CHAPTER 4

DESIGN AND DEVELOPMENT OF RESPONSIVE SUPPLY CHAIN RISK MANAGEMENT MODEL

4.1 INTRODUCTION

Manufacturing organisations are expected to make their products with prompt delivery to satisfy their customers by carrying out efficient supply chain activities. Various SCM models have been adopted since long time by several professionals in different parts of the world. One such widely practiced SCM model (Christopher 1988) is depicted in Figure 4.1.

![General SCM model](image)

**Figure 4.1 General SCM model**

As shown in Figure 4.1, raw materials and semi-finished materials and components are received from the suppliers. The manufacturer processes them to produce the final products. Usually, the final products are delivered to the end customers through several entities, which include distributors and retailers. Using effective information flow, after-sales service is also carried out to retain the customers and market position.
In the event of any disruptions in these supply chain activities, necessary actions are carried out using appropriate strategies to supply the products infused with expected quality to the end customers. Further, follow-up activities are also undertaken to ensure smooth flow of products till they reach the hands of the end customers in time. If the products do not reach the customers in time, it will result in customer dissatisfaction leading to the loss of sales. Thus starting from the procurement of raw materials to the delivery of final products, inevitable losses may occur due to numerous disruptions in the supply chain activities. Ultimately, these disruptions cause time delays in the entire manufacturing cycle.

In real time manufacturing scenario, in order to compensate the time delays, necessary additional production activities are carried out to ensure the fulfillment of customers’ requirements in time. Various strategies like production by working overtime, outsourcing, subunit facility utilisation, subcontracting, leasing of certain quantity of orders, hiring and dropping of additional resources or employees by following hire and fire approach, etc. are used to compensate the occurrence of the time delays. If opportunity exists, organisations also usually undertake various continuous improvement activities to enhance their performance. However, these activities are carried out in a fire fighting manner. Hence, as mentioned earlier in this thesis, a responsive version of SCM model is required to enable the modern manufacturing organisations to reduce and even prevent the time delays. Such a model shall enhance the responsiveness by serving as a link between the various supply chain entities and manage the associated major time delays by efficiently performing the various activities indicated in Figure 4.1. In order to fulfill this need, the RSCRMM was designed. Its conceptual features are presented in this chapter.
4.2 FEATURES OF RSCRMM

RSCRMM was designed with the objective of improving the performance of manufacturing organisations through the reduction of time delays and associated losses in their supply chain activities. The conceptual features of RSCRMM are depicted in Figure 4.2 and it is encompassed with five stages. The activities envisaged under these stages are briefly described in the following five subsections.

4.2.1 Identification and listing of the major time delays occurring in the supply chain of the routine manufacturing practice

In the routine manufacturing practice, the reasons of LPEs and its root causes against the major time delays occurring due to supply chain disruptions are seldom recorded and analysed in detail to reduce and prevent them in future. As mentioned earlier, various strategies are used to compensate the occurrence of these major time delays. Normally, an instant solution or temporary solution or strategy is employed to fulfill the customers’ requirements. But this will affect the effective flow of supply chain activities and dynamic operability of the organisation. This, in turn, will require additional time, efforts and associated cost to timely fulfill the customers’ requirements. Thus it is essential to discuss with the case organisation under consideration for the identification of major time delays in the supply chain of the routine manufacturing practice. As shown in Figure 4.2, the identification of the occurrence of these major time delays in the supply chain activities initiates the RSCRMM practice. It is vital to list out the major time delays observed in the supply chain of a case manufacturing organisation under consideration during a specified investigation period for carrying out further analysis. These major time delays are to be grouped and listed with reference to various supply chain entities.
Responsive supply chain risk management practice

Identification and listing of the major time delays occurring in the supply chain of the routine manufacturing practice

Are customers’ requirements fulfilled in time?

Yes

Routine production planning and control activities

Listing of major time delays

Determination of frequency of occurrence and cost consequence

Is it frequent and cost consequent?

No

Yes

Prioritisation of major time delays using risk ranking

Assessment of loss occurring due to predominant time delay

Detailed analysis using RMT and recommendation of corrective measures

Sensitivity analysis

Education and training programme

Implementation of corrective measures and reassessment of loss occurring due to predominant time delay

Is loss reduced?

No

Yes

Incorporation of corrective measures in the supply chain

Repeat for next predominant time delay

Figure 4.2 Features of RSCRM
4.2.2 Determination of frequency of occurrence and cost consequence

The second stage of RSCRMM envisages the determination of the frequency of occurrence and associated cost consequence of the listed major time delays for carrying out further analysis. During the specified investigation period, each and every major time delay is to be studied in detail with reference to the collected field data along with their frequency of occurrence and cost consequence. These observations are accompanied by recording the field data such as total transactions per annum, average frequency of occurrence of time delays per annum, average percentage occurrence of time delays on total transactions per annum, average time delay per occurrence, standard deviation of average time delay, average additional time required per occurrence, standard deviation of average additional time required, total additional time required per annum and total associated cost incurred per annum. These data are to be collected on the basis of fulfilling the customers’ requirements. This frequency of major time delays varies depending upon the reasons of LPEs and its root causes.

The additional time required to compensate the associated major time delays is based on the nature of the resources required. The total associated cost is to be established per unit time (per hour or day basis) by accounting the required manpower, production, utility, power, cost, maintenance, overheads etc. If it is frequently occurring and significant in terms of cost consequence, then subsequent analysis is to be conducted, or else the routine cycle of production planning and control activities is to be continued. Thus, this step of RSCRMM facilitates the checking and ensuring of the severity of frequency of occurrence and significance of cost consequence of major time delays associated with supply chain activities for carrying out further analysis to achieve loss reduction.
4.2.3 Prioritisation of major time delays using risk ranking

During the third stage of RSCRM, using the result of the detailed investigation, collected field data and experience, the reasons of LPEs caused due to major time delays in supply chain of the case manufacturing organisation are to be summarised for carrying out further analysis using RMT. Risk analysis and assessment concepts (Coppendale 1995; Schlechter 1996) are used to rank the significance of each reason of LPEs to carry out further detailed analysis for achieving loss reduction. The significance of each major time delays is further assessed by assigning weightings to the severity of frequency of occurrence and significance of cost consequence. The frequency of occurrence and cost consequence are categorised into various levels for ranking them based on assigned weightings. The severity is assessed using a weighting matrix, which is formed by dispersing the weighting categories of frequency of occurrence column-wise and the weighting categories of cost consequence row-wise. In accordance with their significance, the net effect is further assessed by using this weighting matrix.

The listed major time delays are located in the cells of the weighting matrix based on the weightings assigned to their frequency of occurrence and cost consequence. Risk numbers are calculated against all the major time delays by multiplying the weightings assigned to their frequency of occurrence and cost consequence. In order to gain maximum benefits, the major time delay with product of weightings greater than a critical value is considered as predominant time delay for carrying out further detailed analysis. The major time delay with the highest risk number is considered as the predominant time delay, whereas the major time delay with the lowest risk number is considered as the nonpredominant time delay. The predominant time delays are to be short listed for carrying out further analysis to achieve loss reduction. If there are many predominant time delays, then one by one
the risk based initiatives are to be made using risk ranking. Furthermore, detailed analysis of the impact of the most predominant major time delays is to be carried out to achieve loss reduction.

4.2.4 **Assessment of loss occurred due to predominant time delay**

After prioritising and selecting the predominant time delay, the loss incurred due to the occurrence of this time delay is to be assessed in terms of per unit of product manufactured. The loss refers to the cost incurred on account of currently occurring major time delays and associated LPEs. It includes the costs associated with additional efforts in terms of time, resources, labour, consumables, overheads etc. exerted to compensate major time delays and associated losses. The cost details pertinent to the selected predominant time delay during the investigation period are calculated by referring to the collected field data, and then those details are converted into loss in money value per unit of product manufacturing. It is used as a performance indicator for easy interpretation. The loss associated with the predominant time delay is calculated using the target production, actual production, cost incurred per quantity and cost incurred for additional production activities in the manufacturing organisation. This is the fourth step of RSCRMM.

4.2.5 **Detailed analysis using RMT**

Appropriate RMTs are to be applied for carrying out the detailed analysis of the predominant time delay. The detailed analysis is carried out for achieving loss reduction. The detailed analysis carried out in four stages, which are explained in the following four subsections:
4.2.5.1 Recommendation of corrective measures

It is used to identify the root causes and the reasons of LPEs caused by the predominant time delays in the supply chain of the case manufacturing organisation. After identifying the root causes of the predominant time delay, necessary corrective measures are evolved, recommended and implemented to reduce and eliminate its recurrence in future. The corrective measures are recommended using RM strategies like risk reduction, risk sharing, risk retention and risk avoidance. Out of them, RSCRMM is incorporated with the risk reduction strategy to minimise the risk of LPEs or negative consequence or both that are associated with major time delays while carrying out the supply chain activities. These corrective measures are recommended under three categories namely manufacturing process oriented, man power oriented and material oriented.

4.2.5.2 Sensitivity analysis

During this stage sensitivity analysis is to be conducted for studying the impact of time delay, spending of additional time and their associated cost. This elaborate analysis is to be performed to determine how sensitively the results and conclusions vary while changing these parameters.

4.2.5.3 Education and training programme

During this stage, appropriate education and training programme on RSCRMM practice is designed and practiced to educate and train the employees for acquiring sufficient knowledge and skills to implement corrective measures. This education and training programme is to be practiced in three modules, namely process-oriented, material-oriented and man power-oriented.
4.2.5.4 Implementation of corrective measures and reassessment of loss occurred due to predominant time delay

The recommended corrective measures, education and training programme are implemented in the case manufacturing organisation and monitored during the pilot investigation period. The severity of loss due to the recurrence of the same predominant time delay is again reassessed for checking the loss reduction. If the loss is reduced, then the incorporation of corrective measures in the supply chain will be carried out. Then, the next cycle of routine production planning and control activities is to be continued. After that, the first step of the responsive SCRM practice will be again continued with the incorporated corrective measures for achieving further loss reduction. Or else, the above process of responsive SCRM practice is to be repeated for achieving loss reduction by using alternate strategies.

The value of reassessed loss is used for evaluating the effectiveness of the corrective measures implemented during the pilot investigation period. If the loss occurred due to that predominant time delay is reduced to an acceptable level, then the same steps could also be applied for analysing the next predominant time delay. Otherwise, alternative corrective measures are to be designed and carried out for achieving loss reduction within the acceptable level. Similarly, repeated analysis may be conducted and suitable corrective measures may also be developed against the next predominant major time delay to reduce the loss.

The above four stages collectively constitute the fifth and last step of the RSCRMM. The streamlined incorporation of these steps facilitates the execution of responsive SCRM practice for achieving loss reduction in real time manufacturing scenario.
4.3 CONCLUSION

RSCRMM was designed with the objective of reducing the losses associated with major time delays along the supply chains of manufacturing organisations. RSCRMM acts as a responsive link between the various entities of the general SCM model. The interaction of RSCRMM with the various entities of general SCM model is depicted in Figure 4.3.

![Interaction of RSCRMM with general SCM model](image)

**Figure 4.3 Interaction of RSCRMM with general SCM model**

RSCRMM also serves as a diagnosis and decision making framework for enabling continuous improvement through the reduction and prevention of major time delays along the supply chains and LPEs along with their root causes. RSCRMM is flexible in nature, and hence, modifications could be effected to meet the requirements of the manufacturing organisations. The practicality of RSCRMM was investigated by conducting two separate case studies. An IPDSS incorporating RSCRMM was also developed to assist the documentation, processing speed, data summarisation and certain level of decision making. The working of this IPDSS was examined by conducting another exclusive case study. These case studies are described in the following three chapters. The capability of RSCRMM in reducing the losses associated with major time delays occurring along the supply chains of manufacturing organisations is demonstrated in these three chapters.