Regional transportation development for development at fertilizer plants in North Sumatra (case study)

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Abstract. Supply chain activity has an opportunity for the occurrence of risk. Therefore, risk management is needed in the handling of risk with the aim to minimize the risk level and impact of those risks. PT. XYZ of PT Pupuk Indonesia (Persero) engaged in the fertilizer industry. The main product produced is urea fertilizer. In the production process, the factory is supported by adequate production facilities and international standard technology. Currently, PT XYZ does not yet have risk management which explicitly discusses the proposed risk management along with the handling strategies required by the company. By looking at the current condition of the company, in order to achieve the goals to be achieved the company needs a good supply chain planning such as by identifying the risks that exist in the supply chain and preventive measures. Performed risk analysis and evaluation of potential supply chain companies using HOR (House Of Risk) tools. After the research there were 42 risk events and 42 risk agents. With the 80/20 pareto approach, 9 risk agents are planned for mitigation action. There are 11 recommended risk mitigation actions recommended to the company in the hope of addressing the risk of urea fertilizer supply chain.

1 Introduction

A supply chain can be defined as a network which consist of several companies (including suppliers, manufacturers, distributors and retailers) who cooperate and both directly or indirectly engaged in achieveing customer's demands. Supply chain activity has an opportunity for the occurrence of risk. Therefore, risk management is needed in the handling of risk in the aim to minimize the level of risk and risks' impact [1].

PT XYZ is a subsidiary company of PT Pupuk Indonesia (Persero) engaged in the fertilizer industry. The main product is urea fertilizer. In the production process, the factory is supported by adequate production facilities and international standard technology. Vendors are an important part of supply chain management in PT XYZ because all production materials, both auxiliary materials for production, chemical additives to production machines' spare parts are supplied by selected vendors after a tender / auction.

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Initial observations showed that there was a delay in the delivery of helping chemicals from 2 days to 106 days. Another problem found in the company is the failure of the bidding process, so that the bidding done repeatedly and resulted the length of the PR process time until the issue of PO and the document confirmation of the specification of the working unit is not available [2-3].

Currently, PT XYZ still does not have any risk management that explicitly discusses the proposed risk management along with the handling strategies required by the company. By looking at the company's condition today, in order to achieve the goals, the company needs a good supply chain planning such as by identifying the risks that exist in the supply chain and preventive measures. Therefore, this research identifies potential risk events occurring in a supply chain, what factors cause the risk to occurs, the relationship between these factors and risks, and how the handling strategy can be used in PT XYZ to handle the risks that usually occur in the supply chain.

In this research will be analyzed and evaluated the risk that potentially appears on the company's supply chain using the HOR (House Of Risk) tools developed by Pujawan and Geraldin. The concept of HOR is similar to the House of Quality (HOQ) concept derived from the Quality Function Deployment (QFD) method. According to Geraldin [4], the HOQ concept will help to design strategies, to identify risks and prioritize risk events that must be addressed first and design a mitigation strategy to reduce or eliminate identified risk agents.

This research is needed for local development. This is necessary for the development of the North Sumatra region, where transportation problems are very influential on product delivery. The company is currently experiencing supply chain problems that affect the timeliness of product acceptance to consumers.

Research on risk mitigation applying the House of Risk (HOR) approach has been conducted and published in a journal entitled "Analysis and Improvement of Risk Management Supply Chain of Rafting Sugar Supply With House Of Risk Approach" and Managing Quality Risk in A Frozen Shrimp Supply Chain: A Case Study [1, 9].

2 Research method

The research begins with the review and data collection at PT. XYZ. Data obtained through interviews are mapping of company activity based on SCOR model, assessment of severity on risk event, assessment of occurence on risk agent, relationship assessment at risk event with risk agent, mitigation action, assessment of difficulty level on mitigation action and correlation relationship between risk agent with mitigation action [5].

The method used in this study is the approach of House of Risk (HOR) which consists of 2 phases. House of Risk Phase I has the following stages:

1. Identify the risk events that can occur in every business process. Performed through supply chain mapping (plan, source, make, deliver and return).
2. Estimate the impact of some risk events (if they occur) ie Severity (S_i).
3. Identify the source of risk and assess the probability of occurrence of each risk source ie Occurence -O_j-.
4. Calculate the relationship of each risk source and each risk event.
5. Calculate the potential aggregate risk group (ARP_j) with the formula $ARP_j = O_j \sum S_i R_{ij}$.
6. Rank risk sources based on a collection of potential risks.

While House of Risk Phase II has the following stages:

1. Select multiple risk sources with a high priority ranking that may use pareto analysis from ARP_j.
2. Identify consideration of relevant actions for the prevention of sources of risk.

3. Determine the relationship between each preventive action and each source of risk-Ejk-.
4. Calculate the total effectiveness of each action as follows TEk = ΣARPjEjk.
5. Estimate the degree of difficulty in performing each action.
6. The priority ranking of each action (Rk) in which rank 1 gives the highest meaning of action with ETDk.

3 Result and discussion

3.1 Identification of *risk event* and *risk agent*

Risk identification is a stage to know the risk event that interfere with supply chain activity at company and to know risk agent that cause risk event identification is done through interview at PT. Fertilizer Iskandar Muda. Risk event obtained by mapping of supply chain activity based on SCOR model, then Severity rating for every risk event. The result of risk event identification and assessment can be seen in Table 1.

The scale used in the severity scores is a scale of 1-10 with the meaning of value 1 (no disturbance effect) and value 10 (risk of causing harmful interference) [6].

Table 1. Risk Event Identification and Assessment

Major Processes	*Sub – Processes*	*Risk Event*	*Code*	*Sev.*
Plan	Demand Forecasting	Determining the number of inaccurate requests	E_1	4
	Material Planning	The difference between registered and available stock	E_2	5
		Error in writing specification of the requested item	E_3	7
		The requested item is already obsolete (no longer production)	E_4	5
		Needs of sudden and urgent goods	E_5	7
		Insufficient / accurate media parameters	E_6	4
Plan	Production Planning	Changes in production plans are sudden	E_7	3
		A sudden machine failure occurs	E_8	7
	Shipping Planning	Mistakes of product delivery plans	E_9	5
		Change of import license of goods from the government	E_{10}	5
	Resource Adjustment with Supply Chain Requirement	Non-conformity of existing resources with supply chain requirements	E_{11}	7
Source	Supplier Selection	The selection is repeated due to the failure of the tender	E_{12}	5
		Inappropriate supply partner supply field	E_{13}	7
		Offering partner prices above the available budget	E_{14}	6
	Product Delivery Scheduling from	Delay in goods delivery by	E_{15}	5

	Supplier	vendor		
	Product Acceptance	Error goods received from vendor	E_{16}	6
		Incomplete document delivery of goods from partners	E_{17}	4
Source	Quality Checking	Received goods do not meet the quality set by the company	E_{18}	7
	Provision of Payment Authorities of Submitted Products	Error authorizing payment of goods from vendor	E_{19}	4
	Procurement of goods	Damage of goods while in the warehouse	E_{20}	6
Make	Production Scheduling	Delay in production schedule	E_{21}	4
		The occurrence of damage to machine / mechanical	E_{22}	7
	Production process	No production activities	E_{23}	6
		Production is unable to meet demand	E_{24}	7
		Production activities are disrupted	E_{25}	5
		The resulting product is not good / not perfect	E_{26}	7
	Product Quality Check	Product quality does not conform to existing standards	E_{27}	6
	Packaging Process	Leakage of product packaging	E_{28}	3
		The packaging is dirty	E_{29}	2
Deliver	Shipping Selection	The shipping capacity of the product is less	E30	3
		Incorrect submission of document submissions	E31	3
		Inadequate transportation / less	E32	4
		Lack of transport workers	E33	4
		The product is damaged while in the warehouse	E34	3
	Delivery of goods	Delay of product delivery	E35	5
		The occurrence of contamination of goods when shipping	E36	2
	Warehousing Activities	Unkempt packaging	E37	2
		Damage when handling the product	E38	2
	Delivery of goods Acceptance and Verification of Goods by Consumer	Driver's negligence	E39	3
		Product delivery error	E40	3
Return	Return of product / defect to supplier Return of defective product from consumer	Late arrival of product / goods replacement from vendor	E41	4
		Delay return of product / goods from consumer	E42	4

Based on Table 1. There were 42 risk events contained in the company's supply chain.

Risk agents are things that can cause a risk event to occur that can disrupt the supply chain activity in the company. Risk agents are obtained from interviews that are then encoded by using letter A which aims to facilitate further readings. Risk assessment agent

conducted at the time of interview with the PT. XYZ by giving the value of occurence on the assessment form. The result of risk agent identification and assessment can be seen in Table 2.

Table 2. Identification and Assessment of Risk Agent

Risk Agent	*Code*	*Occurance*
Forecasting inaccuracies	A_1	4
Significant increase in consumer demand	A_2	4
Seasonal factors	A_3	2
Misinformation and communication	A_4	2
Lack of coordination	A_5	2
Error in vendor selection	A_6	3
The occurrence of trouble / damage suddenly	A_7	6
Materials interruptions in transit	A_8	2
External factors	A_9	3
Checking recipient parts of raw materials is not accurate	A_{10}	3
The delivery procedure is not organized	A_{11}	2
There was an interruption to the raw materials during the trip	A_{12}	2
Sets the terms of supplier criteria	A_{13}	3
Purchasing SOP	A_{14}	1
The purchase list does not include clear specifications	A_{15}	7
Efficiency factor during the process	A_{16}	4
Unused materials / goods	A_{17}	2
Less planning when the process will be done	A_{18}	2
Factor reliability of machine tools during the process	A_{19}	7
Gas supply is disrupted	A_{20}	6
Machine / equipment failure occurred	A_{21}	6
Lack of care management	A_{22}	6
Package contamination occurs during the storage process	A_{23}	3
Power supply is disrupted	A24	2
Internal factors of the company	A25	2
Improper quality checks	A26	2
productionShutdown	A27	7
Sudden material demand	A28	6
Loss / weight reduction / content of the product	A29	1
Limited transportation equipment	A30	3
Labor shortage	A31	2
Changes to the sales plan	A32	2
Less coordination in the warehouse	A33	2
Less coordination of shipping parts	A34	2
Natural disasters	A35	1
Interruption during the trip	A36	3
Unsafe transportation by environmental factors	A37	3
Limited warehouse production area	A38	2
Lack of communication	A39	3
The carrier is damaged	A40	3
Impaired IT system	A41	2
The packing of the returned item does not meet the specifications	A42	3

The scale used in the value of occurence is the scale of 1-10 with the meaning of value 1 (The occurrence of the cause of risk is almost not happening) and the value of 10 (The occurrence of the cause of risk almost always occurs) [6].

Assessment level of risk event relationship with risk agent conducted during interview with PT. XYZ by way of giving relatonship value on the form. The scale used in the

relationship value is 0, 1, 3 or 9 where 0 indicates no relationship, 1 low (low), 3 moderate, and 9 indicates high ties [6].

3.2 Calculation of *Aggregate Risk Potential* (ARP)

ARP calculations are obtained based on the formula:

$$ARP\, j = Oj\, \Sigma\, Si\, Rij \tag{1}$$

When:
ARP j   : Agregate Risk Potential
Si   : Severity
Oj   : Occurance
Rij   : Relationship

Example calculation ARP1 as follows:
Discovered: $O_1 = 4$
                $R_{11} = 9$ $S_1 = 4$
                $R_{12} = 1$ $S_2 = 5$
                $R_{15} = 1$ $S_5 = 7$
                $R_{111} = 1$ $S_{11} = 7$
Asked : ARP_1
Answer: $ARP_1 = Oj\, \Sigma\, Si\, Rij$
                $ARP_1 = 4\cdot[9(4)+1(5+7+7)] = 220$

Determination of priority risk is performed by looking at the highest ARP value using the 80:20 pareto chart. Pareto diagram of ARP Risk Agent can be seen in Figure 1. From the pareto diagram and the table is then seen the percentage of risk agent has an effect of 80% of the ARP value for the planned action mitigation. [7]
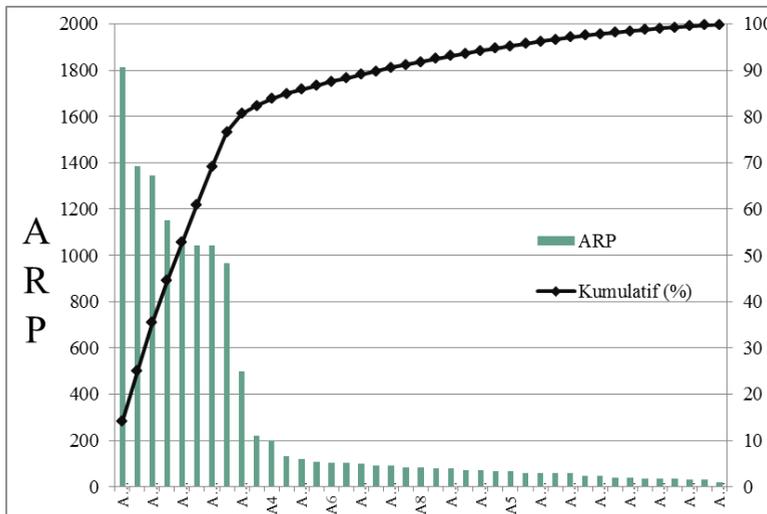

Fig. 1. Aggregate Risk Potential Obtained from Risk Agent Pareto Diagram

3.3 1st Phase house of risk

House of Risk Phase I is used to determine which risk agents are prioritized for mitigation action. With the 80% - 20% pareto approach, 20% of the risk causes will impact 80% of potential risk, from Figure 1. above can be seen 9 risk agent of 21% which gives an impact of 80.58% against the potential risk, 9 such risk agents:

1. Shut down production (A27).
2. Sudden material demand (A28).
3. Reliability factor of equipment / machine during process (A19).
4. Disturbed gas supply (A20).
5. Lack of care management (A22).
6. The occurrence of trouble / sudden damage (A7).
7. The occurrence of damage to machinery / equipment (A21).
8. The purchase list does not include clear specifications (A15).
9. The power supply is disrupted (A24).

3.4. 2nd Phase *house of risk*

Upon the completion of the HOR of Phase, the second Phase is conducted to produce risk mitigation actions to handle priority risk agents in Phase IHOR. [8-9]

Based on the results of the 9 priority risk agents that will be addressed, 11 risk mitigation actions are made:

1. Provision of adequate spare parts (PA1).
2. Coordination and confirmation of specification of goods / spare parts with the user (PA2).
3. Agreement with PT. Perta Arun Gas on the provision of emergency gas derived from regasifikasi (PA3).
4. Improved coordination between parts (PA4).
5. Schedule and perform preventive maintenance and predictive maintenance (PA5).
6. Turning the Around Factory (per ± 18 months) (PA6).
7. Substitute equipment / spare parts of factories that have been obsolete (PA7).
8. Improve the performance of production planning and inventory control (PA8).
9. Tighten cooperation, collaboration and information (PA9).
10. Provide power generator / generator set for production purposes (PA10).
11. Coordination with utility unit of power plant (PA11).

In HOR Phase II, Total Effectiveness is calculated. Total effectiveness can be calculated based on the formula:

$$TE_k = \Sigma ARP_j E_{jk} \tag{2}$$

Explanation:
TE   : Total Effectiveness
ARP   : Agregate RiskPotential
E   :Effectiveness

Example calculations for TE1 are as follows:
Discovered: $ARP_{27} = 1813$; $ARP_7 = 1044$; $ARP_{21} = 1044$
                         $E_{127} = 3$ $E_{17} = 3$
                         $E_{121} = 3$

Asked : TE_1
Answer: $TE_k = \Sigma ARP_j E_{jk}$
                        $TE_1 = [(1813 \cdot 3) + (1044 \cdot 3) + (1044 \cdot 3)] = 11703$

Furthermore, TEk calculation is entered into House of Risk Phase II. The value of Effectiveness (level of relationship between mitigation and risk agent) is 0, 1, 3 or 9 where 0 indicates the absence of linkage, 1 low (low), 3 moderate, and 9 indicates high ties [4].

After the calculation of TEk then calculate the Effectiveness to Difficulty Ratio which can be calculated by using the formula:

$$ETDk = \frac{TE_k}{D_k} \qquad\qquad (3)$$

While:
ETD   : Effectiveness to Difficulty Ratio
TE   : Total Effectiveness
D   : Difficulty

Example calculations for ETD1 are as follows:
Discovered: $TE_1 = 11703$
                   $D_1 = 5$
Asked : ETD_1
Answer: $ETDk = \frac{TE_k}{D_k}$
                   $ETDk = \frac{11703}{5} = 2340{,}6$

The scale used in the Difficulty score is a value of 3, 4, 5 with the meaning of value 3 indicating low difficulty, moderate 4 and 5 showing high difficulty [4]. Assessments and calculations on risk mitigation actions are incorporated into Phase II HOR as in Table 3.

Tabel 3. *2ⁿᵈ Phase of House of Risk*

Risk Agent	Risk Mitigation Action											ARP
	PA_1	PA_2	PA_3	PA_4	PA_5	PA_6	PA_7	PA_8	PA_9	PA_{10}	PA_{11}	
A_{27}	3		9		9	3				3		1056
A_{28}								9	1			917
A_{19}					9	9	1					750
A_{20}			9						3			624
A_{22}				1	9	9			3			585
A_7	3				9	3						510
A_{21}	3				3	3	3					420
A_{15}		9		3					3			329
A_{24}										9	9	312

Tabel 4. *2ⁿᵈ phase of House of Risk*

Risk Agent	Risk Mitigation Action										
	PA_1	PA_2	PA_3	PA_4	PA_5	PA_6	PA_7	PA_8	PA_9	PA_{10}	PA_{11}
TE	11703	8694	26685	3960	50499	33357	4476	12474	10926	9921	4482
D	5	3	5	3	4	5	3	3	3	5	3
ETD	2340,6	2898,0	5337,0	1320,0	12624,8	6671,4	1492,0	4158,0	3642,0	1984,2	1494,0
Rank	7	6	3	11	1	2	10	4	5	8	9

4 Conclusion

The conclusion that can be obtained after finished the data processing and problem-solving analysis on Supply Chain Risk and Supply Mitigation at PT. XYZ with House of Risk Approach (HOR) is as follows:

1. Identification of risks that contained in the supply chain activities of PT. XYZ generates 42 risk events and 42 risk agents
2. *First Phase of* House of Risk produces 9 risk agents of 21% which gives an impact of 80.58% on potential risks based on pareto diagram ie shutdown of production (1813), sudden material demand (1386), reliability factor of equipment / machine during process (1044), the occurrence of trouble / damage (1044), the occurrence of damage to machinery / equipment (1044), the purchase list does not include clear specifications (966), the supply of electricity disturbed (498).
3. Obtained 11 supply chain mitigation plans of PT. XYZ
4. House of Risk Phase II produces risk mitigation action recommended to PT. Iskandar Muda Fertilizer in mitigating risks to the company's supply chain activities. The Company can perform risk mitigation actions starting from the action with the highest Effectiveness to Difficulty Ratio value that is scheduling and doing preventive maintenance and predictive maintenance (12624.8), Turn Around factory (per ± 18 months) (6671,4), agreement with PT. Perta Arun Gas on the provision of emergency gas derived from regasification (5337), improving the performance of production planning and inventory control (4158), strengthening cooperation, collaboration and information (3642), coordination and confirmation of specifications of factory / spare parts with user (2898) , provision of adequate spare parts (2340.6), providing power generators / generator sets for production purposes (1984,2), coordinating with utility generating units 1494, substituting obsolete plant equipment (1492) coordination between sections (1320).

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