity	the date
1076	1200	S3	2023-06-07	280	2023-06-08
946	1200	S3	2023-06-14	1330	2023-06-15
1096	1200	S3	2023-06-21	1050	2023-06-22
46	store reimbursement	store reimbursement	store reimbursement	1050	2023-06-29
1151	1249	S3	2023-07-05	1295	2023-07-06
881	1200	S3	2023-07-12	1470	2023-07-13
856	1200	S3	2023-07-19	1225	2023-07-20
831	1200	S3	2023-07-26	1225	2023-07-27

Fig. 19 Updated Material Order Plan after Reviewing reports on 6/5/2023

The status reports on the project were last updated on 6/5/2023, reflecting the completion of various tasks (PC footing, RC footing, Column G, and Slab G). There was an increase of 80 m3 for Column S1, 600 m3 for Slab S1, 70 m3 for Column S2, and 700 m3 for Slab S2. S1 = 140 L.E./bag, S2 = 130 L.E./bag, and S3 = 120 L.E./bag are the current costs from the suppliers. As shown in Figure 19, the material order plan is then revised.

7. Conclusion

However, many of the models and frameworks developed in the West have pushed for policies that would be counterproductive in developing countries. The vast differences between the developed world's and developing world's construction sectors present the greatest challenge to transplanting a model intended for use in the developed world. Developing countries frequently suffer shortages of both key resources and trained labor, making it difficult to adapt to fluctuations in the cost of manufacturing inputs and ongoing adjustments made to project needs. Therefore, contracting companies may have difficulty determining the best route through the supply chain to complete a project at the most affordable cost and best set of criteria possible within the allotted time frame. Overlapping so many components in the execution of the supply chain in building projects causes delays in the implementation of the works, increases in cost, and a decline in quality. In order to remove the bottleneck, the contracting company must do a comprehensive analysis of the supply chain.

The CSC is most challenging at the points when different actors or processes interact with one another. The model's flexibility means it can produce varied results based on the inputs. The model includes a planning section, a supplier's section, and an inventory section. The model computes the discrepancy and adjusts its predictions accordingly. A test project was used to verify the model. The input data was updated to test the model's adaptability. The results were computed and compared to those predicted by the models. The results were identical either way. More project departments (financial, transportation, equipment, etc.) will need to be added once the model has been developed to calculate the total cost of all activities.

Data Availability

The corresponding author can provide the data that underlie this study upon request.

Conflicts of Interest

The authors state that they have not received any personal benefits from any individuals or organizations that could influence the outcome or interpretation of this research.

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Author Contributions

All authors contributed to the study's conception and design. [Mohamed Eslam El-Madany] was responsible for the study design and the first draft of the manuscript. [Mostafa Hassan Kotb] and [Abdul Radi Abdul Rahim] helped with the material preparation, data collection and analysis. [Alsayed Mohamed Nagy] also assisted with the data analysis. All authors reviewed and approved the final version of the manuscript.

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