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Supply Chain Collaboration under Uncertainty

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Summary

In fluctuating economic conditions such as global recession, supply chains operate under changing conditions of uncertainty. The impact of this uncertainty and associated risk might be mitigated by collaboration. This paper proposes a model of supply chain collaboration based on information exchange and decision coordination at both the strategic and tactical levels. However, a collaborative supply chain can be exposed to associated risks such as the failure of individual actors. Governance regimes can facilitate collaboration at the strategic and tactical level and mitigate valid apprehensions about collaboration that the actors may have. Governance can be considered as a critical factor in achieving collaboration. The paper argues for explicit rules to regulate information exchange and decision coordination at the strategic and tactical level. An illustrative case study of an automotive supplier from the electronics industry is used to explain the model..

Keywords: Supply Chain, Collaboration, Uncertainty, Governance, Model, Design Structure Matrix

1. Introduction

According to a survey by management consultants PRTM, senior management at global companies consider the impact of recession on supply chains as massive and hard-hitting (PRTM, 2011). Supply chains, are subject to increasing uncertainty. This paper argues that creating a collaborative supply chain can limit the impact of uncertainty and advocates for a governance regime that can facilitate collaboration; a governance regime should have clear rules regarding what information is shared under which circumstances. Supply chain actors also need to trade-off between reducing risk through collaboration and the potential consequences of collaborating partners going out of business. The paper proposes a model using a Design Structure Matrix (DSM) to understand the relationship between supply chain collaboration, uncertainty and governance. An illustrative case is used where generic supply chain operations are modelled for collaboration. The issues considered in this paper have strategic significance (involves decisions regarding the setting of a supply chain) and tactical importance (achieved through complimentary goals and objectives).

Uncertainty can be classified as "known" uncertainties, based on past cases, and "unknown uncertainties", about events, that could not have been foreseen, e.g. 9/11 and its impact on the aerospace industry (Earl and Eckert, 2005). The uncertainty can be under the control of the supply chain, as endogenous uncertainty arising from the product or the corporate context or exogenous uncertainties such as the context of the use of the product, the market or the wider political and cultural context (de Weck et al. 2007). Uncertainties arise

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from various sources (Lessard & Miller, 2001) - technical, industry, national, markets and natural events and can be either supply, demand or technology related (Chen and Paulraj, 2004).

Collaboration in supply chains can be defined as two or more independent actors working jointly to plan and execute operations with greater benefit than acting in isolation (Simatupang & Sridharan, 2008). Collaboration requires coordination in strategic and tactical level decisions; which may result in the need to share sensitive data and information. Tactical decisions involve processes to achieve the strategic objectives (Hasan et al., 2011; Johnson, 2008). The importance of collaboration and information exchange is reinforced in the Collaborative Planning Forecasting and Replenishment (CPFR) concept (Whipple & Russel, 2007). Software systems such as Customer and Supplier Relationship Management (CRM, SRM), which focus at the operational level are not adequate to handle the potentially sensitive information in strategic and tactical level decisions.

Supply chain *configuration* represents the structure of relationships. In most supply chains many relationships are simple buy and sell relationship, where a product is bought at the requested price without much negotiation. The configuration of supply chain is not homogenous and parts of the supply chain have different configurations. Configurations in supply chain have been classified by Sturgeon et al. (2008) as: adversarial - with minimum information exchange and no overall responsibility for the supply chain; captive - where a powerful actor coordinates major supply chain decisions with asymmetric information exchange and takes overall responsibility; or collaborative - where responsibilities are shared by the actors. The collaborative configuration emphasises the success of the whole supply chain rather than particular actors. It is exposed to associated risks of failure of a particular actor but should also be flexible so that suppliers can leave and new ones be added. Traditionally supply chains were organised hierarchically, where one dominant player controlled their first tear suppliers, who in turn controlled their own suppliers. A collaborative supply chain can also be non-hierarchical; where power imbalance among actors does not create any decision-making concentration in the hands of a sub-group of actors.

Governance concerns the rules that control the relationships between actors in a supply chain (Sturgeon et al, 2008). This can help overcome barriers that discourage collaboration at a strategic and tactical level. Governance also addresses decision coordination and information exchange in supply chains. These rules control relationships among actors and affect strategic and tactical information exchange. In value chain research (Kaplinsky and Morris, 2000), governance is classified as: Legislative (rule making), Judicial (rule monitoring) or Executive (assistance in compliance).

2. Propositions and model

This paper investigates two propositions about colloboration in supply chains:

- Collaboration at the strategic and tactical level can limit the impact of uncertainty.
- Governance regimes can facilitate collaboration at the strategic and tactical level and mitigate valid apprehensions about collaboration that the actors have.

The approach to addressing these issues is by modelling a generic supply chain operation in a two step approach. First, in the case of a specific supply chain scenario (e.g. a customer requests a change which initiates knock on activities for the focal company and its supplier) dependencies between activities are identified in (i) a customer, (ii) a focal company and (iii) a supplier. These dependencies are modelled in a Design Structure Matrix (DSM) (Browning,

2001). A DSM provides a simple, compact, and visual representation of a complex system that supports innovative interpretations for system decomposition and integration. It allows engineering teams to express associated problems and articulate corresponding solutions. A DSM is a square matrix with identical row and column labels. An activity based DSM has activities as element on the rows and column. A mark in the DSM signifies that corresponding elements are dependent. In this application a dependency means uncertainty will propagate between tasks, but no specific value, such as a probability or weight is attached to it. Reading down a column shows the activities to which uncertainty is sourced from. For example if Activity A is a source of a particular uncertainty or subject of external uncertainty, which in turn affects Activity B, then Activity A and B are considered to have a dependency. Details regarding the dependent activities, the roles that are involved, the area of collaboration and unwanted consequences of collaboration have to be identified and abstracted to provide an overview model. The final step is to investigate a governance structure for the dependencies identified to understand whether governance can facilitates collaboration. Figure 1 is an illustration of the approach, which could be applied at any degree of collaboration.

Figure 1. Model for collaboration

3. Illustrative case to explain the model

We use an illustrative case study of a fictitious automotive supplier in the electronics industry, which was based on confidential information from multiple partners in an EU project and general literature. The supply chain configuration considered here is non-hierarchical and constitutes of three main actors; a customer, a focal company and a supplier. Therefore, there is no concentration of supply chain decision-making in the hands of a sub-group of actors. The dependencies between the activities arising from the response to a change request from the customer are modelled in a Design Structure Matrix (DSM). The activities in the illustrative supply chain covering the customer, focal company and the supplier describe a generic process of dealing with change requests. They are grouped as follows:

- customer activities: request change (C1), evaluate focal company proposal (C2), agree change with the focal company (C3);
- focal company activities: evaluate customer change request (F1), change required decision (F2), evaluate supplier's proposal (F3), agree change with the supplier (F4), prepare proposal for the customer (F5), agree change with the customer (C3)
- Supplier's activities: evaluate change request by the focal company (S1), proposal for the focal company (S2), agree change with the focal company (F4).

The DSM matrix of these activities C1-C3, F1-F5 and S1-S2, associated with a customer change request in this automotive case example is presented in Figure 2. These activities are subjected to various types of uncertainty. The customer has supply uncertainty whereas the focal company may fail to deliver on time. The focal company faces (i) demand uncertainty (e.g. erratic demand and resource shortage) (ii) supply uncertainty (e.g. fail to deliver on time) and (iii) technology uncertainty (e.g. untested technologies). In addition there are inherent uncertainties regarding the activities. For the sake of simplicity and analysis only one type of uncertainty is considered here, i.e. "Requirement can't be completely fulfilled (U)". However, considering this DSM it is important to note that since the specific objective of this paper is to study cross supply chain collaboration (between different actors), dependencies between activities of a single actor are not considered (sub-matrix within the boxes represent these activities by a single actor).

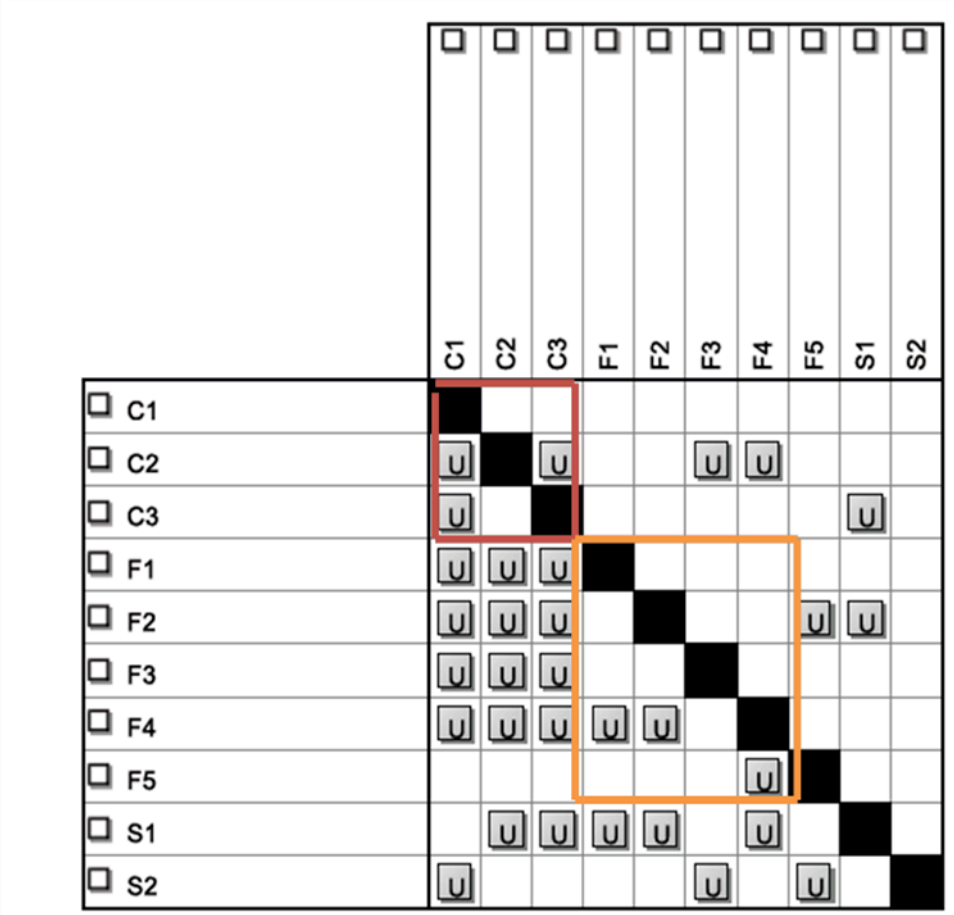

Figure 2. Uncertainty DSM

This paper will analyse one of the dependencies identified in Figure 1. The uncertainty "Requirement can't be completely fulfilled (U)" can affect the activity "Evaluate focal company proposal (C2)". The uncertainty U can be traced to the following activities (In Figure 2, column 2 having dependencies with Row 4, 5, 6, 7 and 9):

- *Focal company evaluate customer change request (F1)*
- *Focal company change required decision (F2)*
- *Supplier evaluate change request by the focal company (S1)*
- *Focal company evaluate supplier's proposal (F3)*
- *Focal company agree change with the supplier (F4)*

4. Collaboration

The uncertainty U (requirement can't be met) will have an effect on activities in all the three actors in the supply chain. For example, it will have a bearing on F2 (*focal company change required decision)* and F4 (*focal company agree change with supplier*) in a sense that the focal company may have to deviate from their plan and thus agreeing a change not in line with their true requirement. All these ultimately will affect C2 (*Evaluate focal company proposal*), since the customer may not understand the difficulty in complying with their initial request. However, the underlying cause of the uncertainty U (*requirement can't be met*) may be due to the combination of any of the following- a lack of common understanding, technical difficulties on the part of the focal company, resource shortage, a know how gap or a improper statement of work agreed by the supplier. While evaluating the technical and

financial aspects, the customer may fail to acknowledge all of these valid reasons and the supply chain may come to bottleneck situation. In this particular case, collaboration in the form of knowledge sharing, resource sharing, joint statement of work, decisions coordination, etc may limit the impact of uncertainty U. We propose that in order to limit the impact of uncertainty, these activities which in total involve all the actors of the supply chain could be coordinated through different forms of collaboration. These forms of collaboration include:

- The presence of a common nerve centre (information exchange through information systems, workshops, pre-agreed decision coordination on point to point basis) between the actors in the supply chain which can facilitate collaborative interaction and coordination between- the customer, the focal company and the supplier.
- People to people communication between various roles in different actors to ensure visibility of problems and obstacles throughout the supply chain.
- Exchange of information, knowledge, know how, technical help if required through cross supply chain resource utilisation. For example through workshops or help in technical understanding between supply chain actors.

However, in order to collaborate it is first necessary to define the roles that will participate in collaboration; the way collaboration will take place; and what will be collaborated upon. This paper identifies the relevant roles, sub-activities, processes and critical information involved in the activities C2, F1, F2, F3, F4 and S1 with dependency in uncertainty U. These roles are active and the activities, sub-activities, processes takes place and information is collected by certain roles irrespective of the level of collaboration. Therefore, the supply chain actors have to only decide where amongst these sub-activities and processes they will initiate coordination; they do not start them from the scratch in collecting this information for the sake of collaboration. The following list explains in detail the jurisdiction of collaboration amongst C2, F1, F2, F3, F4 and S1:

Customer- evaluate focal company proposal (C2)

Roles involved: system requirement engineer (SRE), software module leader, sourcing, program Manager.

S*ub-activities, processes and critical information for potential collaboration:* evaluation of technical aspect, evaluation of management aspect, evaluation of financial aspect, statement of work, economic impact, resources, controls.

Focal company- evaluate change request (F1)

Roles involved: committee to analyze risk feasibility, application architect, software designer, sales.

Sub-activities, processes and critical information for potential collaboration: analyze risk and feasibility, cost, delay to the change request, technical resources required, impact analysis.

Focal company- change required decision (F2)

Roles involved: software module leader, software designer, sourcing.

Sub-activities, processes and critical information for potential collaboration: modification and new requirements, modified Request for Quote (RFQ) content, target price.

Focal company- evaluate supplier proposal (F3)

Roles involved: system requirement engineer (SRE), software module leader, sourcing, program manager (PM).

Sub-activities, processes and critical information for potential collaboration: evaluation of technical aspect, evaluation of management aspect, evaluation of financial aspect, statement of work, economic impact, resources, controls.

Focal company- supplier agree change (F4)

Roles involved: program manager (focal company), supplier project leader, sourcing (focal company), sales (supplier.)

Sub-activities, processes and critical information for potential collaboration: statement of work, economic impact, technical details, activity interaction.

Supplier- evaluate change request by the focal company (S1)

Roles involved: software project leader, committee to analyze risk and feasibility, software designer, sales.

Sub-activities, processes and critical information for potential collaboration: analyze risk feasibility, cost, delay to the change request, technical resources required, impact analysis.

5. Governance

The collaboration between supply chain actors to mitigate uncertainty needs to be governed. It is very important since a supply chain actor can often be part of other supply chains. In essence a supply chain actor can be doing business with competing customers. In addition, often there are informal networks through which critical information can pass. Therefore, actors can have a valid apprehension on what unwanted information might be leaked through extensive collaboration and coordination. Therefore the underlying governance structure and procedures are critical to collaboration across supply chains.

In our illustrative case of the customer change request there is a dependency between activities identified through the DSM between activities C2, F1, F2, F3, F4 and S1 involving uncertainty U. For the dependency between C2 and S1 (Column 2 and Row 9 in the DSM) coordination takes place in the "statement of work" and the system requirements engineer (SRE) from the customer company participates in the risk analysis conducted by the supplier. In this case some stakeholder roles at the supplier may be concerned that there is an information leak. In cases like these a governance structure based on prior assessment of consequences should be able to guide the stakeholder roles on the conditions and boundaries of their actions. In addition there may be formal non-disclosure agreements and procedures to draw on in conflict situations which are determined prior to collaboration. Furthermore, in the absence of a proper governance structure for collaboration, a stakeholder role may decline to disclose necessary information. Although all the actors and associated stakeholder roles will have their individual standard procedures for operation, this paper advocates a governance structure customised for dependent activities (e.g. C2, F1, F2, S1, F3 and F4 for the customer change request) spanning all the actors. We conclude that a governance structure focused on the dependencies can help avoid confusion and increase transparency; in this way supply chain governance acts as a facilitator to collaboration.

5.1 Categories of governance

For the purposes of this discussion we consider three main categories of governance (Kaplinsky and Morris, 2000):

- Legislative governance: rule making, refers to all aspects of setting explicit and binding rules.
- Judicial governance: assessing, monitoring and thus enforcing pre-agreed rules.
- Executive governance: assistance with following and complying with rules, how to support "adhering to rules." .

The sub-sections 5.1.1, 5.1.2 and 5.1.3 provide suggestions for collaboration rules as part of a governance regime applicable to the illustrative case of the customer change request activities.

5.1.1 Legislative governance

Understand the requirement of the collaborative network-
The supply chain actors in this case should clearly identify the requirement, consequences, features and the nature of information exchange at the beginning of collaboration. That is while collaborating in planning activities, details regarding execution should be identified at the beginning of the relationship.

Perform strategic alignment-
Entering into a new collaborative relationship involves strategic implications. The supply chain actors should ensure that their organisations are functionally aligned with requirements of the collaboration and the business. For example, the organisations should ensure synergy in their own functions and those across other actors. Further, roles within organisations should possess appropriate authority.

Command access to intellectual property, documents and commitments-
Supply chain actors should pre-agree on document access. The nature of access to any intellectual rights within the supply network should be clear and mutually understood. The supply chain actors should convene meetings, as appropriate to share commitments.

5.1.2 Judicial governance

Catalogue the location of sensitive data-
Supply chain actors should protect information that they don't want to exchange or even if they do want to exchange, it is imperative that the location or the target role to which the information pertains, is identified clearly and unambiguously.

Analyse the impact of strategic/tactical information exchange with other actors-
The supply chain actors and associated stakeholder roles within the actor organisations, should fully understand the consequence of information exchanges. An estimate should be made regarding the amount of exposure the organization faces and a measure of the potential magnitude of inappropriate use of sensitive data should be estimated. It should be ensured that data owners are under appropriate control and engaged effectively in information exchange.

Identify the hidden links between companies in a supply network-

A supply network can have hidden, perhaps informal, information pathways between companies. This means that information can flow formally or informally in a way not entirely apparent to an each actor in the supply chain. In the same supply network a supplier could directly supply another component or service to the customer, thereby forming more indirect 'lattice' type structure of connections. This also means that information can reach the same point through different routes. With corresponding modifications derived from the routes, information may appear to be conflicting along the different paths

5.1.3 Executive governance

Ensure that employees understand the benefits of collaboration-

This is particularly critical. If the employees are not fully aware of the reasons for collaboration, they might be reluctant to collaborate in an inefficient manner. Therefore, it is important that employees treat collaboration as part of the company's vision.

Provide training for relevant employees-

Roles involved in collaboration should be well trained so that they are aware of the authority of stakeholder role. Lack of training can result in unwanted information leaks.

Establish guidelines and norms for effective collaboration-

Collaborative practices cannot be visualized as something complicated and confusing. In general this means that expertise is confined to certain individuals in particular roles. Clear guidelines on collaborative roles will ensure that even in case of employee transfer collaboration is not affected.

6. Conclusion and future work

As illustrated in Figure 1, after following all the steps in the model one reaches the critical decision on whether to setup a collaborative supply chain configuration or not. However, it is true that often supply chain actors embark on a relationship and then sort out the details. But, we believe it is an iterative process and due diligence should be provided to these issues both before and during collaboration. Our ultimate concern here is essentially a policy decision regarding the supply chain which is taken by top level management. Therefore it can be considered as strategic. However, the strategic objective is only achieved upon completion of other complementary goals and objectives that are distinguished as tactical. In this model tactical objectives are: identify uncertainty embedded in the dependencies between activities, the underlying business basis of the collaboration, roles to be involved in collaboration, and finally the unwanted consequences of collaboration. The governance regime also provides an overarching framework to outline strategy (legislative governance) and tactical objectives (judicial governance) for the supply chain.

This paper has discussed ongoing research regarding supply chain collaboration in the presence of uncertainty. It is hoped that the collaborative principles mentioned in this paper will make the stakeholder roles in the supply chain prepared for uncertainties and contingent eventualities. This brings clarity to situations regarding steps to follow for specific supply chain scenarios and therefore works as a standard procedure. The paper acknowledges that the governance regime advocated for collaboration requires assessment of specific supply chain scenarios. However, clear governance across legislative, judicial and executive categories is

necessary so that the fruit of collaboration does not have detrimental unintended consequences. In fact the necessity for effective governance is being felt more keenly with the unfolding of more and more financial disasters in the current economic recession. The conceptual model that this paper discusses is a novel approach to understanding the intricate proportionality between collaboration in supply chains, governance and the impact of uncertainty. Although the illustrative case in this paper considered only one type of uncertainty for simplicity, these activities are plagued by many such uncertainties. It would be interesting to study the relations and dependencies among different uncertainties; how collaboration between cross supply chain actor activities can mitigate them; and a subsequent robust governance regime. Given the complexity of the issues involved and the variety of views of the different stakeholder roles, we are exploring Bayesian subjective probability methods to investigate how different views from different roles affect coordination and network causality in supply chains.

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