Modelling Drivers of Coordination Risk in Production System

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Abstract:
The production system process involves the coordination of a wide range of dissimilar and interconnected activities that’s why it involves more risk and uncertainty. When an organization coordinate with a differently located organization, it is very critical to established relations with new suppliers and sometimes it may bring about coordination and language problems. Coordination risk is the major risk in the entire production system because many suppliers are supply raw material to the organization. Coordination risks are very volatile and also often more difficult to observe, so they may go unnoticed. The main objective of this paper is to identify and understand the mutual interaction among various drivers of coordination risk which affects the performance of production system. To this effect, authors have identified various drivers through extant review of literature. From this information, an integrated model using interpretive structural modelling (ISM) for drivers of coordination risk in production system is developed and the structural relationships between these drivers are modelled. Further, MICMAC analysis is done to analyse the independent power and dependency of drivers which shall be helpful to managers to identify and classify important conditions and to reveal the direct and indirect effects of each condition of coordination risk on production system.

Keywords: Coordination risk, Production system, Interpretive Structural Modelling (ISM), MICMAC analysis

1. Introduction
Production system is defined as "The procedure, approaches or planning which contains all functions required to gather the inputs, process and produce finished product" or it can also be defined as the method of converting input to output. Production system utilizes infrastructure, funds, materials and labour to produce finished product. Production system has three main components i.e., Input, Conversion Process and Output [1].

The production system process consists of risk and uncertainty because it involves the coordination of a wide range of dissimilar and interconnected activities. Coordination between any organization in a new location with the main organization in other country is very complicated. When an organization moves to a different location, it is very critical to established relations with new suppliers and sometimes it may bring about coordination and language problems. Risk of wrong decision for coordination of new organization creates a risk of misuse by partners, increased level of dependency and loss of technical experience, sudden shift in supplier and customer demand. Risks related with supply chain and coordination are another category recognized in international production literature [2].

Coordination risk exist when there is a miscommunication among employees of organization. A coordination risk occur when there is necessary to coordinate about the process system but organization
may not be able to attain [3]. Efficient network coordination among suppliers depends upon information sharing that it may increase the efficiency of production system [4]. Coordination risk is “the risk of failure of one player’s investment due to the probable absence of complementary investments by other players in different phases in the supply chain” [5]. When decision makers ignore the optimal system target lack of coordination arises because they have incomplete information.

Coordination risk happens when decision taken by persons may contribute to a collective result and the decision rules followed by person may be not known [2]. Contributing factor of coordination risk are demand and supply uncertainty, such uncertainty may arise from external sources. Inter-organizational information systems (IOS) is a system which is used within supply chain management (SCM) to improve business processes and to enable better working relations between two organizations. Coordination risk contribute to deviation from optimal behaviour. Coordination risk arise from two factors:

1. A lack of common information.
2. A lack of trust between two organizations [2].

Mutual knowledge problems and trust are the two main elements of coordination risk. Experimental studies indicate that how failures of mutual knowledge problems can affect coordination risk. The other element is trusting that other person will truly carry out the optimal ordering policy [2].

Due to lack of coordination in planning problems are created in urban freight transport [6]. Even when the technology advancements, the face-to-face communication is still the most effective way of communicating with others. Therefore, distribution of the teams near located workspaces, will increase the coordination and communication risk [7]. Coordination means two or more groups work together skillfully. In other words, the groups are responsible for specific tasks but work interdependently for mutual target [8]. Uncertainties in supply and demand is due to lack of coordination between two members. Coordination between persons help in dealing inter-dependencies and decreasing uncertainties [9].

According to above literature, many researchers have been created various number of models, methods to study the impact of coordination risks on production system. In this research relationship among several types of coordination risks is found. Due to the complex nature of coordination system, to analyse the inter-relationship among various risks is very difficult [10].

In this research, various methods such as FBN, TNT, FMEA are used to study the interrelationships (see, e.g., [11]; [12]; [13]).

Interpretive structural modelling (ISM) is used by the author. It is a well-established methodology for identifying relationships among specific items.

The main objectives of this research are:
1. Classify drivers of coordination risk related to production system.
2. Create the relationship between drivers using ISM.
3. Suggest a structural model for drivers of coordination risk of production risk.
4. Classify the drivers into several categories using MICMAC analysis.

2. Interpretive Structural Modelling (ISM)
ISM is an interactive learning process. From this method we can define how items or risks are related. According to relationship among items, an overall structure is taken out from the set of items. After modelling and finally overall structure is represented in a diagraph model [14]. It is used to identify interrelationships among various parameters which describe an issue or a problem [15].

In ISM a set of dissimilar directly and indirectly related variables are arranged into a systemic model. The existence of directly or indirectly related variable makes the structure of system more complex. It then becomes difficult to deal with this type of system. Hence, a methodology is required which helps to identify a structure within a system [16].
Four symbols are used to represent the relationship between variables (p and q) are shown below:

- \( V \): Factor p influence factor q
- \( A \): Factor q influence factor p
- \( X \): Factor p and q influence each other
- \( O \): p and q are unrelated

This data is indicated in the arrangement of binary matrix called initial reachability matrix (IRM). If variable p reaches variable q, then the entry is 1 and if variable p does not reach variable q, then entry is 0 [16].

3. Identification of drivers of coordination risk in production system

There are many factors of coordination risk. Few factors with literature support are discussed as follows:

**Table 1: List of drivers of coordination risk**

| S.No. | Factors                        | Definition                                                                 | References                                                                 |
|-------|--------------------------------|---------------------------------------------------------------------------|---------------------------------------------------------------------------|
| 1     | Incomplete information flow    | Incomplete information flow due to communication losses and unnatural resources. | (Canzian et al., 2013), (Keyhani & Chatterjee, 2012), (Ozdemir-Gungor et al., 2018), (Keyhani & Annaswamy, 2012), (Lindblad et al., 2018) |
| 2     | Lack of information sharing    | Sharing of information leads to appropriate decision making within organization. | (Alawamleh & popplewell, 2011), (Somuyiwa et al., 2011), (Xu & Chen, 2016), (Tavella & Hjortso, 2012) |
| 3     | Loss of communication          | Communication is essential to any organization. Uncertainty is due to less communication. | (Alawamleh & popplewell, 2011), (Dietrich et al., 2013), (Safronova, 2011) |
| 4     | Lack of top management commitment | Lack of top management commitment will lead to a failure to meet objectives. | (Alawamleh & popplewell, 2011), (Rahman et al., 2013), (Lodgaard et al., 2016), (Kumar, 2014) |
| 5     | Mutual knowledge problems      | A lack of mutual knowledge problems seems to be the main obstacle to communication. | (Croson et al., 2014), (Edwards, 2011), (Thomas et al., 2014), (Angeletos & Lian, 2018), (Ingram & Maye, 2016), (Dugnas, 2017) |
| 6     | Lack of trust between partners | Trust that occurs between partners tells how much partners believe in others. | (Croson et al., 2014), (Alawamleh & Popplewell, 2011), (Jagd, 2010), (Samantra et al., 2016) |
4. ISM methodology

4.1 Contextual relationship establishment among risks
In this research 8 risks are identified. To analyse the risks, a relationship of ‘reaches to’ form is used. It means one risk influence another risk. From this method, a contextual relationship is obtained.

Few specialists, from several organizations associated to production system were consulted to support in making the contextual relationships between the risks. SSIM is developed by using following four symbols which are used to indicate the relationship between variables (p and q) [31].

1. V is denoted from risk p to risk q (means risk p influence risk q).
2. A is denoted from risk q to risk p (means risk q influence risk p).
3. X is denoted for both direction relations (means risks p and q influence each other).
4. O is denoted for no relation between the risks (means risks p and q are unrelated) [31].

4.2 Final reachability matrix with driving power and dependence power (FRM)
After finding the relationship among risk the final reachability matrix is developed.

| S.No. | Factors                              | 1 | 2 | 3 | 4 | 5 | 6 | Driving Power |
|-------|--------------------------------------|---|---|---|---|---|---|---------------|
| 1     | Incomplete information flow           | 1 | 1 | 0 | 0 | 1 | 4 |               |
| 2     | Lack of information sharing           | 1 | 1 | 0 | 0 | 1 | 4 |               |
| 3     | Loss of communication                | 1 | 1 | 0 | 0 | 1 | 4 |               |
| 4     | Lack of top management commitment    | 1 | 1 | 1 | 0 | 1 | 5 |               |
| 5     | Mutual knowledge problems            | 1 | 1 | 0 | 1 | 1 | 5 |               |
| 6     | Lack of trust between partners        | 1 | 1 | 0 | 0 | 1 | 4 |               |
|       | Dependence                           |   |   |   |   |   |   | 6             |

4.3 ISM based level of risk
By using partitioning method those elements whose reachability and the intersection sets are same indicate at highest level.

| S.No. | Factors                              | Level |
|-------|--------------------------------------|-------|
| 1     | Incomplete information flow           | I     |
| 2     | Lack of information sharing           | I     |
| 3     | Loss of communication                | I     |
| 4     | Lack of top management commitment    | II    |
| 5     | Mutual knowledge problems            | II    |
| 6     | Lack of trust between partners        | I     |
5. ISM model development
ISM model is developed after applying all the steps of ISM.

![Diagram of ISM model](image)

**Figure 1**: The level of coordination risk is shown by ISM model

6. MICMAC analysis
Matrice d'Impacts croises-multiplication appliquéan classment (cross-impact matrix multiplication applied to classification) is referred to as MICMAC. The aim of MICMAC analysis is to analyse the dependence power and driving power of factors. The principle of MICMAC is based on multiplication properties of matrices [20]. According to their dependence power and driving power, the factors are classified into four categories as follows [32].

1. Autonomous risks: This type of risks has weak driving power as well as weak dependence.
2. Linkage risks: This type of risks has strong driving power as well as strong dependence.
3. Dependent risks: This type of risks has strong dependence power but weak driving power.
4. Independent risk: This type of risks has strong driving power but weak dependence power [33].

![Diagram of MICMAC analysis](image)

**Figure 2**: indicates the results of MICMAC analysis.

7. Conclusion
In this research, authors identified 6 factors i.e. Incomplete information flow, Lack of information sharing, Loss of communication, Lack of top management commitment, Mutual knowledge problems, Lack of trust between partners that may affect the performance of production system. ISM model and MICMAC approach is used to determine the relationship between them. They classify the risks under
four categories namely independent, linkage, dependent and autonomous. The final results attained with the help of ISM. Some of the results are as follows:

(a) From figure 2, it is observed that two drivers Lack of top management commitment (4), Mutual knowledge problems (5) have strong driving power and are less dependent on other drivers. Therefore, these two drivers are considered as the root causes for all drivers.

(b) It is observed that four driver’s Incomplete information flow (1), Lack of information sharing (2), Loss of communication (3), Lack of trust between partners (6) are considered as the most important drivers. Management of organisation should recognize the dependence of these drivers on other drivers.

8. References

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