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RESEARCH PAPER

Optimization and Analysis of Supply Chain Management Performance by Improving Inventory Management Model in Residential Construction

Halim Dwi Putra[1*], Iphov Kumala Sriwana[2] & Husni Amani[3]

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ABSTRACT

The construction industry is one of the high-demand industries related to business and projects. Robust materials management that is subject to inventory management is the highest factor to enhance the Supply chain management (SCM) performance that will indicate the project's success within the complexity of the project. This research aims to measure the performance of Supply Chain Management at PT Cahaya Amal Taqwa as a new housing developer who focuses on subsidized housing that faces a project delay because they have less data documentation and analysis from previous projects. The issue is most newcomer construction projects never analyze and measure their supply chain management (SCM) which leads them to confusion about the project improvement. The research uses the Supply Chain Operational Reference (SCOR) method to know how much inventory management impacts supply chain management performance and how it overcomes the issues. Most studies only measure the SCM performance and show which aspects need to be developed without any scheme of solution offered. This research presents the scheme of improvement for the inventory model and provides forecasting for the whole SCM performance after the implementation of a new model of inventory management. The findings confirm that inventory management significantly impacts the whole supply chain management performance in the construction industry. The development of a solution system brought comprehensive results by classifying KPIs for inventory management and an interdependence network was created to define the new model of inventory system for the solution. This research proves that improving an aspect will impact significantly the whole SCM performance instead of improving KPIs one by one.

KEYWORDS: *Construction; SCM; Inventory management; KPI; SCOR..*

1. Introduction

The whole retrospection is needed in each industrial aspect [1]. The complexity in operational and sustainability have been some issues in improving the organization's performance[2]. Supply chain management is one of the best perspectives for understanding an industry's overall performance because it is a series of activities that include planning, managing, and scheduling product flows from procurement to consumer distribution [3]. The supply chain is designed in such a way that it can be carried out most effectively and efficiently through Supply Chain Management [4]. The supply chain is a continuous process that begins with the purchase of raw materials and ends with the finished product [5]. It includes several functions such as sales forecasting, purchasing, production, distribution, sales, and marketing, as well as three main flows: materials, information, and money [6].

In the construction industry, the flow of the supply chain is the focus to be improved. The operations of construction mostly rely on the success of supply chain management [7]. The success of construction project implementation is highly dependent on technical and managerial aspects [8]. The close and exact

* **Corresponding author: Halim Dwi Putra**
halimdp@student.telkomuniversity.ac.id

1. *School of Industrial Engineering, Telkom University, Bandung, , Indonesia.*
2. *School of Industrial Engineering, Telkom University, Bandung, , Indonesia*
3. *School of Industrial Engineering, Telkom University, Bandung, , Indonesia.*

cooperation throughout the execution stage becomes an important factor in enhancing the efficiency of overall performance [9]. Complexity in the system of a project refers to interactions among all components that have various characteristics [10]. The complexity of the construction project results the high uncertainty and risk along with demanding time constraints [11]. The construction process highly relies on raw materials, and inventory management is the capital success of the operation itself [12]. Materials management affects the efficiency of construction for 30%-80% of total construction cost [13].

Material management can be enhanced by 4%-6% labor productivity [14]. 27.7% of the working time is spent because of a lack of tools and materials in the right place and time [15]. The ability to manage materials has a significant influence on a company's profitability [16]. The right amount of inventory supports the business operation, the lack of inventory will affect to customer service level and excess inventory will carry a big cost and production problem [17]. The significant role of inventory will determine the high level of risk that can happen if inventory management is poor [18]. The rise of cost comes from the existence of inventory and inventory size, the cost can be increased if the demand and stock are poorly adequate which brings shortage and impacts to large out of stock [19]. A company that has a high ratio in inventory is likely to have bad financial performance. [20].

The relationship between the financial performance of companies is significantly positive to their inventory performance [21]. Inventory management is important in the construction process because nearly 60% of the money is spent on the inventory [22].

The recent case happened at PT Cahaya Amal Taqwa. PT.Cahaya Amal Taqwa is a housing developer focused on subsidized housing that collaborates with the bank as the key for the circulation of capital money to build houses [23]. In the operation, they face lots of problems for the supply chain, the most obvious one is project delay which is as much as 9 months in the previous project. The delay can be caused by many things such as they don't have any schedule planning, not being able to track the construction progress, never measuring their supply chain performance, and what aspects need to be improved [24]. The construction processes are various which makes it hard to forecast and calculate the requirements that cause delays in the construction but the operation costs such as salary still need to be paid. Procurement is complicated for this company because there is no planning and analysis [25]

Moreover, this company never analyzes its whole supply chain management. These things cause the company confusion about which aspect they need to improve first to get efficient solution implementation [26] This research becomes totally important for PT Cahaya Amal Taqwa because a good supply chain in the construction industry will be able to prevent many problems, especially in the earlier stage [27]. Problems include attitude issues, myopic focus, and a lack of understanding of suppliers and subcontractors. Furthermore, a lack of communication in the construction industry leads to less transparency in the supply chain [28].

Tight schedules and unrealistic lead-time requirements for material and equipment cause additional problems [29]. The emergence of a large problem cannot just be relied on inventories, although this research focuses on inventory management, a glance at supply chain management analysis needs to be done to see how it impacts to the overall performance of PT Cahaya Amal Taqwa [30].

Some previous applications confirm that the improvement of SCM in construction is essential because it mainly impacts to project cost [31]. An effective supply chain will establish organizational linkages, reduce delivery time as well as improve the quality of deliverables [32]. Furthermore, SCM performance measurement will give a big insight into the improvement opportunities [30].

Those explanations above generate a clear gap in PT Cahaya Amal Taqwa which never analyzes its whole supply chain management causing the company confusion about which aspect they need to improve first to get efficient solution implementation. Another gap that can be improved from previous research is there is no direct improvement planning that focuses on inventory management after analyzing the whole supply chain performance. The motivation of this research is to help PT Cahaya Amal Taqwa be aware of their current SCM condition and related to construction projects the hypothesis that the inventory aspect will help the construction industry perform better on their supply chain management will be assessed in this research.

The application of this research will be used to help the company have an overview of the improvement on their SCM especially on the inventory aspect, this research will provide the reference model of inventory that can be used for the improvement itself.

Thus, this research aims to draw the supply chain network of PT Cahaya Amal Taqwa draw the supply chain network, measure the performance using the SCOR method of a company's total supply chain with the assessment of the performance of delivery and fulfillment [33]. Then, the analysis of how much the inventory management aspect contributes to the performance. In the end, if they have bad inventory, the research directly will build an improved model from inventory management.
Here are the research questions,

1. How is the SCM network and performance at PT Cahaya Amal Taqwa?
2. How the Inventory Impact to the SCM Performance in PT Cahaya Amal Taqwa ?
3. How does the inventory management model improve the SCM performance in PT Cahaya Amal Taqwa?

2. Literature Review

2.1. Supply chain management

Supply Chain Management (SCM) or supply chain management is very important for a company because it can help the development of a company achieve success [34]. Supply Chain Management consists of selecting suppliers, planning logistics, and distributing supplies [6]. Supply Chain Management itself is an activity of managing activities to obtain these raw materials into goods in process or semi-finished goods and finished goods, then sending these products to consumers through a distribution system. These activities include the traditional purchasing function and other important activities related to suppliers and distributors [35]

2.2. Inventory management

Inventory management is intended for all activities in developing and managing the inventory levels for raw materials, semi-finished materials, and finished goods that are purposed to the adequate availability of supplies and the costs of stocks which is essential to keep the production in a good path, the market matching and the distribution system defined[12]. The value of inventory in raw materials, components, assemblies, consumables, WIP, and finished goods needs to be kept and used as the needs received [36]. Productivity and profit maximization can be achieved if inventory management balances the cost and required customer services [37]. In inventory management, stocks of capital from an organization must be controlled properly and managed closely to perceive efficiency [38]

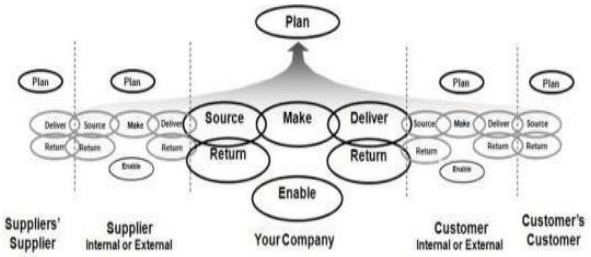

Fig. 1. SCOR model

2.3. Performance measurement

Performance measurement is comparing the actual results obtained with those planned, in other words, the targets that have been targeted must be examined to what extent the achievements have been made to achieve the goals [39]. Performance measurements and metrics have an important role in setting goals, evaluating performance, and determining actions for future programs [40]. To improve company performance, it is necessary to implement a supply chain management strategy[41]. Information sharing, long-term relationships, collaboration, and process integration are part of the factors that affect the performance of supply chain management [42]. Companies need to pay attention to information sharing as the basis for implementing supply chain management, then long-term relationships that can provide competitive advantages for companies, cooperation which is the best alternative in optimal supply chain management, and process integration as a combination of all existing activities [43].
Performance measurement using SCOR can measure the company from upstream to downstream [44]. This is what makes SCOR superior to other methods that tend to only measure company internals [45].

2.4. Supply chain operational reference (SCOR)

The Supply-Chain Operations Reference (SCOR) model is a model developed by the Supply Chain

Council (SCC). The SCOR model is used to measure and improve the performance of a company's total supply chain. This model includes the assessment of the performance of delivery and fulfillment of requests, inventory and asset management, production flexibility, warranties, process costs, and other factors that affect the assessment of the overall performance in the supply chain [46]

As a reference model, it is a SCOR model based on three main pillars, namely:

1. Process modeling: Reference for identifying the supply chain process model to facilitate translation and analysis
2. Performance measurement: Reference to measure the performance of the enterprise's supply chain as a measurement standard.
3. Application of best practices: Reference to determine the best practices required by the company.

The SCOR model itself contains several parts and is organized around the five main management processes Plan, Source, Make, Deliver, and Return as seen in Figure 1.

By describing a supply chain using building block processes, the model can be used to describe very simple or very complex supply chains using sequences from almost any supply chain This model has been able to describe and provide a basis for supply chain improvement for global projects as well as site-specific projects.

The model also provides performance attributes and supply chain measurement metrics. The performance attributes and their metrics are shown in Table 1. The performance attributes are supply chain criteria that allow to analyze and evaluate the supply chain against other supply chains with a competitive strategy [47].

Tab. 1. SCOR attributes

No	Attribute	Definition	Metric level 1
1	Reliability	All about fullfill the order, amount, time, condition and correct documentation so that the product can be reliable if the order accomplished well	Perfect order fullfillment
2	Responsiveness	The speed and performance also the profesionality reflect to work and needs of costumer	Order Fullfilment cycle time
3	Agility	The ability to respond to the change and transorfamation to sustaining the supply chain	Supply chain flexibility and adaptability
4	Cost	The cost that related to SCM operation with good economics formula	Cost of management and COGS
5	Assets	Effectivity inn assets management	Cash to cash cycle time

2.5. Normalization

Performance fulfillment is defined as the normalization of the performance indicators. Each indicator has a different weight with a different size scale. Therefore, it is necessary to process the parameter equalization using normalization [48]. Here normalization plays an important role to achieve the final value of the performance measurement. The normalization process is carried out using the Snorm De Boer normalization formula [49] As follows :

If larger is better

$$Snorm = \frac{(SI - Smin)}{Smax - Smin} \times 100 \quad [1]$$

If smaller is better

$$Snorm = \frac{(Smax - SI)}{Smax - Smin} \times 100 \quad [2]$$

With :
SI = Actual Performance
Smin = Minimum Performance
Smax = Maximum Performance
In this measurement, each indicator weight is converted into a certain value interval, namely 0 to 100. Zero (0) is defined as the worst and one hundred (100) is defined as the best. Thus, the parameters of each indicator are the same, after which a result can be analyzed. In this measurement, each indicator weight is converted into a certain value interval, namely 0 to 100. Zero (0) is defined as the worst and one hundred (100) is defined as the best. Thus, the parameters of each indicator are the same, after which the results can be analyzed. Table 2 shows the performance indicator monitoring system.

Tab. 2. Indication of Performance

Performance	Indication	Notation
<40	Poor	
40-50	Marginal	
50-70	Average	
70-90	Good	
>90	Excellent	

3. Research Methodology

3.1 Research limitation

This research is intended for Subsidized housing projects located in Payakumbuh, West Sumatera Indonesia with a study case at PT Cahaya Amal Taqwa as the housing developer. The research mainly uses primary data collected in 2023-2024. This research assumed that inventory management has a big impact on the overall performance of supply chain management on construction projects.
This research intended to improve the supply chain management performance by focusing on inventory management solutions. This research brings a new algorithm to access problems which indicates to more likely to focus on the procedures not just on the numerical calculation. This research is a combination of the literature and real conditions from the object that might impact the subjectivity of the result.

3.2 Methodology

Figure 2 shows the research procedures that later will be called the algorithm of this research. Data collection will start with a literature study that helps to get the big picture about supply chain tendency in property commodities. Observation and interview will be conducted with the commissary, manager, head of the division, and staff. The information will be used to construct the supply chain network of PT Cahaya Amal Taqwa, the Supply chain network will be described and analyzed to know the process flow and each process impact and relationship.
The next interview will be based on the supply chain network that has already been built to determine the key performance indicator (KPI), the KPI will equipped with inventory management attributes so it can be compared to the overall score later.

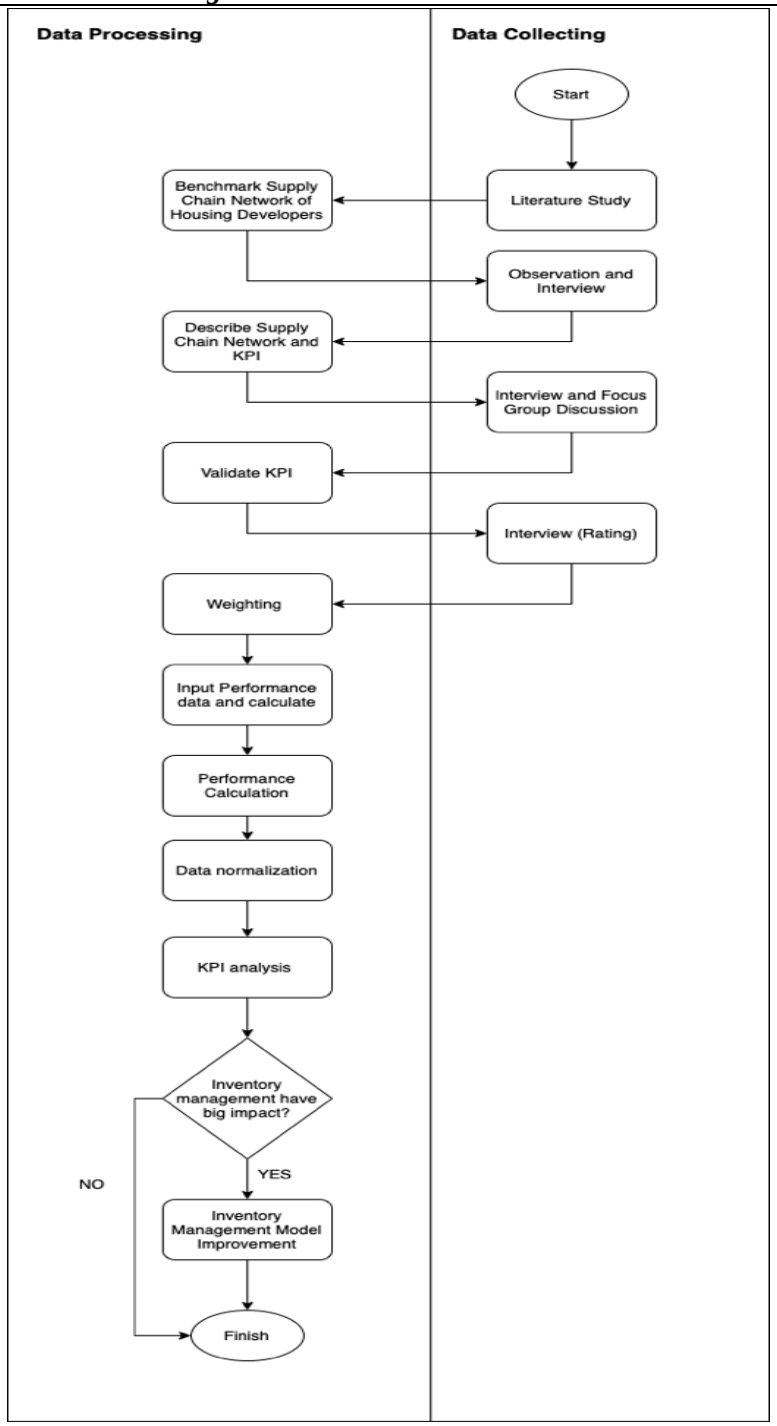

Fig. 2. Research methodology

This process is expected to find the match in the supply chain network and KPI that will be validated through focus group discussion (FGD). Validated KPI will proceed to the SCOR model along with the measurement metric and its performance for each. From the KPI that is already constructed on the SCOR model, those KPIs will be weighted using rating through an interview, this interview will be separated into two processes first, one-on-one for voting then a communal interview to validate the voting result. Due to metrics having different measurementparameters, the data normalization needs to be done with the Snorm de boer method. This normalization is intended to make all data in the same parameter so that the overall performance can be calculated. Performance calculation can show which KPI needs improvement, from some of the indicators will be brought up for improvement plan by proposing alternative solutions and analysis of the inventory indicators, whether the inventory system will improve or not.

4. Result and Discussion

4.1. Supply chain network

Based on a literature study and benchmarking, the supply chain network can be divided into 2 patterns which are a general pattern and a particular pattern [50] A general pattern is built by the general relationship of contracting (General Contracting Method) and a particular pattern can emerge based on the practice of business and operation. A particular pattern mostly caused by the relationship between entities and responsibility is called the Separate Contracting Method. Here is the general pattern of the supply chain in property commodities as shown in Figure 3.

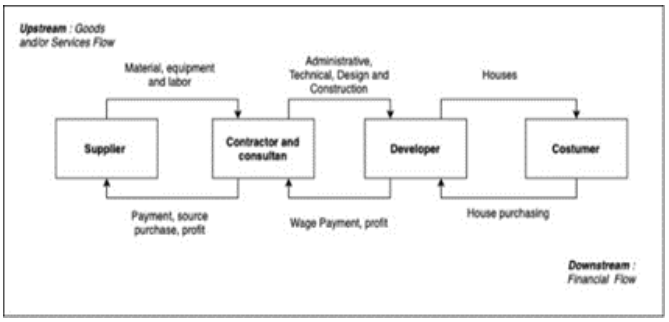

Fig. 3. General supply chain network for residential construction

Based on observation and interview, now the particular pattern for the supply chain network in PT.Cahaya Amal Taqwa can be generated. As stated, the relationship of the contract will affect the network pattern. Figure 4 is the particular pattern for the Supply Chain Network at PT Cahaya Amal Taqwa. The relationship of those parties can be divided into 2 as well which are the supply relationship and the contract relationship. The contract relationship will reflect the flow of financial/profit.

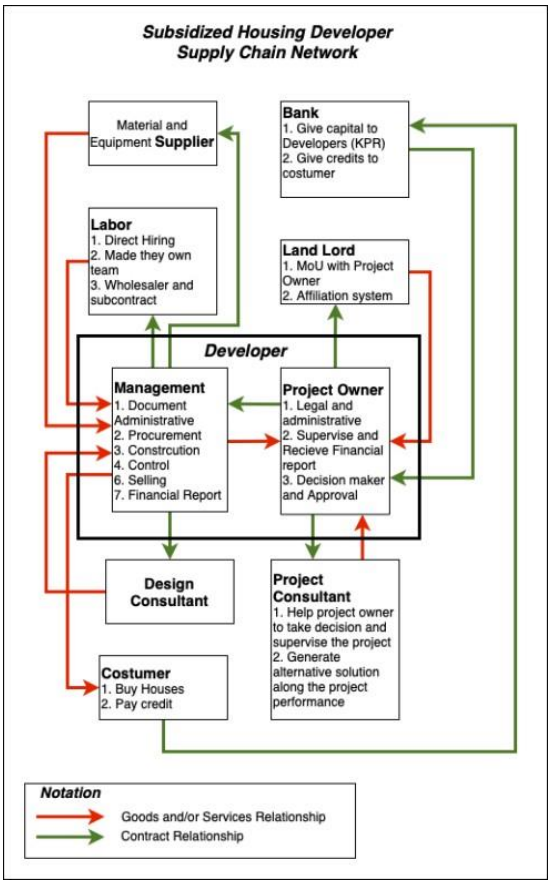

Fig. 4 Supply chain network PT cahaya Amal Taqwa

In practice, it found that the supply chain network can be different because it can be affected based on the variety of variables involved. In PT Cahaya Amal Taqwa they don't work with the contractor, but the developer has a project owner who makes their management team to manage the project. The finance flows start from the bank because subsidized housing is a government program that leans it to the bank as a credit provider and the developer as the project actioner. The developer has many affiliations to make their operation profitable and low risk. Besides the bank the affiliation also with the landlord. The project owner as the highest level of the hierarchy and hires a consultant to help supervise and improve the project.

The flow of this supply chain network starts from the initiation of the project owner to build subsidized housing in a certain location. The project owner will proceed with the legal and administrative proposal of the potential project to the bank. Once the bank accepts to affiliate, the bank will give developers capital for a potential project. The project owner also creates a contract with the landlord to affiliate. The capital given by the bank will be forwarded to the management team, and management will do their task such as procurement of materials and equipment as well as direct hiring labor. Labor here makes their work scheme with their team. Along the process, the management team will report to the project owner as well as sell the houses. After a customer purchases a house, the bank will issue the credits for them, and they will pay the credit based on the agreement. If the developers sell a unit house, the full price of payment will be issued, and the developers will get the profit from it.

4.2. SCOR model and KPI validation

KPIs were collected from benchmarks on a literature study and validated through interviews and focus group discussions. Key performance indicators can be defined and directed to the validation of several stakeholders in various perceptions. The source for KPI was taken from the most relevant cases in other studies which are subject to SCM and Inventory Management performance [51], [52], [53], [54], [55], [56]. Table 3 shows the validated KPI by interview and focus group discussion with stakeholders. After defining the KPI, the SCOR model need to be built. Figure 5 is SCOR model for SCM of PT Cahaya Amal Taqwa. The yellow color on Table 3 indicates the KPIs that are related to inventory management performance.

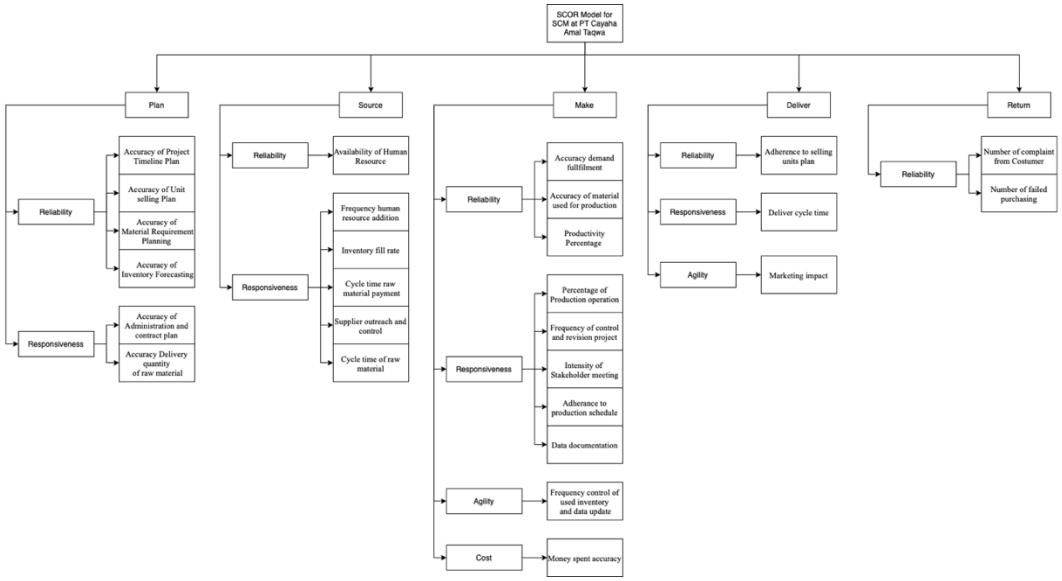

Fig. 5. SCOR model for residential construction

Tab. 3 Validated KPIs

No	Validate KPI	Units
1	Accuracy of Administration and contract plan	Days
2	Accuracy of Project Timeline Plan	%

3	Accuracy of Unit selling Plan	Units
4	Accuracy of Material Requirement Planning	%
5	Accuracy of Inventory Forecasting	%
6	Accuracy Delivery quantity of raw material	%
7	Cycle time of raw material	Day
8	Availability of Human Resource	Human
9	Frequency human resource addition	Times
10	Inventory fill rate	%
11	Cycle time raw material payment	Day
12	Supplier outreach and control	Times
13	Accuracy demand fullfilment	%
14	Percentage of Production operation	%
15	Accuracy of material used for production	%
16	Frequency of control and revision project	Times
17	Frequency control of used inventory and data update	Times
18	Intensity of Stakeholder meeting	Times
19	Adherance to production schedule	%
20	Productivity Percentage	%
20	Productivity Percentage	%
21	Money spent accuracy	%
22	Data documentation	Times
23	Deliver cycle time	Days
24	Adherence to selling units plan	%
25	Marketing impact	%
26	Number of complaint from Costumer	Times

27	Number of failed purchasing	Times

KPIs Related to Inventory Management Performance

4.3. KPIs weighting

The weighting process is done by asking 5 stakeholders which are the commissary, head of production, head of procurement, construction worker, and project consultant. That weighting scale with percentages calculated in each level starts with the score general model, the attributes, and the metric. This weighting will help to get the impact of each metric, attribute, and the SCOR process itself. Table 4 shows the weighting result for each KPI.

Tab. 4. KPIs Weighting Result

SCOR	Attributes	Metrics (KPI)	Weighting KPI	Final Weight
Plan (28%)	Reliability (64%)	Accuracy of Project Timeline Plan	24%	0,043
		Accuracy of Unit selling Plan	20%	0,0358
		Accuracy of Material Requirement Planning	30%	0,0538
		Accuracy of Inventory Forecasting	26%	0,0466
	Responsiveness (36%)	Accuracy of Administration and contract plan	43%	0,0433
		Accuracy Delivery quantity of raw material	57%	0,0575
	Reliability (36%)	Availability of Human Resource	100%	0,1008
Source (28%)	Responsiveness (64%)	Frequency human resource addition	15%	0,0269
		Inventory fill rate	24%	0,043
		Cycle time raw material payment	17%	0,0305
		Supplier outreach and control	18%	0,0323
		Cycle time of raw material	26%	0,0466
		Accuracy demand fullfilment	32%	0,0213
		Accuracy of material used for production	32%	0,0213
		Productivity Percentage	36%	0,024
		Percentage of Production operation	24%	0,0209
		Frequency of control and revision project	20%	0,0174
		Intensity of Stakeholder meeting	20%	0,0174
		Adherance to production schedule	26%	0,0226
		Data documentation	10%	0,0087
		Frequency control of used inventory and data update	100%	0,0696
		Money spent accuracy	100%	0,0667
		Adherence to selling units plan	100%	0,0408
		Deliver cycle time	100%	0,0328
		Marketing impact	100%	0,0064
		Number of complaint from Costumer	54%	0,0378
		Number of failed purchasing	46%	0,0322

Tab. 5. Performance Measurement Result

SCOR	Weighting SCOR	Attributes	Weighting Attributes	Mterics (KPI)	Weighting KPI	Units	Performance	Smin	Smax	Snorm Normalization	Weight	Performance
Plan	28%	Reliability	64%	Accuracy of Project Timeline Plan	24%	%	37	0	100	37	0,04	1,59
				Accuracy of Unit selling Plan	20%	Units	75	0	120	63	0,04	2,24
				Accuracy of Material Requirement Planning	30%	%	45	0	100	45	0,05	2,42
				Accuracy of Inventory Forecasting	26%	%	10	0	100	10	0,05	0,47
		Responsiveness	36%	Accuracy of Administration and contract close	43%	Days	50	40	60	50	0,04	2,17
				Accuracy Delivery quantity of raw material	57%	%	65	0	100	65	0,06	3,73
Source	28%	Reliability	36%	Availability of Human Resource	100%	Human	85	0	100	85	0,10	8,57
		Responsiveness	64%	Frequency human resource addition	15%	Times	3	0	5	40	0,03	1,08
				Inventory fill rate	24%	%	45	0	100	45	0,04	1,94
				Cycle time raw material payment	17%	Day	12	7	14	71	0,03	2,18
				Supplier outreach and control	18%	Times	12	10	27	12	0,03	0,38
				Cycle time of raw material	26%	Day	13	7	14	14	0,05	0,67
Make	29%	Reliability	23%	Accuracy demand fullfilment	32%	%	55	0	100	55	0,02	1,17
				Accuracy of material used for production	32%	%	40	0	100	40	0,02	0,85
				Productivity	36%	%	60	0	100	60	0,02	1,44
		Responsiveness	30%	Percentage of Production operation	24%	%	50	0	100	50	0,02	1,04
				Frequency of control and revision project	20%	Times	6	4	14	20	0,02	0,35
				Intensity of Stakeholder meeting	20%	Times	5	4	10	17	0,02	0,29
				Adherance to production schedule	26%	%	42	0	100	42	0,02	0,95
				Data documentation	10%	Times	3	2	8	17	0,01	0,15
		Agility	24%	Frequency control of used inventory and data update	100%	Times	8	2	20	33	0,07	2,32
		cost	23%	Money spent	100%	%	30	0	100	30	0,07	2,00
Deliver	8%	Reliability	51%	Adherence to selling units plan	100%	%	75	60	120	25	0,04	1,02
		Responsiveness	41%	Deliver cycle time	100%	Days	14	7	21	50	0,03	1,64
		Agility	8%	Marketing impact	100%	%	70	0	100	70	0,01	0,45
Return	7%	Reliability	100%	Number of complaint from Costumer	54%	Times	4	0	12	67	0,04	2,52
				Number of failed purchasing	46%	Times	8	0	12	33	0,03	1,07
Overall Performance												44,69

Perfromance	Incication	Notation
<40	Poor	
40-50	Marginal	
50-70	Average	
70-90	Good	
>90	Excellent	

4.4. Performance measurement and analysis

Data for performance calculation was gathered from less data documentation. It's obvious that the company already lacks data documentation. More data and information were mostly collected through interviews and quantitative estimation. Some of the data and parameters were taken from benchmarking with other companies in general conditions. The estimation is confirmed by the company that the data can reflect their real condition. Table 5 shows the result of the performance measurement. The overall performance of Supply Chain Management at PT Cahaya Amal Taqwa is 44,49 which is classified as a marginal performance. The improvement is urgently needed because 11 KPIs have poor performance, 5 KPIs have marginal, 8 KPIs perform average, 3 KPIs can be said good, and none of them have excellent performance. A holistic improvement is one of the solutions regarding the performance dominantly poor.

4.5 Inventory contribution analysis

From all the processes the contribution of Inventory can be calculated as shown in Figure 6. The performance of Inventory Management KPIs is 20 from a total of 45 and the weight from inventory is 51 from a total of 100 which concludes that inventory affects more than half of performance itself. But instead of reaching the 51 inventories only contributed 20 for the performance which the rate of inventory management performance only 38%. This calculation gives an insight that inventory management in PT Cahaya Amal Taqwa needs a holistic improvement that is compatible with the performance of the overall supply chain.

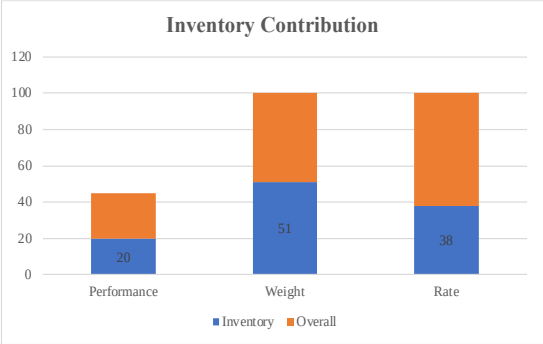

Fig. 6. Inventory contribution to SCM performance

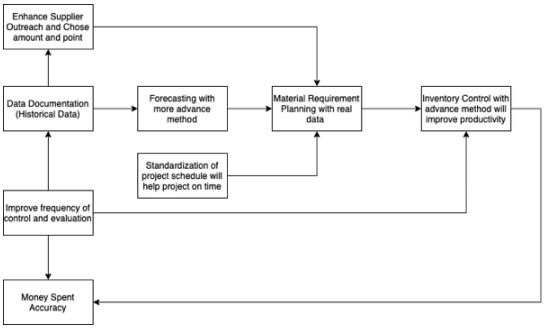

Fig. 7. Improved inventory model

4.6 Alternative solutions and inventory model improvement

From the calculation, 11 KPIs have poor performance which urgently needs to be improved. From them, 5 KPIs related to Inventory Management Performance. So, all KPIs that have poor performance and all KPIs that are related to Inventory management as much as 18 KPIs will be analyzed through a relationship network and obtain the best solution system for the whole supply chain management to improve performance. Figure 7 gives the relationship between problems that describe how information and operation relate and impact each other.

The network shows a strong relation between problems. A systematic model improvement from the alternative solution can be built. If a system proposes to solve problems, it will solve them fully or partially. The model improvement also can eliminate KPI which assumes solved and full performance. Table 7 shows some alternative solutions that give full and direct impact to the KPIs on supply chain management. Figure 8 is a new Inventory Model improvement with the alternative solution, the relationship between them able to solve the problem in one take.

After the model develops some insight can be gathered. Table 7 shows the alternative solution and explanation of the KPIs.

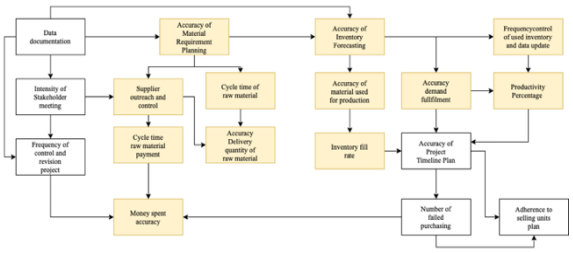

Fig. 7 Interdependence network of bad performance KPIs

Tab. 6. Alternatives solution for inventory system KPIs maximization

Alternative Solution	Impact	Maximized KPI
Frequent Data Documentation and analysis(Historical Data)	This solution will help to provide more exact solution with data analysis as well as support to take certain decision for the managerial	1. Intensity of stake holder meeting
Enhance Supplier Outreach and Chose amount and point	If the supplier sticks with the company, some of the responsibilities will lean on them, which the company doesn't need to worry about. It's all about good collaboration. Choosing the correct supplier can be done by data documentation.	1. Cycle time of raw material 2. Cycle time of raw material payment 3. Accuracy delivery of raw material
Improve frequency of control and evaluation	With stick control and evaluation based will provide more update data, and the project can always be on track. With evaluation, some bad performance and be improved immediately. With this some of measurement is don't need to be conducted anymore	
Forecasting with more advance method	The forecasting is help to build a good plan for the materials procurement and control.	1. Inventory fill rate
Material Requirement Planning with real data	MRP that built correctly will help to procure correct amount, time, and quality for the material that affect to the operation and production itself, will improved another KPI	1. Accuracy of material used for production
Inventory Control with advance method	The control on inventory will help to increase productivity and another operational issues. With great inventory control will help maintain the good operational	1. Productivity Percentage 2. Accuracy of demand fulfillment
Standardization of project schedule will help project on time	The standardization on schedule will help increase the accuracy of all operational and reduce ambiguity as well as data will have good pattern to be documented.	1. Number of failed purchasing 2. Adherence to selling unit plans 3. Money spent accuracy

Tab. 7. Expected SCM performance for new inventory model

Mterics (KPI)	Units	Performance	Smin	Smax	Snorm Normalization	Weight	Performance
Accuracy of Project Timeline Plan	%	100	0	100	100	0,18	18,27
Accuracy of Unit selling Plan	Units	75	0	120	63	0,04	2,24
Accuracy of Material Requirement Planning	%	100	0	100	100	0,08	7,51
Accuracy of Inventory Forecasting	%	100	0	100	100	0,09	8,96
Accuracy of Administration and contract plan	Days	50	40	60	50	0,04	2,17
Availability of Human Resource	Human	85	0	100	85	0,10	8,57
Frequency human resource addition	Times	3	0	5	40	0,03	1,08
Supplier outreach and control	Times	27	10	27	100	0,17	16,68
Percentage of Production operation	%	50	0	100	50	0,02	1,04
Frequency of control and revision project	Times	14	4	14	100	0,02	1,74
Adherance to production schedule	%	42	0	100	42	0,02	0,95
Data documentation	Times	8	2	8	100	0,03	2,61
Frequency control of used inventory and data update	Times	20	2	20	100	0,11	11,50
Deliver cycle time	Days	14	7	21	50	0,03	1,64
Marketing impact	%	70	0	100	70	0,01	0,45
Number of complaint from Costumer	Times	4	0	12	67	0,04	2,52
Overall Performance							87,92

Perfromance	Indication	Notation
<40	Poor	
40-50	Marginal	
50-70	Average	
70-90	Good	
>90	Excellent	
100	Improved	

The maximized KPI written in Table 6 is assumed to be eliminated on the previous system or have 100% performance. The weight for maximized KPI will distributed to the KPIs that Improved and KPIs that improved with alternative solutions assumed to have 100% performance.

4.7 Result reliability of inventory management model

Table 8 shows the performance improvement of the alternative solution or new inventory model adapted to the SCM of PT Cahaya Amal Taqwa. From 18 KPIs that are being analyzed, this research focuses on 7 KPIs to improve which eliminates another 11 KPIs that are highly related one to another. The 7 KPIs are modeled into Inventory Management that comes as one system solution for the company. Table 8 provides the information on overall SCOR performance is 87,92 classified as good performance and close to excellent. Figure 9 shows how the improvement in inventory management affects the whole SCM performance. The process for solution formulation and focus aspect just bring high benefits for supply chain performance. The performance increases by more than 90% which indicates reliable solutions.

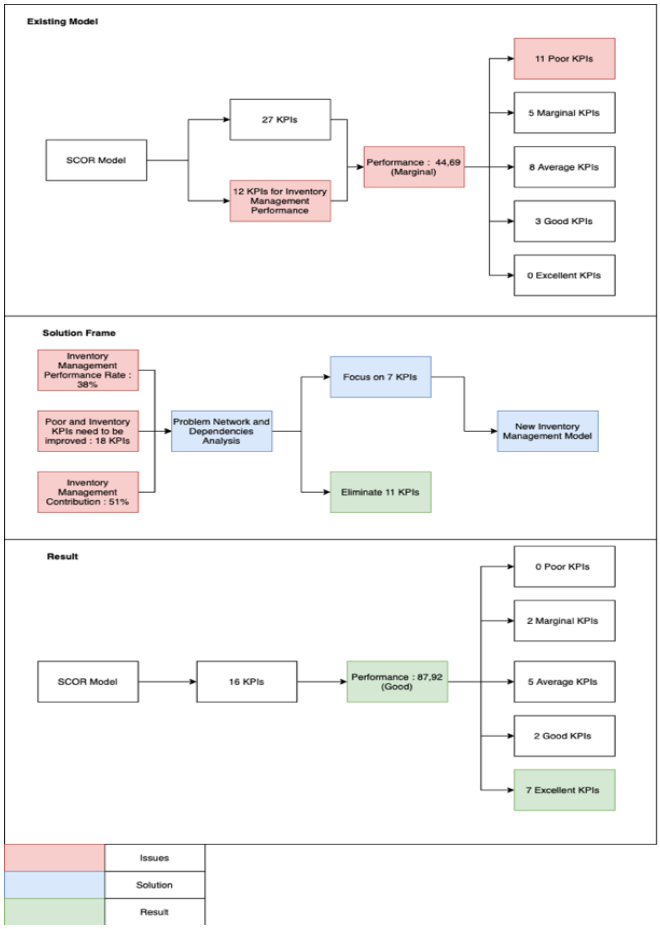

Fig. 9. Result reliability

4.8. Managerial implication

Managerial implication become essential if there is some change on the company due to the findings of this research. There are some favorable implication that can be used.

1. This research give clear insight to improve the performance on Supply Chain Management through improving the inventory system. Thus, this research only a reference that needed future consideration from the company
2. This research shows the result that a good inventory model significantly impact to the whole performance of Supply Chain Management. So, the managerial need to pay full attention on controlling the project and develop the system
3. The improvement is categorized as massive, so the company need to be careful on the development and also make it step by step.
4. Some of variables such as improvement cost, human resources ability, availability of tools and technology is ignored. So the company can take the decision for the development based on the company current condition and ability
5. The procedure of this research is totally reliable to be used for the future analysis if there is any change on the KPI, performance data, variables, and etc.
6. This research bring an elimination algorithm for the KPI, so if a system develop some of KPI will be automatically eliminated. The company should be aware that a system that developed can bring new KPIs, so in the future can be elimination and replacement of KPIs.
7. This research just give a big picture of the solution that required the company to be more aware with the technical, flow, and analysis for the development.

5. Conclusion

The measurement of supply chain management on the construction industry is done in this research with a recent focus on the inventory management model. Most studies only measure the SCM performance with SCOR and show which aspects that need to be developed without any scheme of solution offered. This research introduces

new procedures to improve SCM performance by creating a system to eliminate some of the problems and found that inventory management affects more than 50% of the whole performance of supply chain management.

This research presents the scheme of improvement for the inventory model and provides forecasting for the whole SCM performance after the implementation of a new model of inventory management

This research also confirms that improving an aspect such as inventory will impact significantly the SCM performance instead of improving KPIs one by one. The development of a solution system brought comprehensive results for this research.

The attention needs to be drawn by classifying the KPIs into several aspects and creating the interdependence of each other KPIs to know how to create a scheme for effective solutions.

For instance, several KPIs were classified for inventory management, and an interdependence network was created to define the new model of inventory system for the solution.

There are some technical details of results for the study case at PT Cahaya Amal Taqwa.

1. Supply Chain Network has successfully represented the whole flow of the company activities
2. There are 27 KPIs for the existing SCOR model and 12 KPIs represent inventory management performance.
3. The performance of the existing SCOR model is 44,49 which is classified as marginal. 11 KPIs have poor performance, 5 KPIs have marginal, 8 KPIs perform average, 3 KPIs can be said good, and none of them have excellent performance.
4. Inventory Management KPIs contribute for 51% of the whole weight, give 20 performances from 44,69, and have 38% of the performance rate
5. 18 KPIs that are being analyzed, this research focuses on 7 KPIs to improve which eliminates another 11 KPIs that are highly related one to another. The 7 KPIs are modeled into Inventory Management that comes as one system solution for the company
6. The final result after improvement show that the performance of the SCOR model is 87,92 which increase of more than 90% than existing

Although this research seems reliable for managerial and theoretical needs. Some of the actions can be taken for the improvement.

There are several possible avenues for future investigation:

1. The data gathered have high subjectivity because of benchmarking, interviews, and quantitative estimation. Future research is better to do longitudinal data collecting before building the measurement's frame
2. The variable of the company's ability to implement the solution is ignored in this research and the result is an expected one. The upcoming research suggested to include this variable to formulate the most suitable system to be applied
3. This research only gives an overview of the improvement area and does not provide details of technical for alternative solutions. The next research is better to find some tools to help design the applicable solution

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