Supply Chain Risk Management in Newspaper Printing Using FMEA and FTA Methods: A Case Study

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Abstract

In the newspaper supply chain, the printing process, the procurement of paper, ink, and printing plates to the distribution of newspapers to consumers are the main business processes. The risk involved in the supply chain of the newspaper industry is particularly large. Supply chain risk management is used to identify and mitigate the negative impacts of supply chain performance. This study aims to identify operational risks in the newspaper supply chain using the Failure Mode and Effect Analysis (FMEA) and Fault Tree Analysis (FTA) methods and create alternative mitigation strategies. Risk measurement in FMEA is done by using a risk matrix, namely the Risk Priority Number (RPN). As a result, 27 operational risks have the potential to disrupt the newspaper printing process, with critical risks occurring in the newspaper delivery process. Then identify the factors causing the critical risk from the top event to the root cause of the risk (basic event). The results received are the causes of risk in the form of error splicing, unstable roller, inaccurate plate, unpredictable weather, lack of worker skills, pests and diseases, purchase forecast error, old transport, and traffic jam.

Keywords
Supply Chain Risk Management, Failure Mode, Effect and Analysis, Risk Priority, Number, Fault Tree Analysis

1. Introduction

Newspapers are made of low-cost paper that contains the latest news in various topics. In the supply chain of the newspaper industry, the printing company is the main entity that has several processes, namely the procurement of raw materials, printing plates and newspapers, and also distributing newspapers to customers. The entities involved are suppliers, newspaper printers, newspaper publishers, agents, and customers. Suppliers in this supply chain consist of ink suppliers, newspaper suppliers, and plate suppliers. While in the customer entity is divided into two groups, namely regular customers and customers break up. All entities have a role to play in the decision-making, movement of information, and added value of a product. Supply chain process performance becomes the focus for designing systems that can minimize time and cost. Supply chain management is important in lowering costs in today's changing and challenging economic times, which will hopefully lead to improved customer satisfaction (Valmohammadi, 2014).

Risk is a potential loss in the production process, which can have a bad impact on the company (Monahan, 2008). The risks that exist in the supply chain of the newspaper industry are quite heavy. Tight delivery deadlines and zero inventory lead to very short time frames for production and distribution. Besides, there is pressure from the redaction room to encourage the start of production later to make the latest news and also pressure from distribution to start production as early as possible (Sartika et al., 2018). Risks need to be identified to map out risk characteristics that will impact supply chain performance (Nasution, 2014). Without risk management, risk disruption can have an impact on a company's performance (Lutfi, 2012). Some of the risks that may occur for supply chain newspaper printing companies are uncertainty of orders from customers and raw materials used (Acharyulu, 2014), consumer decline (Boonkleaw et al., 2010), delayed delivery (Papathanassopoulos, 2001), and waste of resources at the time of distribution (Chiang et al., 2009).

Supply Chain Risk Management (SCRM) is defined as the risk that occurs due to the process of moving material from supplier to end customer (Christopher, 2003). SCRM is conducted through coordination between supply chain entities to ensure corporate profits (Tang, 2011). It is used to identify and mitigate the negative impacts of supply chain performance (Astutik et al., 2016). Companies need good supply chain planning by identifying the risks in the supply chain. SCRM is an unavoidable and necessary task to identify supply chain risks that can impact certain problems in a company (Lavastre, 2012).

Based on the statement, the study take the issue of supply chain risk management in the newspaper industry. The research aims to identify operational risks in the newspaper supply chain using the Failure Mode and Effect Analysis (FMEA) and Fault Tree Analysis (FTA) methods as well as create alternative mitigation strategies.

1.1 Objectives
This research aims to identify operational risks in the newspaper supply chain using Failure Mode and Effect Analysis (FMEA), Fault Tree Analysis (FTA) methods, and create alternative mitigation strategies.

2. Literature Review
2.1 Failure Mode and Effect Analysis
Failure Mode And Effects Analysis (FMEA) is an engineering technique used to define, identify, problems, errors and so on from systems, designs, processes and/or services before a product or service is received by consumers (Stamatis, 1995). There are three types of assessment in Failure Mode and Effect Analysis (FMEA), namely severity, occurrence, and detection. Severence is a score of 1-5 which corresponds to the serious effects of the existing failure mode. The bigger the effect, the bigger the score.

1. Severity
   Severity is the seriousness of the effects caused by the failure mode (Ridho et al. 2020) . Severity can be determined from the level of damage generated by the risk event in the company. The assessment for severity can be seen in Table 1 below which has several criteria with a certain rating value.

Table 1. Severity Rating

Skalar	Parameter	Description
1	Not significant	Downtime < 5 minutes
2	Small	Downtime 5-10 minutes
3	Medium	Downtime 10-30 minutes
4	Large	Downtime 30-60 minutes
5	Very Significant	Downtime > 60 minutes

2. Occurrence
   Occurrence is the level of likelihood of a risk event occurring (Ridho et al. 2020). The assessment for occurrence can be seen in Table 2 below, which has several criteria with certain rating values.

Table 2. Occurance Rating

Skalar	Parameter	Description
1	Rarely happening	Frequency 1-3 events
2	Somewhat Rarely Happens	Frequency 4-6 events
3	Might happen	Frequency 7-10 events
4	Often occurs	Frequency 10-20 events
5	Almost Definitely Happening	Frequency > 20 events

3. Detection

Detection is how much control is given to risk events found during the operation process. The assessment for detection can be seen in Table 3 below which has several criteria with certain rating values.

Table 3. Detection Rating

Skalar	Parameter	Description
1	Very high	Very high chance of detecting errors (9/10 times)
2	High	High chance to detect errors (7/10 times)
3	Moderate	Moderate chance to detect errors (5/10 times)
4	Low	Low chance of detecting errors (2/10 times)
5	Almost impossible	Almost undetectable error (0/10 times)

2.2 Risk Priority Number (RPN)

Risk Priority Number (RPN) is a technique used to analyze risk by relating potential problems identified in Failure Mode and Effect Analysis (FMEA) . (Tri Sulistiyono et al., 2008)

$$RPN = S \times O \times D$$

After knowing the RPN value, then the next step is to determine the critical RPN. The critical RPN value provides information on the RPN value limit of the existing failure mode. If the RPN value of each failure mode is above the critical value, then the disturbance is categorized as a disturbance that must be handled immediately by the company. The following is the calculation of the critical value of RPN.

$$\text{Critical Value RPN} = \frac{\text{Total RPN Value}}{\text{Total Risk Value}}$$

2.3 Fault Tree Analysis (FTA)

Fault Tree Analysis is an analytical tool that translates graphically the combinations of errors that cause system failure. This technique is useful in describing and assessing events in the system (Foster, 2004). FTA shows the logical relationship of the underlying causes to the problems which are the main causes listed above. FTA has special symbols in its creation. The symbols and their meanings can be seen in Figure.1

Figure 1. FTA Symbol
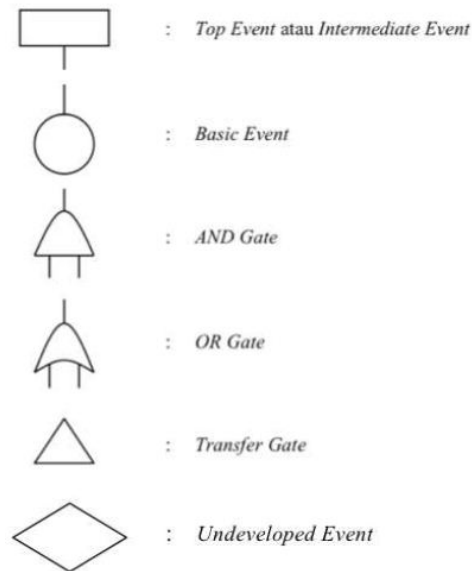
3. Methods

Identification of operational risks that disrupt the newspaper printing process can be done with document review and interview techniques. The stages of data collection and processing in this study are as follows:

a. The necessary data collection is the business process in the printing company and the risk events that occur in it. Business processes are divided into five, namely plan, source, make, deliver, and return.

b. Risk assessment using the FMEA (Failure Mode and Effect Analysis) method. The FMEA method is a risk analysis technique used to evaluate the results of failure and prioritize failure to the effects that occur. FMEA is essentially adapted for material and equipment failures, but along with necessity, FMEA can be used to analyze human error and performance failures. Risk measurement in FMEA is carried out using the RPN risk matrix (Risk Priority Number) by calculating the values of the severity of the risk that occurs, factors of the possibility of occurrence of risk, and the level of possible causes of risk can be detected (Badariah et al. 2012).

c. Analyze of the causes of risk using FTA (Fault Tree Analysis). The critical risks obtained from RPN calculations are used as top events in the analysis of root causes of risk (basic event) (Sufa and Khoiriyah, 2017).

d. Design mitigation strategies that can be applied in newspaper printing companies in order to reduce the occurrence of risk agents in the supply chain (Kusnindah et al. 2018).

4. Data Collection

This research was conducted based on the results of document review and interview techniques. The data collected are as follows: risk events that occur, the severity of the risks that occur (severity), possible risk factors (Occurence), and the level of possible causes of risk can be detected (Detection). Risk events, severity, and Occurrence in this study use the considerations of a previous study entitled "Supply Chain Risk Management in Newspaper Company: House of Risk Approach" conducted by Sintya Ratnasari, Muhammad Hisjam, and Wahyudi Sutopo. The following are the identified risk events that occurred in newspaper printing companies listed in Table 5.

Table 5. Risk Event (Ratnasari et al. 2018)

Major Process	Sub Process	Risk Events
Plan	Demand Forecasting	Forecast error
	Production plan	Error calculation of requirements raw material

Major Process	Sub Process	Risk Events
	Inventory Control	Planning error of raw material purchase schedul
		Out of raw materials (paper and ink)
		Sudden changes in production planning
Source	Procurement ProcessProcurement Process	Damage raw materials from supplier
		There are expired raw materials
	Supplier Evaluation and Development	The amount of raw materials received does not match the order
		Availability of raw materials from empty suppliers
		Lack of raw material quantity from supplier
		Delay in delivery raw materials form supplier
Make	Production	Design and color mismatch with production
		Error while printing plate
		Broken plate
		The machine stopped operating
		Error on setting production machine
		Newspaper revision
		Late receipt of newspaper softfile
		An error occurred the number of products produced
		Unable to ship product according to the number of requests
Delivering	Packaging	Delay in sending newspape
		Long hauling distance
	Delivery product to customers	There was a disaster during the delivery process
		Products delivered to wrong destinatio
Return	Returning rejected items to supplier	Return product from customer
	Handling return from customer	Shortage of raw material
		There was a disaster during the return process

5. Results and Discussion

a) Risk Priority Number (RPN) Calculation

These following are the results of the RPN calculations that have been carried out in Table 6. Severity and occurrence values are obtained from the results of the previous reference paper (Ratnasari et al., 2018).

Table 6. RPN Calculation

Major Process	Sub Process	Risk Events	Severity	Occurrence	Detection	RPN
Plan	Demand Forecasting	Forecast error	1	3	2	6
	Production plan	Error calculation of requirements raw material	1	3	3	9

Source	Inventory Control	Planning error of raw material purchase schedul	1	1	2	2
		Out of raw materials (paper and ink)	1	4	3	12
		Sudden changes in production planning	4	3	4	48
	Procurement ProcessProcurement Process	Damage raw materials from supplier	1	2	4	8
		There are expired raw materials	3	2	3	18
	Supplier Evaluation and Development	The amount of raw materials received does not match the order	4	1	3	12
		Availability of raw materials from empty suppliers	5	3	4	60
		Lack of raw material quantity from supplier	1	1	4	4
		Delay in delivery raw materials form supplier	1	1	4	4
Make	Production	Design and color mismatch with production	5	4	4	80
		Error while printing plate	4	3	4	48
		Broken plate	4	4	5	80
		The machine stopped operating	4	4	5	80
		Error on setting production machine	4	3	4	48
		Newspaper revision	4	3	4	48
		Late receipt of newspaper softfile	4	2	3	24
		An error occurred the number of products produced	1	2	3	6
		Unable to ship product according to the number of requests	1	2	3	6
Delivering	Packaging	Delay in sending newspape	5	4	5	100
		Long hauling distance	3	5	4	60
	Delivery product to customers	There was a disaster during the delivery process	2	3	4	24
		Products delivered to wrong destinatio	2	2	3	12
Return	Returning rejected items to supplier	Return product from customer	3	3	4	36
	Handling return from customer	Shortage of raw material	2	1	4	8

		There was a disaster during the return process	1	1	5	5
Total Occurrence Risk		27		**Total RPN**		**848**

After knowing the RPN value, then the next step is to determine the critical RPN. The critical RPN value provides information on the RPN value limit of the existing failure mode. If the RPN value of each failure mode is above the critical value, then the disturbance is categorized as a disturbance that must be handled immediately by the company. The following is the calculation of the critical value of the RPN.

$$\text{Critical Value RPN} = \frac{\text{Total RPN Value}}{\text{Total Risk Value}}$$

$$\text{Critical Value RPN} = \frac{848}{27}$$

Critical Value RPN = 31,40

So it was found that the values that were above the critical value were the risk of sudden changes in production planning, availability of raw materials from empty suppliers, designs and colors that were not in accordance with production, errors when printing plates, machines stopped while operating, errors in production machine settings, revisions. newspapers, late delivery of newspapers, long haul distances and product returns from customers. Based on these results, it can be seen that the highest value above the critical value is due to delays in newspaper delivery. So that it can be determined the causes of these risk factors in a tree diagram or called Fault Tree Analysis to the root of the problem.

b)   Analysis Using the Fault Tree Analysis Method

Based on the results of the RPN calculation above, it can be seen that operational risk with a high critical value is in the delay in the newspaper delivery process. Then the critical risk is identified the factors causing the risk from the top event to the root cause of the risk (basic event) using Fault Tree Analysis. In Figure 2, the following is a Fault Tree Analysis of the risk of delays in newspaper delivery.
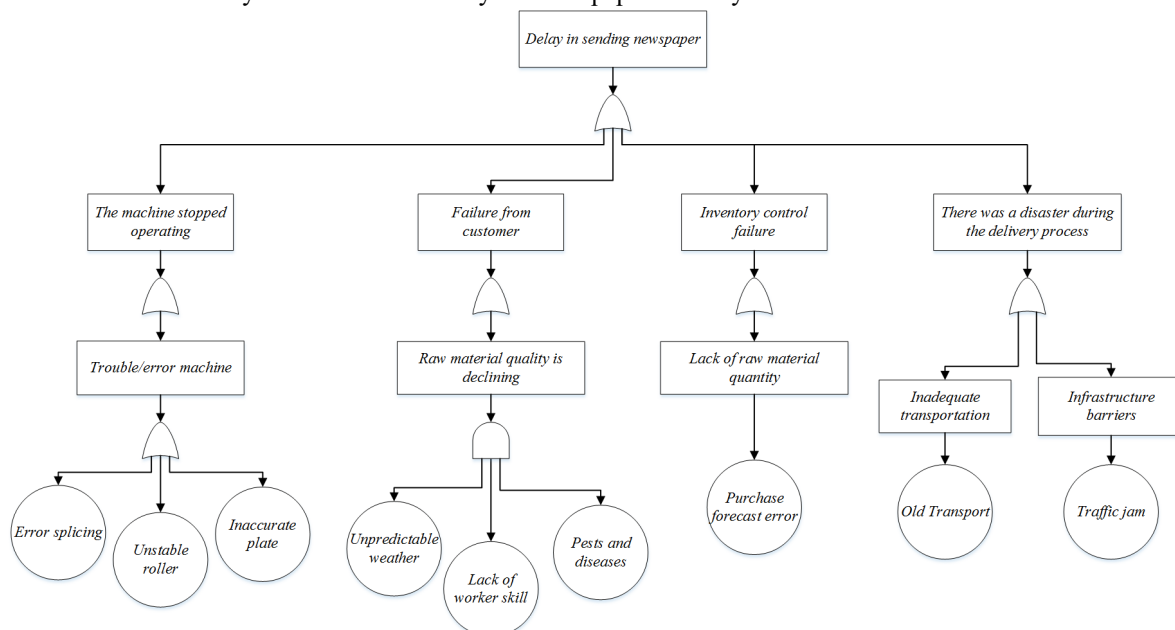

Figure 2. Fault Tree Analysis of Newspaper Delivery Delays

Based on the results of the identification of the causes of the risk of delay in the delivery of newspapers above, it can be seen that the machine stopped operating, the failure of the supplier, the failure of inventory control and the accident occurred during delivery.

The engine stops operating due to engine trouble such as errors during the splicing process, roller instability, and plate shifts. The failure of the supplier is due to the declining quality of raw materials due to unfavorable weather factors, minimal worker skills and being attacked by pests and diseases. unfavorable weather, minimal worker skills and disease pests. Furthermore, the failure of inventory control was caused by running out of stock of raw materials in the warehouse due to an error factor in the estimation of the purchase of raw materials. Meanwhile, the occurrence of a disaster during delivery was caused by inadequate transportation due to the age factor of transportation and the existence of infrastructure obstacles such as being stuck in traffic jams. Furthermore, the basic risk above is given a proposed improvement solution by determining a risk mitigation plan.

C. Risk Mitigation

After determined the basic event of delayed delivery of newspapers, then made risk mitigation. Risk mitigation can be used by companies as a consideration in reducing risk. Here is a plan to mitigate the risk of delayed delivery of newspapers in Table 7.

Table 7. Risk Mitigation

No.	Risk Event	Risk Agent	Mitigation Strategy
1	Trouble/ error machine	Error splicing	Using more imported double-sided tape so it sticks strongly.
		Unstable roller	Inspection of the machine before use and routine maintenance.
		Inaccurate plate	Arrangements during production activities and installation of stronger plates.
2	Raw material quality is declining	Unpredictable weather	Keep material in the right shade and temperature.
		Lack of worker skill	Provide supplier workforce training.
		Pests and diseases	Routine control and keep the storage area clean.
3	Lack of raw material quantity	Purchase forecast error	Make safety stock of materials.
4	Inadequate transportation	Old transport	Transportation check before departure.
5	Infrastructure barriers	Traffic jam	Ensure that the route used is smooth at the time of departure or use an alternative route.

6. Conclusion

Based on the results and analysis, it can be concluded that there are 27 operational risks have potential to disrupt the supply chain of newspaper printing. These include 5 risks in the process plan, 6 risks in the source process, 9 risks in the make process, 4 risks in the delivering process, and 3 risks in the return process. The highest risk with a value of RPN 100 occurs in the delivering process, namely delays in newspaper delivery. Then análisis of risk causes include the machine stopped operating during the production process, failure from the customer, failure of inventory control, and disaster during delivery process. This event is used as a top event. While the basic event obtained is error splicing, unstable roller, inaccurate plate, unpredictable weather, lack of worker skills, pests and diseases, purchasing forecast errors, old transportation, and traffic jam. Furthermore, each basic event is given risk mitigation so that the supply chain in newspaper printing runs well. This study has not counting the risk cost so it is expected that future research can consider the cost.

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