Risk analysis in the precast concrete industry supply chain

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Abstract. Supply chain management (SCM) is a concept and strategic step that is currently widely used by small and medium industries to increase their productivity. Risk analysis in the supply chain is an important issue, because often companies are not aware of the risks until the risks emerge and become a problem for the company. The research results show that supply chain risk management in the precast concrete industry can be carried out based on the level of risk, namely by accepting risk, mitigating risk, sharing risk, and avoiding risk. Risk management at a critical level is included in risk avoidance, where risks cannot be avoided so extraordinary handling must be carried out, immediately and as quickly as possible in order to minimize the impact of greater risks. The risk categories that emerge are included in the risk management group of accepting risk, mitigating risk, and sharing risk where risk management is still considered easier for companies to handle.

1 Backgrounds

It is known that progress in the development of the business world in Indonesia is increasing every year, including business developments in the construction sector. As construction projects increase, the need for materials increases. One of the construction materials that is experiencing an increase in demand every year is precast concrete material. The increasing need for precast concrete is based on the advantages of using precast concrete materials, including saving processing time, neater results, easier work, and others [1].

However, this increase needs to be supported by the role of an efficient supply chain. Risk analysis in the supply chain is an important problem, because often companies are not aware of the risk until the risk appears and becomes a problem for the company, so it requires a lot of resources to resolve it, even though risk identification from the start in supply chain management can increase the market share of SMEs [2]. The made to order system pattern in the precast concrete industry actually has shortcomings in its implementation, namely consumer uncertainty in determining the product they want to produce and the readiness schedule for use [3]. This uncertainty requires further analysis regarding possible risks to the supply chain that may occur. During the supply chain process from the beginning to the manufacturing process and delivery of products and products to consumers, there may be risks such as product damage, or even the manufacturer having to replace a product. Therefore, in this regard, it is important to conduct a study on supply chain risk analysis in precast concrete. Research conducted by Utomo et al., (2019) explains that in the precast concrete industry, there are potential risks identified starting from the planning carried out to run the business well (plan), the resources used (source), the transformation process carried out out carried out to manage raw materials into products (make), delivery of consumer products (deliver), and returns that occur from consumers and suppliers (return) [4].

2 Risk and risk management

The definition of risk according to the Big Indonesian Dictionary (KBBI) is an unpleasant (harmful, harmful) result of an action or action. The definition of risk according to Hanafi (2006) risk is the magnitude of the deviation between the expected return and the actual return [5]. According to Utomo et al., (2022) there are four ways or strategies that can be done in handling risk based on the level of risk, which include: 1. Accept risk, is a risk strategy at a minor level by accepting the risks that occur and maintain the risks as they are 2. Mitigate risk, is a risk strategy at a moderate level by reducing the impact and frequency of occurrence of risks that have the potential to harm the risk owner. 3. Share risk, is a risk strategy at the major level by sharing the risk with the parties involved in a mutually agreed cooperation agreement. Avoid risk, is a risk strategy at the critical level by taking extraordinary actions to minimize risk [4].

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3 Supply chain

Supply chain or Supply Chain was first used in 1980 by a number of logistics consultants, then in 1990 the supply chain was further analyzed by a number of academics. The supply chain is a series of interrelated companies and customers in the distribution of goods or services from the place of origin to the buyer or customer. The supply chain is a series of integrated processes and product flows from an organization or company that are joined in one supply chain to meet the needs of buyers or customers. If the supply chain is a physical network, then supply chain management (SCM) is a method, tool or management.

3.1 Supply chain risks

According to Cavinato (2006), supply chain management risk is divided into five categories, as follows. 1. Material flow or physical flow, is a flow or network in which there is actual movement of material flow both within the company and between companies, either in the form of transportation, mobilization of servers, movement of shipments, storage and supplies. 2. Financial flow, is a flow or network that contains the movement of money flows between organizations, the use of investment for the entire chain (or network), as well as the debt and receivable processing system. 3. The flow of information, is a flow or network in which there is a process of moving data, capturing and using data, thus enabling a structured information exchange process. 4. Relational flow, is a network of appropriate linkages between suppliers, organizations and customers of the organization in producing maximum benefits, including the internal supply network throughout the organization. 5. The flow of innovation, is a renewal network that occurs between the parties involved in the supply chain so as to create effective and efficient products and services. This network is very relevant today, bearing in mind the need for readiness to face intense competition between construction companies [6].

Precast concrete is a concrete component without or with reinforcement that is cast before being assembled into a building, or as a concrete component that is cast in place rather than in its final position within the structure. Precast concrete is produced en masse and repeatedly. Precast concrete elements made in the field (factory) are connected at the building site to form a complete structure. Fabrication can be carried out at the project construction site or at a precast concrete industry company which is made by means of pre-tension (tensioning before casting) or posttension (tensioning after casting).

4 Population and sample

Population is a generalization area consisting of objects or subjects that have certain qualities and characteristics determined by researchers to be studied and then conclusions drawn [7]. The population in this study were all precast concrete industry workers in South Denpasar District, precisely on Jln. By Pass Ngurah Rai Suwung Denpasar, totaling 18 people including 3 workers and 15 workers.

4.1 Sample determination method

The sample is part of the number and characteristics possessed by the population of a population [7]. Sampling means taking only a portion of the population to describe the population as a whole. In this study the technique or sampling method used is saturated sampling. According to Sugiyono (2017) saturated sampling itself is a sampling technique that uses all members of the population as samples [7]. The sample in this study was 18 people who were precast concrete industry workers in South Denpasar District, precisely on Jln. By Pass Ngurah Rai Suwung Denpasar.

4.2 Data analysis techniques

The analytical method is very important to identify relevant variables so that research results are obtained in accordance with the objectives. As input for carrying out this analysis is data and information from the respondents' questionnaires. After the data was collected, statistical data analysis was carried out using the SPSS (Statistical Program for Social Science) version 26 program to determine the validity and reliability of data regarding risk analysis assessments in the precast concrete industry supply chain.

4.2.1 Validity test

Validity test is used to measure whether a questionnaire is valid or not. A questionnaire is said to be valid if the questions in the questionnaire are able to reveal something that the questionnaire will measure [8]. Measuring validity in this research was carried out by conducting a bivariate correlation between each indicator score and the total score (Pearson Correlation Coefficients) through the SPSS program. If the correlation coefficient between each indicator and the total score shows a positive total score and the magnitude is above 0.30 and is significant, it can be concluded that each indicator question or statement is valid.

4.2.2 Reliability test

Reliability Test is a tool for measuring a questionnaire which is an indicator of a variable or construct. A questionnaire is said to be reliable or reliable if a person's answers to statements are consistent or stable over time [8]. Reliability measurement in this study used the Cronbach Alpha Test (α). A research instrument is said to be reliable if it gives a Cronbach Alpha value > 0.70 [8].

4.3 Risk Failure Mode and Effect Analysis (FMEA)

The data in this study were collected through a questionnaire. The questionnaire contains identification of any supply chain risks that have occurred at the

research location. Next, risk identification groups were carried out that were identified based on the results of a questionnaire that had been filled in using a 1-5 Likert scale to determine the risk probability and impact values. Then proceed with the risk analysis stage using the Risk Failure Mode and Effect Analysis (FMEA) method, namely calculating risk on a scale of probability and risk impact in order to obtain a risk index value. The next stage of risk analysis is to carry out risk mapping, by placing the risk value on the mapping level and risk management. In risk mapping, the risk levels are classified into four, namely minor, moderate, major, and critical.

The supply chain stages of the make to order system at the research location are divided into five activities, namely planning (plan), procurement of raw materials (source), production (make), product delivery (deliver), and product return (return). At each stage of the supply chain, the number of risks that arise or may arise is identified and then a risk analysis is carried out using the FMEA method. After carrying out risk analysis using the FMEA method, the risk level for each type and stage of risk is known, namely minor, moderate, major and critical levels. Next, a risk management analysis is carried out with the following strategy. a. Accept risk, is a risk strategy at a minor level by accepting the risks that occur and maintaining the risks as they are b. Mitigate risk, is a risk strategy at a moderate level by reducing the impact and frequency of risk occurrence that has the potential to harm the risk owner. c. Share risk, is a risk strategy at a major level by sharing the risk with the parties involved in a mutually agreed Cooperation agreement d. Avoid risk, is a risk strategy at the critical level by accepting risk with extraordinary actions to minimize risk.

The use of sections to divide the text of the paper is optional and left as a decision for the author. Where the author wishes to divide the paper into sections the formatting shown in Table 2 should be used.

5 Research results and discussion

Respondent characteristics indicate the identity of the respondents used in this research. Respondents in the precast concrete industry have different characteristics of identities when filling out the questionnaire. The characteristics of the respondents in this study can be seen in Table 1

Table 1. Characteristics of respondents.

No.	Respondent Characteristics	Frequency	Percentage
1	By Gender		
	Woman	5	27.78%
	Man	13	72.22%
	Amount	18	100%
2	Based on Age		
	21-30 Years	9	50%
	31-40 Years	5	27.78%
	> 40 Years	4	22.22%
	Amount	18	100%
3	Based on Work		
	Foreman	3	16.67%
	Worker	15	83.33%
	Amount	18	100%

5.1 Research instrument test results validity test

The respondents used in this study were 18 precast concrete industry workers. Previously, validity and reliability testing was carried out on the questionnaire used as a research instrument in this study. An instrument is said to be valid if it has a coefficient greater than 0.30 with a significance value smaller than 0.05 [9].

Based on the results of the validity test presented in Table 3, it can be seen that the risk indicators in assessing probability and impact used in this research have a correlation coefficient value greater than 0.30 with a significance value smaller than 0.05. This shows that the statement items in the research instrument are valid and suitable for use as research instruments.

5.2 Reliability test results

The reliability test for this research instrument uses the Cronbach's Alpha value, which is a tool for measuring a questionnaire which is an indicator of the variables studied which in this research is used to measure the probability and impact of supply chain risks in the precast concrete industry. A research instrument is said to be reliable if the Cronbach's Alpha value is greater than or equal to 0.70 [9]. The results of the research instrument reliability test can be seen in Table 4 below.

Table 2. Reliability test results of research instruments.

Variable	Cronbach's Alpha	Information
Probability	0.956	Reliable
Impact	0.962	Reliable

Source: Primary data processed (2023)

Based on the reliability test results presented in Table 2, it can be seen that all the indicators used in this research have a Cronbach's Alpha coefficient of more than 0.7. So, it can be stated that the research instrument has met the reliability or reliability requirements so that it can be used for further analysis.

5.3 Risk analysis

Data analysis was carried out based on the results of filling out a questionnaire with a Likert scale of 1-5 from the level of rare risk with a value of 1 to 5 for the risk that most often occurs (almost certain), as explained in Table 5 below.

Table 3. Probability and impact scale.

Levels	Probability	Impact
1	Seldom happen (*rare*)	Very No significant (*minimum*)
2	Small possibility happen (*unlikely*)	No significant (*minor*)
3	Possibility For happen (*possible*)	*Moderate*
4	Big possibility happen (*likely)*	Significant (*major*)
5	Hamper Certain happen (*almost certain*)	Very significant (*critical*)

Source: [4] (Utomo *et al.*, 2019)

5.4 Risk identification

Table 4. Identified supply chain risks in the precast concrete industry.

Code	Risk
R1	Uncertainty price sale product preprint consequence go on down price material standard material
R2	Error calculation planning need material standard material between stock warehouse with procurement booking to subcon
R3	There is addition or change booking product
R4	Amount power part production limited or minimal power experienced production _
R5	material natural as well as competition get material standard material cause exists monopoly price
R6	Suppliers don't fulfil commitment delivery material standard material with appropriate time and in condition Good
R7	Amount booking request product preprint exceed limit ability capacity production factory
R8	Machine production (batching plan) problems or in condition damaged
R9	Operator machine less production _ experienced
R10	Limitations tool print product preprint
R11	Tool print product many have experienced it damage
R12	Error calculation composition stir preprint
R13	Production product preprint fail consequence quality results product So No in accordance with standard factory
R14	Unpreparedness room for product existing preprints So
R15	Error in laying product preprint So
R16	Uncertainty timetable delivery product pacetak to contractor
R17	Limitations tool transportation for delivery product preprint so you have it producer Because high implementation of delivery volume product So
R18	Lateness delivery product preprint to contractor consequence disturbance condition road (traffic , road ruasa , bancir , etc
R19	Product preprint experience rift in journey delivery to contractor
R20	Return product preprint Because product arrive in condition disabled like crumbling, cracking shrinks and happens bent

Source: Processed Primary Data (2023)

Based on the supply chain stage, the number of risks that arise or may arise in the precast concrete industry will be identified. The results of identifying supply chain risks in the precast concrete industry will later carry out a risk analysis using the FMEA method. Based on the results of observations and interviews conducted by researchers, there were 20 supply chain risks identified. The results of supply chain risk identification in the precast concrete industry are presented in Table 6. Below. Based on Table 6, it can be seen that after conducting observations and interviews related to possible risks that may arise or risks that may arise in the supply chain in the precast concrete industry, as many as 20 risks were identified.

5.5 Risk Analysis using the FMEA

Method After testing the research instrument, namely the questionnaire and having been declared valid and reliable, then the questionnaire can then be used to conduct an analysis of the level of supply chain risk identified in the precast concrete industry based on the probability (P) and impact (I) of the risk. With regard to supply chain risk in the precast concrete industry, an assessment was carried out based on the probability and impact by the 18 respondents used in this study in relation to the 20 previously identified risks. The recapitulation of the results of the respondents' perceptions of the probability and impact of risk in this study is presented in Table 7. The following.

Table 5. Recapitulation of risk analysis calculation results.

Code		Probability Levels (P)	Impact Level (I)	(PxI)	Risk Level
R1	Uncertainty in sales prices for precast products due to fluctuating prices of raw materials	2	3	6	*Moderate*
R2	Errors in calculating the planning of raw material requirements between warehouse stock and procurement of orders to subcontractors	1	3	3	*Moderate*
R3	There are additions or changes to product orders	2	3	6	*Moderate*
R4	The number of production staff is limited or there is a lack of experienced production staff	1	2	2	*Minor*
R5	The scarcity of natural materials and competition for raw materials has led to price monopoly	2	3	6	*Moderate*
R6	Suppliers do not fulfil their commitment to deliver raw materials on time and in good condition	2	3	6	*Moderate*
R7	The number of orders requested for precast products exceeds the factory's production capacity	3	4	12	*Major*
R8	The production machine (batching plan) has problems or is in a damaged condition	1	4	4	*Moderate*
R9	Inexperienced production machine operators	1	3	3	*Moderate*
R10	Limitations of precast product printing equipment	1	3	3	*Moderate*
R11	Many products printing equipment were damaged	1	3	3	*Moderate*
R12	Miscalculation of precast mix composition	2	4	8	*Major*
R13	Production of precast products failed due to the quality of the finished product not meeting factory standards	2	4	8	*Major*
R14	Unavailability of space for finished precast products	1	2	2	*Minor*
R15	Errors in laying finished precast products	1	3	3	*Moderate*
R16	Uncertainty in the schedule for delivery of pre-printed products to contractors	2	3	6	*Moderate*
R17	Manufacturers have limited means of transportation for delivering finished precast products due to the high volume of finished product deliveries	1	2	2	*Minor*
R18	Delays in delivery of precast products to contractors due to road conditions (congestion, rough roads, flooding, etc.	1	2	2	*Minor*
R19	The precast product experienced cracks on the way to delivery to the contractor	2	3	6	*Moderate*
R20	Return of precast products because the product arrived in a defective condition such as crumbling, shrinkage cracks and bending	4	4	16	*Critical*

Source: Processed Primary Data (2023)

Based on the results of the risk analysis in Table 7, it can be seen that the level of risk for each type and stage of risk consists of minor, moderate, major and critical levels. Table 7 also shows that supply chain risk in the precast concrete industry is dominated by risks in the major category of 55%, followed by a minor risk level of 20%, a moderate risk level of 20%, and a critical 5%. Furthermore, an analysis of risk management is carried out with the following strategy. 1. Accept risk, is a risk strategy at a minor level by accepting the risks that occur

and maintain the risks as they are 2. Mitigate risk, is a risk strategy at a moderate level by reducing the impact and frequency of occurrence of risks that have the potential to harm the risk owner; 3. Share risk, is a risk strategy at the major level by sharing the risk with the parties involved in the Cooperation agreement that has been mutually agreed upon; 4. Avoid risk, is a risk strategy at a critical level by taking extraordinary actions to minimize risk. Based on the predetermined risk levels in Table 7 regarding supply chain risks in the precast concrete industry, an analysis of risk management and handling efforts is carried out based on the risk level. Management and handling of this risk is carried out based on interviews with employees of PT. Adi Jaya Beton according to the company's experience in dealing with supply chain risks that occur or may occur in the precast concrete industry. Based on this, a critical risk is obtained that needs to be responded to by the company with the considerations that have been prepared at the initial order of the product in order to anticipate the risks that arise. As for the management and handling of supply chain risk, the strategies formulated based on the level of risk can be seen in Table 8. below.

Table 6. Risk management/handling strategy based on risk level.

Code	Levels Risk	Strategy Management / Handling
R1	*Major*	Monitoring prices_sale product with factory comparison others;
R2	*Moderate*	Monitoring and reviewing to data requirements material raw materials owned and purchased from subcontractors;
R3	*Major*	Do communication and discussion return by party buyer related certainty amount ordered products;
R4	*Minor*	Look for or lend addition factory workers others;
R5	*Major*	Discuss with party involvement from buyers and subcontractors;
R6	*Moderate*	Ask lateness delivery and discuss related accepted risk;
R7	*Major*	Making product can subbed to factory others or If possible done on- site production project;
R8	*Moderate*	Discuss with buyer related delay, and soon look for equipment maintenance operator;
R9	*Major*	Give training on less workerstrained;
R10	*Major*	Borrow tool print to factory other or subcon preprint other;
R11	*Major*	Bring in special workers _ for fix tool print;
R12	*Major*	Do negotiation to buyer exists problem in possible production _ delivery will be late;
R13	*Major*	Do discussion and review with buyers;
R14	*Minor*	Look for location temporary for product transit place preprint so;
R15	*Major*	Do effort patching If damage product No sever ;
R16	*Major*	Negotiation with party buyers;
R17	*Minor*	Procurement tool transportation from subcon;
R18	*Minor*	Give clarity to buyer related problem in road;
R19	*Moderate*	Send worker production to location delivery for improvements in place;
R20	*Critical*	Making repeat product preprint.

Source: Primary Data Processed (2023)

Based on the risk analysis carried out, the level of risk that is of particular concern to companies with a very significant impact is risk with a critical level, namely the risk of returning precast products because the product arrives in a defective condition such as crumbling, shrinkage cracks and warping. This shows that the risk with the highest ranking is at the return stage where the level is critical with an explanation of the risk of product returns from consumers due to precast products arriving not in accordance with agreed standards or quality. Risk management at the critical level is included in avoid risk, where risks cannot be avoided so extraordinary handling must be carried out, immediately and as quickly as possible in order to minimize the impact of greater risks. The emerging risk categories are included in the risk management group with accept risk, mitigate risk, and share risk where risk management is still considered to be more easily handled by the company.

6 Conclusion

Based on the results of the research and discussion that have been described previously, it can be concluded as follows. In connection with the identification of supply chain risks in the precast concrete industry, 20 risks are identified that arise or may arise in the supply chain in the precast concrete industry with a made to order system. At the critical level, one risk is identified, namely the risk of

returning precast products because the product arrives in a defective condition such as porous, cracked, shrunken, and bent. Regarding the level of risk, supply chain risk in the precast concrete industry is categorized into four levels, namely minor, moderate, major, critical levels. At the minor level there are four risks, at the moderate level there are four risks, at the major level there are eleven risks, while at the critical level there is one risk. Based on the risk analysis carried out, the level of risk that is of

particular concern to companies with a very significant impact is risk with a critical level, namely the risk of returning precast products because the product arrives in a defective condition such as crumbling, shrinkage cracks and warping. This shows that the risk with the highest ranking is at the return stage where the level is critical with an explanation of the risk of product returns from consumers due to precast products arriving not in accordance with agreed standards or quality. Supply chain risk handling in the precast concrete industry can be carried out based on the level of risk, namely by accepting risk, mitigating risk, sharing risk, and avoiding risk. Risk management at the critical level is included in avoid risk, where risks cannot be avoided so extraordinary handling must be carried out, immediately and as quickly as possible in order to minimize the impact of greater risks. The emerging risk categories are included in the risk management group with accept risk, mitigate risk, and share risk where risk management is still considered to be more easily handled by the company.

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