Cluster Manufacturing: A Supply Chain Perspective

Executive Summary

Supply chain management clusters are geographic concentrations of three or more companies directly involved in the upstream and downstream flows of products, services, finances and/or information from a source to a customer. Clusters extend downstream to channels and customers, as well as laterally to manufacturers of complementary products. They also extend to companies in industries related by skills, technologies or common inputs.

Clusters exhibit some common characteristics: physical proximity; complementary core competencies; activity base; collective growth potential; competitive position; and industrial organization and coordinating mechanisms.

Clusters offer many benefits to member companies:

1. Resources are concentrated in an area, creating the opportunity to streamline and shorten supply chains.
2. Geographic proximity greatly reduces supply chain complexity.
3. Interdependence and mutual trust is heightened between companies that are members of the same supply chain. Research by Noordewier[1] and others establishes that relational elements such as long-term orientation among cluster companies directly improves performance in buyer-seller relationships. Greater interdependence also increases mutual trust, strengthens commitment levels and reduces conflict.
4. Productivity is increased, through faster access to customers and suppliers, faster access to specialized information and better network support for supply chains.
5. It is easier to motivate and measure the performance of supply chain partners.
6. Visibility is greater, due to obvious communication advantages.
7. Flexibility is increased when partners of a supply chain exist in the same cluster.
8. Risk of failure is greatly reduced, due to focus and alignment of efforts of all the partners in the supply chain.
9. Information is shared more quickly and efficiently. Players in a cluster are likely to gain knowledge of new business opportunities more quickly.
10. Gaps in products and services are identified earlier.
11. Feedback loops are shorter, allowing for faster modification of supply chains, which results in significant cost savings.

Cluster Advantages

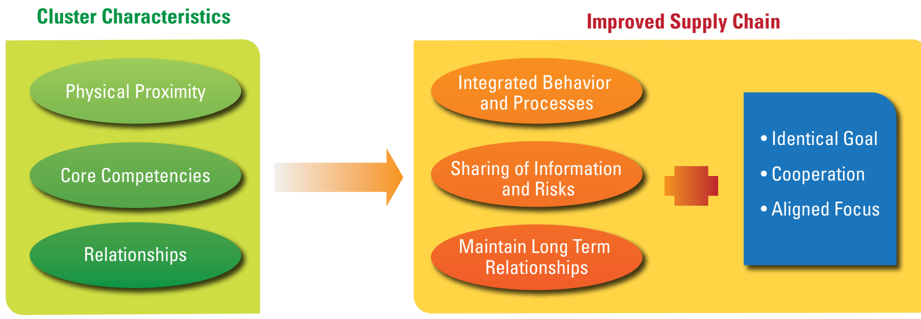

Figure 1

Figure 1 offers a broad framework of the manner in which clusters benefit member companies by improving their supply chains.

Classification

Existing clusters may be further classified into two types. They include value chain clusters and labor pool clusters.

- **Value Chain Clusters:** Value chains are essentially groups of businesses that buy and sell from each other (e.g., hospitals and pharmacies, auto manufacturers and parts suppliers, etc.). Although the benefits of value chain clusters are based primarily on the proximity of companies and not direct cooperation, proximity itself allows for simplified, low-cost supply chains and can be instrumental in implementing JIT (just in time) systems. Value chain clusters can be divided into the following subtypes:
  - **Marshallian District:** This type is based mainly on studies of European clusters and consists of groups of SMEs (small and medium enterprises) cooperating with each other to achieve economies of scale for supply chains and infrastructure. Silicon Valley is a prime example of an urban Marshallian District.
  - **Hub and Spoke:** Groups of large companies surrounded by and interacting with a number of smaller outfits.
  - **Satellites:** Simple groupings of large, branch-plant-type entities form satellite clusters. These clusters are mainly found in rural areas.
  - **State-Anchored:** These are large public or non-profit entities and related outfits such as supply and service firms. They depend on political support for their needs (e.g., SEEPZ, Mumbai, Cyberabad /Hi-Tech City, Hyderabad).

Figure 2 offers a summary of value chain clusters.

Risks associated with value chain clusters include the following:

- Companies can become overly dependent on SMEs for raw materials. If SMEs default,

Value Chain Clusters at a Glance

Cluster Type	Characteristics of Member Firms	Intra-cluster Interdependencies	Prospects for Employment
Marsallian	Small and medium-sized locally owned firms	Substantial inter-company trade and collaboration; strong institutional support	Dependent on synergies and economies provided by cluster
Hub and Spoke	One or several large firms with numerous smaller suppliers and service firms	Cooperation between large (hub) companies and their smaller suppliers (spokes), using the terms of the hubs	Dependent on growth prospects of large (hub) companies
Satellite Platforms	Medium- and large-sized branch plants	Minimum inter-company trade and networking	Dependent on ability to recruit and retain branch plants
State-Anchored	Large public or non-profit entity and related supplying and service firms	Restricted to purchase-sale relationships between public entity and suppliers	Dependent on region's ability to expand political support for public facility

Figure 2

the primary cluster player carries a greater risk of brand dilution.

- Sometimes, one SME is responsible for one type of raw material. This can lead to a monopolistic setting, wherein the SME can apply supplier power over the parent company.
- Lack of competition can lead to inefficiencies on the part of the SMEs.
- It is very easy for SMEs to function as closed units and ignore global developments.

- **Labor Pool Clusters:** These clusters are based on occupational categories. Companies with similar types of occupations and worker skills can draw from a larger pool of potential employees. A major advantage of this type of cluster is that it helps reduce employee search costs. For example, software manufacturers and more traditional manufacturers may both require similar skills, such as in the case of software developers. The close proximity of these companies attracts these occupations to the area of multiple job opportunities. This type of cluster helps increase the productivity of all workers in that region. Some examples of labor pool clusters are distribution, tourism, technological parks, industrial parks, airline transport, etc.

  Some of the risks associated with labor pool clusters are:

  - Since the companies are eyeing a similar labor pool, an excessively competitive employment environment may ensue.
  - Since the labor demand is very high, labor may be able to yield its power over employers.
  - The labor wage rate might be high in these clusters, again because the demand is high. This might lead to a major discrepancy in wage rates of labor across regions.

In general terms, regardless of the type of cluster to which a company belongs, cluster manufacturing may expose the member companies to the following significant risks:

- Cluster members may fail to establish close rapport with others belonging to the same supply chain and with customers, which may defeat the purpose of the cluster.
- Cluster members may strive to maximize return on investment individually at every stage.
- Over-reliance on current best practices within the cluster may strangle innovation.
- Long-term relationships may cause partners to be excessively dependent on each other.
- If cluster members fail to redefine their own goals and objectives to suit the cluster environment, the supply chain within the cluster may not function smoothly.
- Cluster members may become complacent and ignore the importance of the constant development of resources within the cluster.
- It is imperative for cluster members to obtain regular updates on developments in relevant industries outside their cluster.

The Impact of Cluster on Risk

To better understand the impact of a cluster on the risk profiles of SME and parent manufacturers, we have considered an example of an "auto

Summary of Findings of Risk Model

Impact of cluster on reducing risk of supply chain

Risk Profiling of SME (Example: Avtec)									
	Engine Parts	Transmission	Steering	Body	Suspension	Braking	Electrical	Accessories	Average RPN
Risk Priority Number (RPN) without Cluster	162	288	36	18	128	72	288	18	126
Risk Priority Number (RPN) with Cluster	6	32	48	324	96	16	36	81	80
Risk Profiling of Parent Manufacturers (Example: Bajaj Auto)									
	Engine Parts	Transmission	Steering	Body	Suspension	Braking	Electrical	Accessories	Average RPN
Risk Priority Number (RPN) without Cluster	1458	972	64	2	32	648	12	24	402
Risk Priority Number (RPN) with Cluster	324	162	64	4	16	72	8	8	82

Figure 3

Supply Chain Risk Summary With and Without Clusters

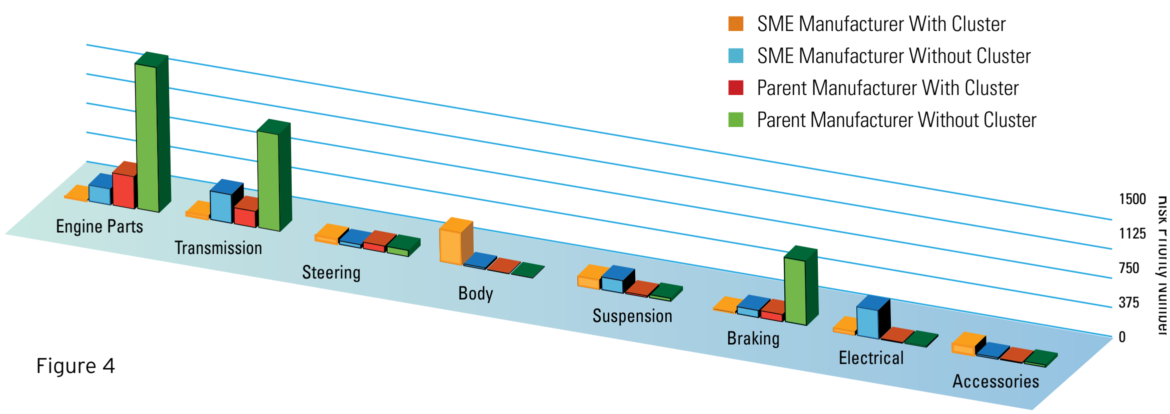

Figure 4

cluster." What follows is a summary of the risk model, with details and methodology provided in Appendix A. The supply chain risk model for all the cases can be seen in Figure 3.

If we look at the average risk priority number (RPN) in the table in Figure 3, we can infer that the cluster offers maximum risk reduction to the parent auto manufacturer when compared with the SME supplier. After considering all the risk-related factors and the change in RPN, we conclude that the concept of clustered manufacturing will be primarily driven by the parent auto manufacturer, because the benefit of clustering to this company in the form of risk reduction is higher than the benefit derived by the SME. (Details of risk factors, RPN, calculation and case-specific analysis are included in Appendix A.)

We conclude that the concept of clustered manufacturing will be primarily driven by the parent auto manufacturer, because the benefit of clustering to this company in the form of risk reduction is higher than the benefit derived by the SME.

Through the qualitative and quantitative (model) analysis seen in Figure 4, we have concluded that Porter's Cluster Model[2] truly benefits supply chain management within the clustered companies. However, a cluster needs to continuously develop strategies to mitigate the various risks inherent in the formation of a cluster that puts a premium on low-value suppliers, selecting quality suppliers, retaining talent and sharing knowledge.

Appendix A

A typical composition of this cluster type is a "parent" (i.e., car or bike manufacturer) and various component suppliers located in the cluster. (For example, Bajaj Auto Vendor Cluster at Pantnagar.)

When Bajaj Auto formed a cluster of suppliers for key OEM parts in its new plant in Pantnagar, its vendors were divided on the basis of 16 technology skills. Only 16 vendors (one for each technology set) were selected from its pool of 800 suppliers. Since the suppliers were single sources for their respective products, each one had to make a large investment in setting up plants with sufficient capacities. Consequently, Bajaj had to directly invest only 1.5 billion rupees (or $329,000) in the facility, enabling it to have a very quick payback period.

Key components sourced from the cluster include lighting systems from Lumax, electrical components from Varroc, ignition systems from Minda and speedometers from Pricol.

The risks for an auto cluster can be specifically viewed from two perspectives: The SME manufacturer's and the parent manufacturer's.

The supply chain risk profile of both would be different, and the impact/need for a cluster to both parties would be totally different from the point of view of supply chain risk.

In general, we classify any auto ancillary supplier in the cluster into eight broad categories based on type of product, technology, value, etc.: Engine Parts, Transmission, Steering, Body, Suspension, Braking, Electrical and Accessories. Each group has varying supply chain risks and different incentives to participate in the cluster. This is different for an SME and parent manufacturer.

Developing a Risk Profile Model Methodology

The supply chain risks were quantified using a concept generally used in the Failure Mode Effect Analysis of any manufacturing process. Every risk was categorized into three levels, and a risk score was assigned to each level. Also, these factors need to be carefully considered for both SME and parent.

1. Risk Factors for the SME

Criticality of the part: If the part being supplied by the SME is very critical to the parent manufacturer, then the risk for the SME going out of business is low. But if the supplier makes a substitutable product, then it has a high risk of being replaced by another company. Risk levels and score are:

Score	Level
1	High Criticality
2	Medium Criticality
3	Low Criticality

- **Complexity of the part:** If the part supplied by the SME is complex to manufacture, then the risk for the SME going out of business is low. But if the supplier makes a simple product like a nut or bolt, then it has a high risk of being replaced by another company. So the risk levels and score are:

Score	Level
1	High Complexity
2	Medium Complexity
3	Low Complexity

- **Size of the SME:** We can generally classify the auto SME into three categories of >5 billion rupees, 2 to 5 billion rupees, <2 billion rupees. The bigger companies are in a better bargaining position than the smaller ones, and so the risk profile changes.

Score	Level
1	> 5 billion rupees
2	2-5 billion rupees
3	< 2 billion rupees

- **Selling price to raw material ratio (value addition):** In an auto cluster, SMEs span the value chain – from simple sheet metal job workers, to complex engine and transmission manufacturers that require knowledge and design skills. We have captured the technical skills aspect in the "value addition" risk factor. If the selling price to raw material ratio is very low (1.1 to 1.25), then there would be huge competition and risk of substitution. Contrast this with an engine manufacturer, with whom the parent auto company shares all its design drawing and details. The SME with higher value addition will have less risk, because this company would develop its skill and knowledge in the process of supplying the parent.

Score	Level
1	>2
2	1.25 to 2
3	1.1 to 1.25

- **Incentive structure:** The parent auto company may offer incentives to the SME or ancillary manufacturer in many ways, ranging from entering into a technical memorandum of understanding with promised quantity, to assigning a recurring purchase order. The risk profile changes according to the incentive:

Score	Level
1	MOU/Technical tie-up
2	Annual rate contract
3	Recurring purchase order

- **Diversification opportunities:** If the SME is manufacturing a product with greater after-market demand (i.e., retail demand), then its dependence on the auto manufacturer is not as significant. But if the SME is highly customized and localized to the cluster, then it is in a highly risky position.

Score	Level
1	Strong after-market (retail) demand
2	Multiple B2B customer or multiple vertical
3	Customized / Localized

- **Packaging required:** Packaging plays a key role in the safety and quality of the product supplied by the SME. Huge investments in packaging and reverse logistics are performed by the SME on behalf of the parent manufacturer. Hence, if there is high expectation for customized packaging with reverse logistics, it would have a different risk profile, compared with general/bulk packaging.

Score	Level
1	General / bulk packaging (CFCs)
2	Standard accessories packaging
3	Customized packaging with reverse logistics

2. Risk Factors for the Parent Manufacturer

- **Criticality of the part:** From the parent manufacturer's perspective, the higher the criticality of the part to the end product, the greater the risk. So here, the level of risk would be the opposite of the SME manufacturer's. Risk levels and score are:

Score	Level
1	Low Criticality
2	Medium Criticality
3	High Criticality

- **Complexity of the part:** Extending the above argument to complexity, we can infer that the higher the complexity of the part, the higher the risk to the parent manufacturer.

Score	Level
1	Low Complexity
2	Medium Complexity
3	High Complexity

- **Transit time to supply:** Transit time becomes another critical factor for the manufacturer. More days in transit means higher risk.

- **Dependence of assembly line on the part:** If the part being sourced is highly entrenched in the operations of the assembly line, and a slight problem in part availability or another problem can cause the assembly line to come to a halt, then this needs to be classified as a high risk. Three methods are generally adopted by manufacturers: JIT supply, milk run and push system with inventory.

Score	Level
1	< 2 days
2	2-10 days
3	>10 days

Score	Level
1	JIT
2	Kanban, milk-run, etc.
3	Push system

- **Contract structure:** If the parent company enters into a technical memorandum of understanding with promised quantity, then it is in a locked condition, which adds risk to existing high supply chain challenges. But with recurring POs, the parent company can change the supplier if there is any quality or supply issue.

Score	Level
1	Recurring purchase order
2	Annual rate contract
3	MOU/Technical tie-up

- **Multiple sources of supply:** As explained by Porter's five forces,[3] additional supply options lower a company's risk.

Score	Level
1	Many options
2	Few options
3	Localized options

- **Packaging required:** Packaging plays a key role in the safety and quality of product supplied by the SME. Customized packaging with reverse logistics would carry higher supply risk compared with general/bulk packaging.

Score	Level
1	General / bulk packaging (CFCs)
2	Standard accessories packaging
3	Customized packaging with reverse logistics

3. Quantifying Risk: Risk Priority Number (RPN) With and Without Cluster

We then take four cases and calculate the RPN for each case to quantify the risk. Higher RPN equals higher risk.

Case 1: SME perspective if it is operating without a cluster.

Case 2: SME perspective if it is operating within a cluster.

Case 3: Parent manufacturer perspective if it is operating without a cluster.

Case 4: Parent manufacturer perspective if it is operating within a cluster.

These cases were created to quantify the benefit of a clustering strategy in reducing supply chain risk. While calculating the RPN, the following formula was used:

RPN = Product of risk score of all auto part groups in the cluster

We repeat with the same set of assumptions for all the cases and understand the impact of clustering to both the stakeholders in the cluster. If the RPN decreases when there is a transition from outside a cluster to within a cluster, then it is evident that clustering actually benefits the stakeholder by reducing its risk. However, as seen in the following section, clustering may not be the best option for all the supply groups.

To start with, let's compare the SME perspective on supply chain risk.

Case 1

Supply Chain Risk Profiling for SME Manufacturer: Without Cluster

	Engine Parts	Transmission	Steering	Body	Suspension	Braking	Electrical	Accessories
Examples	Avtec Bosch Lucas TVS	Avtec Carraro gears	Delphi Rane Sona Koyo	Sheet metal works	Gabriel Autoshox	Bosch Sundaram brake Rane brake linings	–	Pricol Lumax NTN, Goodyear
Criticality of product supplied	3	2	1	1	2	3	2	1
Complexity of part to manufacture	3	2	1	1	2	1	2	1
Size of supplier	1	3	3	3	2	3	3	3
Selling price to raw material ratio (value addition)	3	2	2	1	2	2	3	2
Incentive structure of supplier	1	2	3	3	2	1	2	3
Diversification opportunities	2	2	2	2	2	2	2	1
Packaging required	3	3	1	1	2	2	2	1
Risk Priority Number	162	288	36	18	128	72	288	18

Case 2

Supply Chain Risk Profiling for SME Manufacturer: With Cluster

	Engine Parts	Transmission	Steering	Body	Suspension	Braking	Electrical	Accessories
Examples	Avtec Bosch Lucas TVS	Avtec Carraro gears	Delphi Rane Sona Koyo	Sheet metal works	Gabriel Autoshox	Bosch Sundaram brake Rane brake linings	–	Pricol Lumax NTN, Goodyear
Criticality of product supplied	1	1	2	3	2	1	2	3
Complexity of part to manufacture	1	2	3	3	2	2	3	3
Size of supplier	1	2	1	3	3	1	1	3
Selling price to raw material ratio (value addition)	1	2	2	3	2	2	1	1
Incentive structure of supplier	1	1	2	2	1	1	3	3
Diversification opportunities	2	2	1	2	2	2	1	1
Packaging required	3	2	2	1	2	2	2	1
Risk Priority Number	6	32	48	324	96	16	36	81

The SME perspective: It is clear that the RPN for Engine Parts, Transmission, Suspension, Braking, Electrical and Accessories is reduced, which bodes well given that an SME would be safer in a cluster if its manufacturing-critical components have higher value addition and skill requirement. In contrast, the risk of body parts suppliers or sheet metal workers rises drastically if they get into a cluster because they manufacture undifferentiated products with low skill requirements. They can be easily replaced by the competition. Hence, the parent manufacturer must be mindful of this and offer incentives to contract workers or sheet metal fabricators with quantity assurance and rate agreements to retain them in the cluster.

From here, we will compare the parent manufacturing perspective on supply chain risk.

Case 3

Supply Chain Risk Profiling for Parent Manufacturer: Without Cluster

	Engine Parts	Transmission	Steering	Body	Suspension	Braking	Electrical	Accessories
Examples	Avtec Bosch Lucas TVS	Avtec Carraro gears	Delphi Rane Sona Koyo	Sheet metal works	Gabriel Autoshox	Bosch Sundaram brake Rane brake linings	–	Pricol Lumax NTN, Goodyear
Criticality of product being sourced	3	3	2	1	2	3	2	1
Complexity of part being sourced	3	3	2	1	1	2	1	1
Transit time to supply	3	3	2	1	2	3	1	2
Dependence of assembly line on the product	3	3	2	1	2	3	3	3
Contract structure	3	2	2	2	2	2	1	2
Multiple sources of supply	2	3	1	1	2	2	1	1
Packaging required	3	2	2	1	1	3	2	2
Risk Priority Number	1458	972	64	2	32	648	12	24

Case 4

Supply Chain Risk Profiling for Parent Manufacturer: With Cluster

	Engine Parts	Transmission	Steering	Body	Suspension	Braking	Electrical	Accessories
Examples	Avtec Bosch Lucas TVS	Avtec Carraro gears	Delphi Rane Sona Koyo	Sheet metal works	Gabriel Autoshox	Bosch Sundaram brake Rane brake linings	–	Pricol Lumax NTN, Goodyear
Criticality of product	3	3	2	1	2	3	2	1
Complexity of part being sourced	3	3	2	1	1	2	1	1
Transit time to supply	1	1	1	1	1	1	2	2
Dependence of assembly line on the product	2	1	2	2	1	1	1	1
Contract structure	3	2	2	1	2	2	2	1
Multiple sources of supply	3	3	2	2	2	3	1	2
Packaging required	2	3	2	1	2	2	1	2
Risk Priority Number	324	162	64	4	16	72	8	8

The parent manufacturer perspective: RPN for Engine Parts, Transmission, Suspension, Braking, Electrical and Accessories is reduced, which bodes well given that the parent manufacturer would be safer to have its critical components suppliers inside the cluster. From the manufacturer's perspective, body parts makers would have the least impact on the parent's risk profile, but in practice, they are the most important part of their supply chain.

Footnotes

[1] Thomas G. Noordewier, George John and John R. Nevin, "Performance Outcomes of Purchasing Arrangements in Industrial Buyer-Vendor Relationships," *The Journal of Marketing*, Vol. 54, Nov 4, October 1990, pp. 80-93. http://www.jstor.org/stable/1251761

[2] Porter's Cluster Model was first introduced by Michael Porter in *The Competitive Advantage of Nations, Free Press*, 1998.

[3] Porter's Five Forces is a framework developed by Michael Porter (Harvard Business School) to study the forces that help understand competitive intensity and attractiveness of market. The five forces are: The threat of new competitors/barriers to entry; the intensity of competition; the threat of substitutes; the bargaining power of customers; the bargaining power of suppliers.

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