

Analysis of Simulation in Supply Chain Management Based on System Dynamics and SCOR Model (a Case Study : Newspaper Industry)

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Abstract. Supply Chain Management is a relationship between related components in a company. The relationship between the complex components of supply chain needs to be measured and evaluate the performance so it can be increased by effectively and the company can run the business properly. Case studies conducted in newspaper industry, supply chain cycle in the newspaper industry is less than 24 hours. In this research use simulation to supports making desicion through analyzing the system of the supply chain. The newspaper supply chain was simulated using the system dynamics software. SCOR model used as a tool to speed up the simulation modelling of supply chain. This research was conducted to make the model simulation of performance measurement in newspaper industry started in 2019 to 2022. The final results obtained for the Reliability attributes associated with Perfect Order Fulfillment is 99,59%. Responsiveness attributes associated with the Order Fulfillment Cycle Time about 3.3 hours from the target 4 hours. The Cost attributes was about 80.81% refers from total of material, production, and transportation cost divided by the sales. Agility attributes of upside flexibility about 3.3 hours and upside adaptability about 120.22% by the capacity of the machine. Assets Management attributes with cash to cash cycle time is about 27 days.

Introduction

Newspaper industry has unique supply chain characteristics, one of it is having a short cycle time or cycle time less than one day. The process source-make-deliver-return plan in the newspaper industry only lasts less than 24 hours. The process of preparation of production materials, pre-printed activities, production of making newspaper, distributing products and return of newspaper products is done with a limited time. At present, local newspaper companies have an average newspaper production of around 20,000 copies per day. The production has dropped to 10,000-20,000 from a decade ago. The presence of more than 10 local newspaper competitors also affects the interests and number of customers. Digitalization is also one of the main causes of the decline newspaper products until now.

Newspaper industry system is a make-to-stock, but the number of products every day is based on agent requests every day and there are no newspapers stored or zero inventory. Fluctuations in product demand every day cause uncertainty over long-term raw material planning. This causes management in the newspaper industry supply chain not optimal. Several other causes decreased newspaper and various problems in the supply chain newspaper industry are caused by various cycles in the supply chain such as the customer order cycle, replenishment cycle, manufacturing cycle, and procurement cycle.

One of the way to optimize management supply chain recently is to take a performance measurement approach to the supply chain [2]. Analysis of performance measurement in a dynamic supply chain can be done with the SCOR (Supply Chain Operation Reference) model [6]. The SCOR model is divided into several processes such as Plan, Source, Make, Deliver, Return, and Enable and

the four main things are performance, process, practice, and people [14]. SCOR is also used to speed up the simulations in the supply chain [8]. By conducting analysis of simulations on supply chain it can function to design and planning supply chain performance [10]. Supply chain simulation is a tool for designing, evaluating, and optimizing structures in the supply chain [20]. One goal in simulating the supply chain is to evaluate performance and increase effectiveness in complex supply chains [19].

A few literature stating the system dynamics to simulation supply chain. Ozbayrak, Papadopoulou, Akgun [12] used system dynamic modelling at manufacturing supply chain system. Ashayeri and Lemmes [9] proposes a system dynamics simulation modeling framework which is has been tested, validated with real-life case of LG. Philips Displays Europe. Georgiadis, Vlachos and Iakovou [13] adopt the system dynamics methodology as a modeling and analysis tool to tackle strategic issues for food supply chains. Higuchi and Troutt [16] use scenario based dynamic simulations in the case of short product life cycle of the first of the virtual pet toys. Minegishi and Thiel [14] show how system dynamics contribute to improving the complex behavior of an integrated food industry.

Persson and Olhager [7] present a supply chain simulation at manufacturing of mobile communication system. Vlachos, Georgiadis and Iakovou [4] analyzed supply chain behavior through a simulation model based on the principles of the system dynamics methodology, which can be used to evaluate alternative long-term capacity planning policies. Putri, Sutopo and Hisjam [1] used SCOR simulation method in measuring supply chain performance in newspaper industry case. Lestari et al [5] used simulation in supply chain in measure of performance at palm oil industry in Malaysia with discrete-event simulation (DES). Immawan et al [17] used hybrid SCOR with System Dynamics to measure the performance Make-To-Stock and Make-To-Order production in Batik Industry.

The case of study of this research is related to newspaper industry. Unique industrial complexity and characteristics, causing various problems to emerge in the newspaper industry supply chain cycle. As well as newspaper industry supply chain management which is not optimal. For this reason, research was conducted to measure the supply chain performance using the SCOR model and dynamics simulation using powersim software.

Methodology

SCOR (Supply Chain Operation Reference) is one method used to measuring performance in the manufacturing industry. In order to understand performance measurement at the company, it is necessary to identify the system of supply chains the company first. In the identification of the newspaper industry supply chain, each entity is represented in a box with each type of flow such as material flow, information and data flow, and money flows between entities so that supply chains occur in the supply chain industry. The data of this research was form February 2019 – April 2019. And the attributes of performance measurement used SCOR version 11.0 with simulation using powersim 10.

Newspaper supply chains have various entities involved, suppliers (suppliers of ink, plates, paper), newspaper printing companies that carry out newspaper production processes, companies that make newspaper content and publishers, newspaper agents and customers. The following is an illustration of the newspaper supply chain in Fig.1:

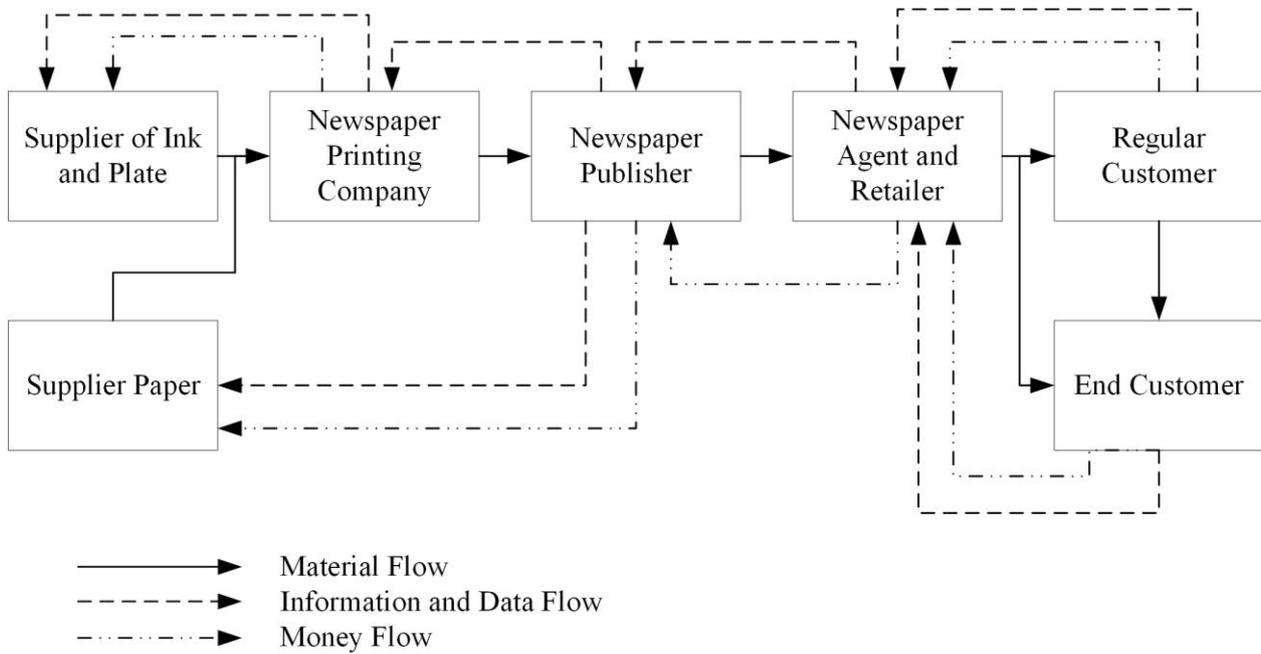


Fig. 1. Newspaper industry Supply Chain

Based on the SCOR version 11.0 Supply Chain Operation Reference Model there are four main things in SCOR's assessment, it is performance, process, practice, and people. SCOR version 11.0 has four level levels, level 1 to 3 are process details and level 4 as the implementation of the three previous levels. In SCOR performance attributes there are several attributes, it is reliability, responsiveness, agility, cost, and asset management efficiency [15]. After identifying the system of newspaper supply chain, the next step is to identify the performance attributes and metrics in the newspaper supply chain. The metrics used are level 1 metrics and level 2 metrics based on SCOR version 11.0 performance attributes. This research uses several level 1 metrics and in level 2 metrics that most influence the company.

The supply chain analysis is carried out using a simulation using the system dynamics method. By doing simulations it can speed up and provide feedback on decision making in supply chain management [8]. To bring it into the simulation, it is necessary to know in advance how the model in the system. In describing this, this study made a causal loop diagram based on performance attributes on SCOR version 11.0 to help understand the system model. CLD (Causal Loop Diagram) provides a simple understanding of the structure in the system. That is by giving a picture of causes and effects on the system. It can be seen on the relationship between variables at each metrics and level SCOR. Each box on the diagram describes the SCOR performance attributes which there are variables and metrics related to that attribute. Variables and metrics that influence each other within or outside the same or different attributes have a relationship that is described by the flow of arrows. So there will be an overview of the system model in the newspaper industry as a whole.

After describing the system model on causal loop diagrams, a model is made on the software, which in this research is done on powersim. Making models on powersim is based on the CLD that has been created. Performance metrics in CLD are considered as levels in the simulation and symbolized by the shape of a box because the value can change based on the effects of the processes that influence it (flow rates). Then the variables associated with the metric are considered as flow or rate in the simulation and symbolized by a circle because it is a target or a certain formula that affects performance metrics. Then there are constants symbolized by the shape of rhombus as parameters so that they have a constant value. Flow rates will affect the flow of information that exists so that it has an effect on the value of a level. So the results can be seen how the performance measurement of the newspaper industry started in 2019 to 2022 through the existing simulation model.

Results and Discussion

Based on the identification of the newspaper industry supply chain that has been carried out, it is known the SCOR process involved in each existing chain. It is necessary to identify performance attributes on SCOR version 11.0 to find out what performance metrics are involved in the newspaper industry. In research carried out, only use several level 1 metrics and level 2 metrics. The following is metrics performance that will be used in simulation in Table 1:

Table 1. Metrics Performance Newspaper Industry

Attributes	Metrics Level 1	Metrics Level 2	Item
Reliability	Perfect Order Fulfillment Percentage	% of Order Delivered in Full	%
		Delivery Performance to Customer Commit Date	%
		Perfect Condition	%
Responsiveness	Order Fulfillment Cycle Time	Make Cycle Time	Hour
		Deliver Cycle Time	Hour
Agility	Upside Supply Chain Flexibility	Upside Make Flexibility	%
	Upside Adaptability	Upside Make Adaptability	%
Cost	Total Cost to Serve	Purchased Material Cost	%
		Production Cost	%
		Transportation Cost	%
Asset Management Efficiency	Cash-to-Cash Cycle Time	Inventory Days of Supply	Days

Based on Table 1 can be seen that some metrics level 1 has been used. From reliability attributes there is one metric on level 1 is *Perfect Order Fulfillment Presentase*. Then on metrics level 2 used *% of Order Delivered in Full*, *Delivery Performance to Customer Commit Date* and *Perfect Condition*. The unit as percentage and the process involved in SCOR is Ship Product in the process Make-To-Stock, Receive and verify Product by Customer and Load Product and Generate Shipping Documents. The other attributes is responsiveness. On the responsiveness there is one metrics on level 1 is *Order Fulfillment Cycle Time*. On responsiveness metrics level 2 used *Make Cycle Time* and *Deliver Cycle Time*. The unit as hour and the process involed in SCOR is Make-To-Stock and Deliver Stocked Product.

From agility attributes there are two metrics on level 2 , there are *Upside Supply Chain Flexibility* and *Upside Adaptability*. Then on metrics level 2 used *Upside Make Flexibility* as the unit hour and *Upside Make Adaptability* as the unit percentage. The process involved in SCOR is proces Make-To-Stock. On the Cost attributes there is one metric on level 1, it is total cost to serve. On metrics level 2 there are *Purchased Material Cost*, *Production Cost* and *Transportation Cost*. All the unit as percentage and the process involved in SCOR is Source Stocked Product, Make-To-Stock and Deliver Stocked Product. And on the Asset Management Efficiency attributes, there is one metrics level 1 has been used. There is *Cash-to-Cash Cycle Time* and on level 2 metrics is *Inventory Days of Supply* which is the unit as days. The process involved in SCOR are Identify, Prioritize and Aggregate

Supply Chain Resources, Balance Supply Chain Resources with Supply Chain Requirements, Establish and Communicate Supply Chain Plans and Transfer Product.

Based on the identification metrics on newspaper industry in the table, hence a causal loop diagram is made to describe the system model in the newspaper industry supply chain. The CLD has been made based on five attributes on the SCOR versi 11.0. The others metrics and variabels involved in case described the system model supply chain of newspaper industry. The following in Fig 2 is causal loop diagram of in the newspaper industry that will be used as model system in a dynamic system simulation :

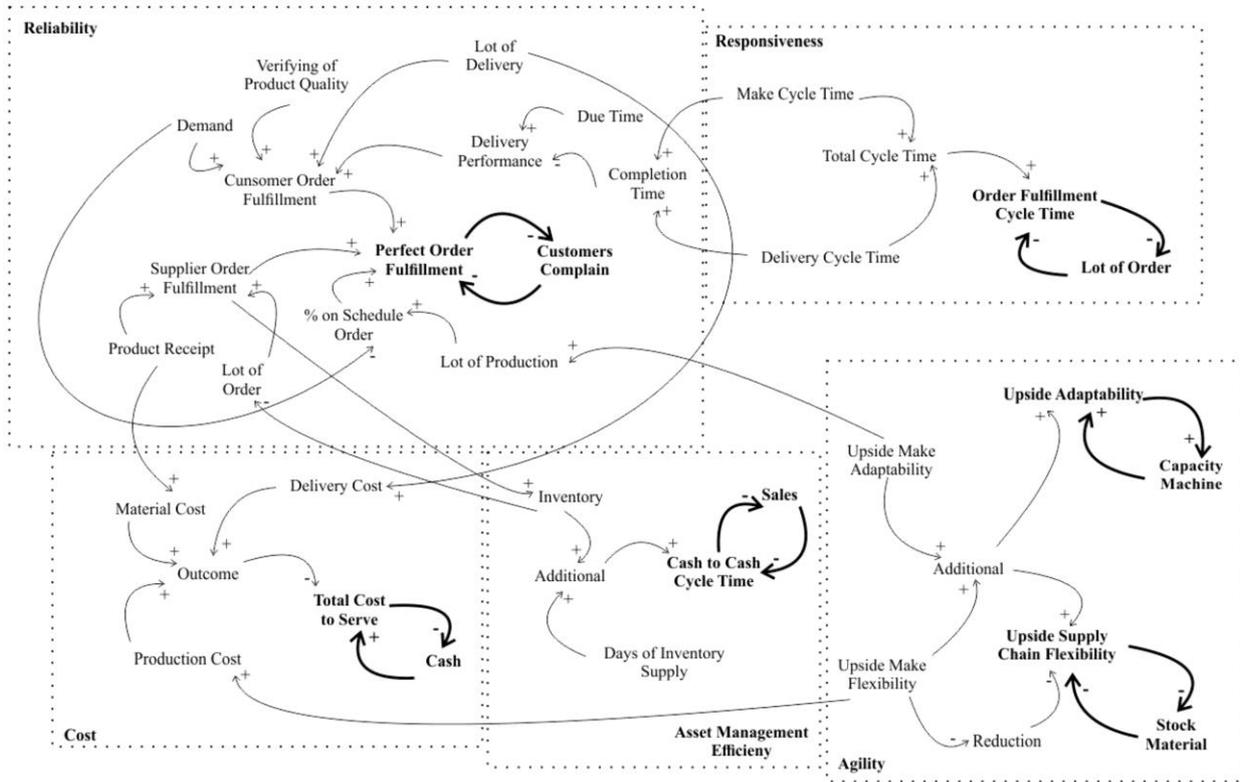


Fig. 2. Causal Loop Diagram Model Newspaper Industry

Based on the CLD on the Fig 2, there is five attributes of the performance on the SCOR version 11.0. Every attributes involved each others and make the system on the supply chain of newspaper industry. On the realibility attributes there is *Perfect Order Fulfillment* as the metrics level 1. *Perfect Order Fulfillment Rate* be affected with *Customer Complain*. If the *Customer Complain* is high so rate of *Perfect Order Fulfillment* will low and otherwise. *Perfect Order Fulfillment* be affected with the *Percentage of Schedule Order*, *Supplier Order Fulfillment* and *Customer Order Fulfillment*. The *Percentage Schedule Order* affected with *Lot of Production* which is affected with *Upside Make Adaptability*. *Upside Make Adaptability* is the maximum sustainable percentage increase in production that can be achieved in certain time with the assumption of no raw material constraints. Then *Supplier Order Fulfillment* affected by *Lot of Order* which is affected by *Inventory* and the others is *Product Receipt* which is affected by *Material Cost*. The *Customer Order Fulfillment* affected by *Demand*, *Verifying of Product Quality*, *Lot of Delivery* and *Delivery Performance*. Which is *Demand* is affected by the *Percentage on Schedule Order*. The *Lot of Delivery* also affected by *Delivery Cost* and *Delivery Performance* affected by *Due Time* and *Completion Time*.

The *Completion Time* is affected by *Make Cycle Time* and *Deliver Cycle Time* on the other attributes, it is responsiveness. The responsiveness attributes there is one metrics *Order Fulfillment Cycle Time*. *Order Fulfillment Cycle Time* affected with *Lot of Order*. Which is if the order is high so the cycle time is high too and it is affected the *Total Cycle Time*. The *Total Cycle Time* is included *Make Cycle Time* and *Deliver Cycle Time*. The other attributes is cost. On the cost attributes there is

one metric, is *Total Cost to Serve* which affected with *Cash* owned by the company. *Total Cost to Serve* affected by the outcomes. Besides, the *Outcomes* affected by *Production Cost*, *Material Cost* and *Delivery Cost*. The *Material Cost* and *Delivery Cost* affected with several variables on the reliability attribut, whereas *Production Cost* is affected by *Upside Make Flexibility* on the agility attributes.

On the agility attributes, there are two metrics, upside supply chain flexibility and *Upside Adaptability*. *Upside Supply Chain Flexibility* affected with *Stock Of Materials* and the *Reduction* also *Additional Production*. Both of *Additional* and *Reduction* of the product will affect the *Upside Make Flexibility*. Which is also affected the *Production Cost* on the cost attributes. Therefore, on the *Upside Adaptability Attributes* affected with *Capacity Machine* and *Additional* of the products. And it is affected to *Upside Make Adaptability* which is affected the *Lot of Production* on the reability attributes. The last attributes is asset management efficiency. There is one metrics involved it is *Cash to Cash Cycle Time*. *Cash to Cash Cycle Time* affected with the *Sales* of product. If the *Sales* is high then the *Cash to Cash Cycle Time* also fast and the otherwise. *Cash to Cash Cycle Time* affected by the *Additional* the production of the products. Which is will affects the *Days of The Inventory Supply* and the *Inventory*. The *Inventory* of raw materials also will be affected the *Lot of Orders* of raw materials.

Based on the CLD in Fig 2 can be described the newspaper industry supply chain model system based on the identification of processes and metrics carried out based on SCOR version 11.0 on the Table 1. Then, the system model is continued on the model in the software. This research will be done using powersim software. The following are the models used in the software in this Fig 3 :

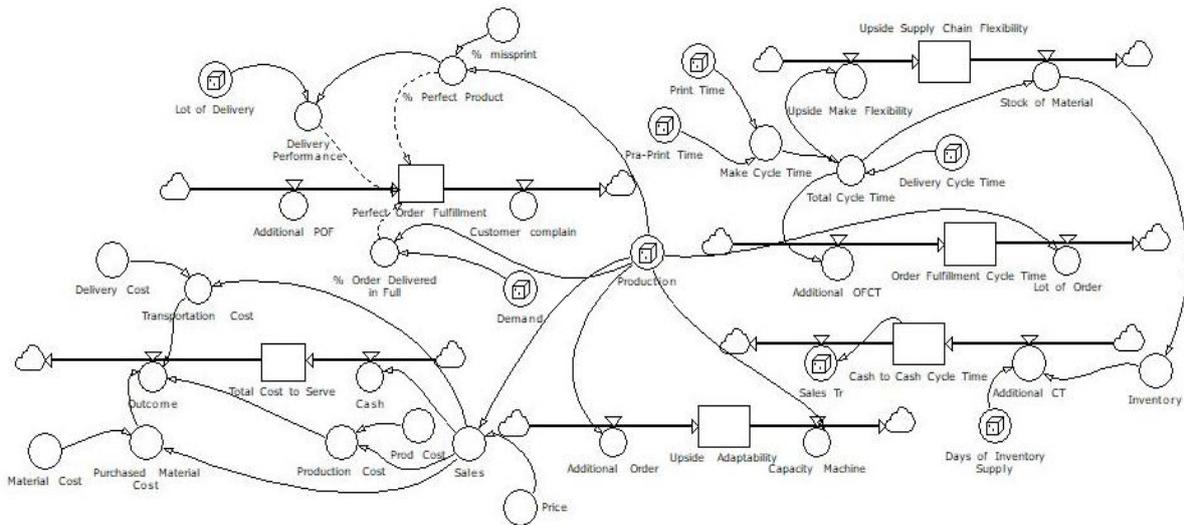


Fig. 3. Powersim Model Newspaper Industry

Based on the model on powersim in Fig 3 it can be done to provide feedback to the company with running the simulation. The results of the simulation is on the Table 2.

Table 2. The Results of Simulation

No.	Attributes	Initial Simulation	Final Simulation	Target
1	Reliability	99.25%	99.59%	99.50%
2	Responsiveness	4.7 hours	3.3 hours	4 hours
3	Agility	4.7 hours and 119%	3.3 hours and 120.22%	4.7 hours and 119%
4	Cost	81.76%	80.81%	80%
5	Asset Management	50 days	27 days	35 days

Based on the Table 2, the final results of simulation using powersim is the value of performance measurement using SCOR model version 11.0 from reliability attributes the values is about 99.59%, the attributes of responsiveness is 3.3 hours, the attributes of agility is 120.22%, the attributes of the cost is 80.81%, and the attributes of asset management is 27 days. From the results the attributes cost still below the target. With using simulations can issue performance value to the company, the performance measurement in the newspaper industry like from the results above in Table 2. The company also can looking for performance that is still below from the target and in low condition and make improvements so the supply chain in the newspaper industry can be done with efficient and optimal.

Conclusion

The simulation model has been done in the real case of newspaper industry. The research can provide the company to measure the performance in the company. Otherwise to know the performance which has the low value and can affected the others chain on the whole supply chain of newspaper industry. And the last to make improvements on the attributes or variables in the newspaper industry supply chain so the industry can work optimal and efficiently. In the future, a research in newspaper industry can be conducted with hybrid method of system dynamics and discrete event simulation on the simulation of performance measurement so the results of performance measurement in newspaper industry can be more optimal.

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