

## Assessment of Retail Supply Chain Using Graph Theory and Matrix Approach

Utkarsh Malik, Prateek Gaba, Parth Sharma, Mohd Tayyab, Ranganath M.Singari  
(Department of Mechanical Engineering, Delhi Technological University, Delhi, India)  
Email: [mdtayyab7809@gmail.com](mailto:mdtayyab7809@gmail.com)

*Abstract : Supply chain is one the forming pillars of the product-based industry in today's world. From the online retail companies like Amazon, EBay, Flipkart, Alibaba to brick and mortar based business firms likes Walmart, big bazar, Easyday, all depend heavily on their supply chains for their growth and sustainability. Supply chain includes all the activities starting from the procurement of the raw materials to the delivery of the final products. Any changes in the supply chain affect each link directly. The following is a research on the retail supply chain industry with the motive of discovering the factors affecting this supply chain. Supply chain of a retail industry is an end to end process including planning, monitoring and controlling all the activities being carried out in the supply chain. The magnitude of affect these factors produce on the supply chain is reviewed by the industry experts on a Likert scale of 1-5. The data collected will then be processed using factor analysis method to find the most affecting factors. Out of the 25 factors, the latent 10 factors were identified and reliability analysis was carried out on it to test data consistency. On these important factors Graph Matrix Theory approach is applied to arrange the factors on the basis of their importance.*

*Keywords: Retail supply chain management, Statistical Analysis, Supply chain.*

### 1. INTRODUCTION

Supply chain management (SCM) is concerned with the management of goods and information within a supply chain such that the required information/raw material/product is available at the desired location. Interlinked networks, channels and node are required to meet the products and services requirements by the end customers in a supply chain. Supply-chain management is defined as the process of design, plan, monitor and control all the supply chain activities in order to get a high-quality product, create a competitive environment and get the most out of every rupee invested in the product i.e. high net value.

Supply chain management finds its application in industries. Besides this it is also highly useful in system engineering, logistics, procurement of raw material and other supplies and information technology. Highly efficient marketing channels are necessary for a successful SCM as SCM strives for an integrated approach in marketing.

Supply chain management is defined as the integration of the activities concerned with the flow and transformation of raw material into final products being delivered to the customers. Along with this, it also includes the integration all the information processing functions with the help of supply chain relationships in order to achieve an upper hand over the competitors.

SCM is concerned with planning and controlling all the activities right from the procurement of raw materials and

other tools, conversion of the raw materials into finished products and finally delivering the finished products to the users. SCM is being implemented basically in order to get an upper hand over the competitors and to increase the flexibility of the supply chain. So, to achieve this organization have started delegating the ownership of raw materials and distribution channels to other organization. The advantage of this is as these activities will be carried out by other firms than the organization will have less activities to manage as a result of which the efficiency of the system will increase and also the cost of the process will reduce.

#### 1.1 Retail Supply Chain

Supply chain in retail industry is an end to end process and has the following characteristics:

- All the activities are interlinked within the system for the flow of information throughout the system.
- SCM in a retail supply chain makes sure that the activities are carried out in a logical order with a predefined time table.
- SCM makes sure that the right products are available at the right place in right quantity at right time.
- The use of information technology has reduced the lead times and has also helped in improving the quality of the product.

Retail Supply Chain Management is the process of planning and controlling all the activities of the supply chain. Retail supply chain is different from a normal supply chain as in a retail supply chain, the volume of the movement of the

products is very high and the retail industry has the need of moving these products within a supply chain at a very fast rate. Retail supply chain management is more complex as the products need to be monitored more efficiently and continuously in order to reduce the number of flaws within the system. This will help in increasing the efficiency of the system and also improve the quality of the product. Manufacturing lead time for the product will also be reduced. So, retail supply chain management is very important for an organization.

Customer satisfaction is the topmost priority of a retail organization so delivery of the right product at the right time is a priority for such organizations. Management of all the activities within the supply chain from procurement of raw materials to delivery of the finished goods is necessary. The consumer today has created the need for transformation in Omni channel retail supply chains. The customers are demanding more varieties with reduced prices. This leads to a competitive environment. Hence, the organization integrate all the distribution channels for better inventory control and to provide better service to the customers.

### 1.2 Objective

The main purpose of the report is to identify the latent factors that affect a retail supply chain and find the order in which they should be dealt with in so that the efficiency of the supply chain can be maximized. The reason for choosing the retail supply chain is the growing complexity both internal factors (due to complex flow of material) and external factors (government policies, weather conditions, etc.).

## 2. LITERATURE REVIEW

Sustainability of a supply chain management process is dependent on the internal and external aspects of the supply chain. Considering both the management and the economic aspects, the importance of sustainability needs to be determined. By comparison of the methodologies used to measure sustainability both qualitatively and quantitatively, the indicators should be categorized into common index and respective index differentiated to industry sections and its own supply chain. Hence, the economic value of sustainability can be determined. For supporting sustainability, the strategy should be such that it can do justice to both external and internal environment, collaboration between organizations and information technology implemented. Previous strategies to adopt sustainability can provide practical and applicable implications. It can be helpful for the company to derive its own introduction process by comparing best practices according to industrial sections.

### 2.1 Identified Gaps

Following is the table which shows the gaps that were found in the various research papers that were studied and mentions the main point of the research done. It gives us an overview of the whole paper that was taken into consideration.

Table 2.1 Identified gaps

AUTHOR	RESEARCH DONE	GAP FOUND
Tseng et al., 2016	The data was collected from electronics manufacturing firms in Taiwan. By analysis, further steps were implemented.	Additional studies are requiring investigation in decision-making role in a complex hierarchical structure and the use of the proposed SSCM framework
Ansari and Kant, 2016	A literature review on SSCM to determine the current status of research and thus analyzing and classifying the relevant papers.	Continuous studies should be carried out in a similar manner so that progress can be made.
Ahmad et al., 2016	A multiple regression analysis was conducted to understand the relationship between internal factors and SSCM practices in the O&G industry	Future research could employ a longitudinal study to obtain a clearer picture of how the internal factors could change companies' Strategies over time.

Silvestre, 2016	Supply chains are dynamic in nature and continuously evolve. Supply learn to innovate, change and become more sustainable.	Further research on the role played by other elements such as supply chain integration and collaboration.		enhancement of sustainable supply chain management practices by aligning them to circular economy concepts.	be addressed to
Luthra and Haleem, 2015	Difficulties faced in implementing SSCM in Indian automobile sector are recognized and analyzed.	The derived ISM based hierarchical model may be tested using Structural equation modelling(SEM).		Based on the model, three types of supply chain strategies were studied and also proposed.	There may be many other factors affecting the selection of SSCM strategy beyond those that have been proposed.
Wang et al, 2014	This paper proposed the Bayesian combination forecasting is an efficient method for retail supply chain.	More complex systems can be tested and resolved to produce results for the same.			
Esfahbodiet al., 2016	The resource dependence lens does a reasonably good job of explaining how firms outsource services to undertake environmental initiatives.	Future studies may test this model using a structural equation modelling methodology.		This research responds to the clarion call for more investigation into the area of sustainable supply chains and their integration into business models and processes by extending the generally accepted “strategic orientation-strategy” relationship to the area of	Although the collected data was in two phases to avoid common method bias, further research could collect data from multiple sources in the firm.
Genovese et al., 2015	The verification of a potential	Further researches will			

	SSCM.	
Quesada et al, 2011	Critical Factors Affecting Supply Chain Management: A Case Study in the US Pallet Industry	The research is limited to a small sector so the factors are limited in number. More factors can be identified taking a look into other sectors as well.
Rockart et al, 1989	Critical success factors (CSF) affecting the supply chain at a broad level. In different industries operating across the globe.	With the advent of new systems and advancement of the supply chain more factors have come to forefront which need to be addressed.
Oke and Gopalakrishnan, 2013	To investigate the types and management of risks faced within the supply chain of a large US retailer.	The relevance of various frame-works on risk categorization was tested out in an empirical study of risk management in a retail supply.
Fleisch and Tellkamp, 2012	to examine the relationship between inventory inaccuracy and performance in a retail supply chain.	Results indicate that eliminating Inventory in accuracy can reduce supply chain cost as well as reduce the level of out-

		of-stock even if the level of process quality, stolen and unsaleable items remains unchanged.
Abidi and Gupta, 2017	Customer relations, efficiency of supply chain, use of technology and planning and investment are important factors.	The study needs to have a larger sample size to get more factors and an accurate data set.
Hudnurkar et al, 2013	Factors and study was found to conduct on Indian market leading to different issues of a developing country.	The study could not account for all the developing countries and the system and therefore needs data from different sources which can be computed on the same scale.

The papers were studied and hence the work done and gaps that were found in each were listed above. This helped us in understanding the retail supply chain management and also the factors affecting it.

### 3. FACTORS AFFECTING RETAIL SUPPLY CHAIN

The papers were studied and hence the work done and gaps that were found in each were listed above. This helped us in understanding the retail supply chain management and also the factors affecting it.

#### ACTORS AFFECTING RETAIL SUPPLY CHAIN

Supply chain management is a highly integrated system of planning, managing and controlling all the activities of the supply chain. As a result, it is affected by many factors. Some of the factors and sub-factors that may affect the supply chain are as follows: -

### **3.1 Environmental Uncertainty**

With the increase in outsourcing activities like raw materials management and distribution channels management, the importance of relationships among organizations has grown. This factor can be further divided into three sub-factors: environment, government support, and uncertainty aspects from overseas.

#### **3.1.1 Company environment**

Company environment is related to the relationship of the organization with the suppliers and the level of trust they share. It can be reduced by critical planning.

#### **3.1.2 Government support**

Government support includes the support the organization receives in importing raw materials or goods from overseas or using domestic products. These are the norms, rules and regulations for the organization as specified by the government.

#### **3.1.3 Uncertainty aspects from overseas**

Outsourcing of raw materials or products from other countries should be done keeping in mind the political uncertainties of the country. Uncertainty can cause risk to the suppliers as the firm will not be investing anymore so there will be a requirement of change in the business strategy.

### **3.2 Information Technology**

Information technology integrates all the activities and information processing functions within the system and thus allows the communications amongst them.

#### **3.2.1 Communication tools**

Communication tools are used for transfer of data transfer. It also helps in communication between the trading parts.

#### **3.2.2 Planning tools**

Planning tools is an important factor for supply chain management. It integrates the resource planning activities in an organization.

### **3.3 Supply Chain Relationships**

Supply chain relationships are important that needs to be considered in order to achieve the goals set by the organization.

#### **3.3.1 Relationship with customers**

Relationships with customers depend on the product quality and cost of the product offered to the customer by the firm

### **3.4 Value Added Process (Manufacturing)**

Value-added processes can be processes for a new product or for an existing product in which modifications are to be made in order to improve their quality and operating performance. Value-added processes are those processes which increase the value of the product in reference to the customers perspective of improve in the product's functioning and quality.

### **3.5 Flexibility**

Customer demands are complex i.e. they want different variety of products. Also, the stiff industrial competition and the fast requirements of the consumers require that the firm should be flexible in its manufacturing. Flexibility can be understood as the ability to react and adapt quickly to changes in the market due to an increase or decrease of customers' requirements, accelerating or decelerating the manufacturing processes when it is requested.

### **3.6 Quality**

Quality is not a bonus for the customer; it is expected. Quality is also important for the acceptance of a product. High costs, low productivity, and loss of market share are directly related to poor quality. Quality is meeting or exceeding the expectations of your customer.

### **3.7 Production System**

The change in the industrial structure helps in improving the efficiency of the manufacturing firm. When the firm is re-arranged into machine cells to produce a part family, it will help in reducing the lead time, cost reduction and also identifying the bottlenecks to improve the production process.

### **3.8 Supply Chain Management Performance**

SCM performance is defined as carrying out operations with high efficiency and effectiveness so as to increase the customer satisfaction. The features included are- measuring all the aspects and comparing them under conditions. It should be consistent with the goals of the firm..

### **3.9 Logistics**

Logistics is defined as the responsibility to design and administer systems to control movement and geographical positioning of raw materials, work-in- process, and finished inventories at the lowest total cost. Logistics should be centered at the collaboration and integration of activities, process scheduling and computer information technology system.

### **3.10 Supplier Market**

Manufacturers should have a good network and relationships with the suppliers. It is necessary for them to focus on the relationships with the suppliers and the customers, customer requirements and integration of the operations in the firm.

### **3.11 Material Sourcing**

Material sourcing is an important factor as the need for low cost raw material either domestic or imported is very high. Some of the firms choose importing raw materials as their source in order to get an advantage over their competition.

### **3.12 Business Management**

Business management consists of leading, planning, organizing, monitoring and controlling all the involved actors and activities in a company to achieve goals and objectives. It



described as “the process of managing networking between companies”.

**3.12.1 Process strategy**

Process strategies are utilized by companies to improve their manufacturing performance and as a result business performance. The process strategy management requires the identification of objectives, the creation of policies and assignment of resources for the plan’s implementation.

**3.12.2 Process performance**

Companies are expected to provide superior quality at low cost. To achieve these goals, they have to look for tools and strategies that help them obtain high process performance. Rework rate, defect rate, and inventory turnover rate are measures of process performance.

**3.12.3 Marketing strategy**

Marketing strategy is defined as the decisions taken by the firm related to the product, marketing activities and marketing resources for the development, communication and delivery of products. This enables the organization to achieve its goals. The main question is how to implement these marketing strategies, if it is advisable to implement them on consideration of the economic cost associated with them and whether they will produce the desired result or not.

**3.12.4 Innovation**

The innovation is the development of a new product and the process of acceptance and implementation of the new product. There are three levels at which innovation can be studied: the sectorial, regional, and project level. Innovation allows companies to growth and survive in the complex markets.

**3.13 Customer Satisfaction**

“How well a product is accepted by a customer?” is what matters to the manufacturing firm. Customers can emphasize more on low cost than high level of quality, faster delivery time, better services etc. Manufacturers are concerned with the sale of their products and will thus adopt policies to increase these sales and improve customer satisfaction. A sub-factor of customer satisfaction is- Customer Service.

**3.13.1 Customer service**

The main aim of the firm is to provide its customers with the best after sale service in an efficient and effective manner without forgetting about information such as product

description, product availability, order status, shipping dates, and assisting them in all what they need. The efficiency of the customer service can be increased by management and implementation of demand forecasting, service levels, order processing and parts/service support.

**3.14 Globalization**

Globalization is one of the biggest factors affecting the supply chain even for firms manufacturing products for local markets. Supply chains should be highly flexible to capture opportunities at the global level and new, cash- rich, emerging market competitors are entering the turf of established players

*Result of factor analysis*

The Factor Analysis is an explorative analysis. The factor analysis groups similar factors into new factors, which for convenience of being different can be called dimensions. Since it is an explorative analysis it does not distinguish between an independent and a dependent variable. Factor Analysis reduces the data in a model by reducing the variables or factors of observations.

A Scree Plot is a simple line segment plot that shows the fraction of total variance in the data as held by each factor. The factors are arranged in descending order and are numbered in a similar arrangement. The factor with the largest contribution is assigned with the first position. The part where the maximum deviation from the path or a sharp turn is noticed is called the elbow of the plot and represents the majority of the factors that are making a contribution in the data

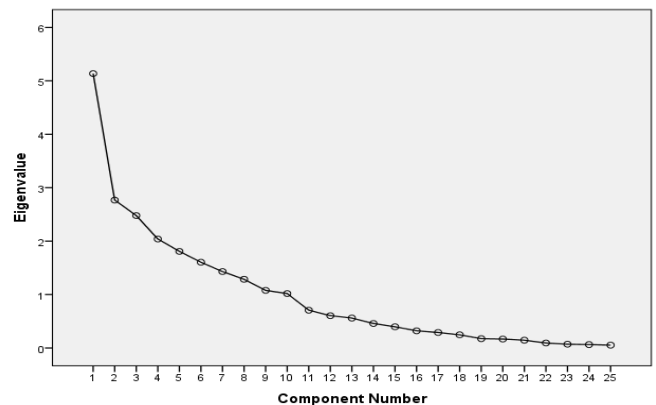


Table 3.1 Total variance explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.136	20.545	20.545	5.136	20.545	20.545	2.699	10.796	10.796
2	2.768	11.071	31.616	2.768	11.071	31.616	2.558	10.231	21.027

3	2.479	9.914	41.530	2.479	9.914	41.530	2.363	9.454	30.481
4	2.040	8.160	49.690	2.040	8.160	49.690	2.294	9.177	39.659
5	1.808	7.234	56.924	1.808	7.234	56.924	2.150	8.600	48.259
6	1.605	6.419	63.343	1.605	6.419	63.343	1.786	7.146	55.405
7	1.430	5.721	69.064	1.430	5.721	69.064	1.786	7.144	62.549
8	1.286	5.143	74.207	1.286	5.143	74.207	1.771	7.083	69.631
9	1.078	4.312	78.519	1.078	4.312	78.519	1.700	6.799	76.430
10	1.019	4.075	82.594	1.019	4.075	82.594	1.541	6.164	82.594
11	.707	2.829	85.422						
12	.605	2.418	87.841						
13	.560	2.240	90.081						
14	.458	1.834	91.914						
15	.397	1.587	93.501						
16	.322	1.286	94.787						
17	.290	1.159	95.946						
18	.247	.986	96.932						
19	.175	.699	97.631						
20	.167	.666	98.297						
21	.145	.581	98.878						
22	.094	.374	99.252						
23	.070	.281	99.533						
24	.063	.253	99.786						
25	.053	.214	100.000						

The rotated component matrix, is the key output of principal components analysis. It contains estimates of the correlations between each of the variables and the

estimated components and gives us valuable information about the analysis

Table 3.2 Rotated component matrix

	Component									
	1	2	3	4	5	6	7	8	9	10
-Quality Control	.793									
-Government regulations and Political environment	.719									
-Economically challenged consumer base	.692								.401	

-Higher Delivery Costs of transportation of goods	.579	.528								
-Material Sourcing	.537		.421							
-Incomplete Shipments		.808								
-Late Deliveries		.749								
-Customer Loyalty		-.578			-.435			.532		
-Communication flow and Communication tools		.462								
-Variable Lead times for order			.682							
-Order Inflation Rise in no. of orders			.677							
-Demand Forecasting			.603		.448					
-Globalization			.594						.414	
-Customer Service and Satisfaction				.845						
-Higher than expected Tax Rates by governments				.753						
-Poor Weather Conditions				.593					.425	
-Planning tools like ERP, MRPM					.897					
-Innovation					.679					.454
-Flexibility						.922				



-Business Management Practices like Process Strategies Marketing										
-Price fluctuations of raw materials on the supplier end							.856			
-Out of stock problems due mismanagement in backrooms							.632			
-Warehouse capacity								.886		
-Training of an Employee									.811	
-Supply chain relationships										.940

A study was done on retail supply chain management and subsequently factors affecting supply chain were identified. A questionnaire was formed and sent to the industry experts which had Likert scale (1-5 where 1 depicted the least effect of the factor on supply chain and 5 depicted the most effect of the factor on supply chain. The factors affecting a Retail Supply Chain were condensed using factor analysis using SPSS statistics software which reduced the factors from 25 to 8. To test the internal consistency of the data, reliability analysis was done using the split half reliability technique. The split half reliability of these variables is depicted by the Cronbach alpha value whose value should be greater than 0.7 for the data to be acceptable. The Cronbach alpha value was 0.769 so the data is acceptable. The following latent factors were identified:

1. Quality to cost
2. Customer experience
3. Product acquisition
4. Market share
5. Planning Development
6. Flexibility
7. Supply consistency
8. Demand fulfilment
9. Economical and geographical scenario
10. Supply chain innovation

*General Methodology of graph theory and matrix approach*

Graph theory is being used more and more these days as it is applied to the areas of mathematics, science and technology. It is currently being used in operations research, Mechanical engineering and Electrical engineering. Graph Theory and Matrix approach originated from combinational mathematics. It uses logic and a set of steps to derive the result of the problem that it is being used on. It helps to understand the system and sub-system. Further it will analyse the sub-system at the component level. It helps in selecting the most suitable choice from among a large number of alternatives for a given problem. The graphs are used to represent almost any physical situation involving discrete objects and relationship among them. A digraph shows how the elements are interdependent and is expressed with the help of nodes and edges. Matrices are used for representing digraphs, as it gives one-to-one representation. The permanent of a matrix is used to characterize configurations of a system or the structure of a graph and to develop a unique representation that is independent of labelling.

The methodology of Graph theory matrix approach addressed by various researchers in various fields of science and technology is given. The analysis was extended to the subsystem and to component level for characterization, analysis, identification and comparison of automobile. A permanent function was introduced to carrying out the overall structural analysis thoroughly. GTMA in strip-layout selection in component

manufacturing. The proposed method minimizes the overall cost of the component by minimizing the wastage. An index called, strip-layout selectivity index was deduced to evaluate and rank the various alternatives. GTMA is a versatile tool applied to the field of tribology to assess the maintainability of mechanical systems.

The design alternatives of mechanical systems were compared using maintainability index for selecting and enhancing the maintainability of a system. Selecting the component suitable for a system plays a vital role in reliability of the system. GTMA method is used in selecting a rolling element bearing by evaluation of reliability. A reliability digraph was constructed and reliability matrix was formed to assess the reliability index. GTMA paved its way in selecting a cutting fluid for a given machining operation. A digraph called cutting fluid attributes digraph was developed and a cutting fluid index was deduced to select the right cutting fluid. Graph theoretic approach is used in the field of machining and manufacturing to evaluate the machinability of work materials. Machinability attributes were considered in developing the machinability attributes digraph.

The methodology of GTMA addressed by various authors for analysis, evaluation and selection of optimal combination or parameters is given below:

Step 1: Identifying the attributes or factors that influence the process or system. This is done using the data available in the literature or by conducting survey from the experts.

Step 2: Identifying the sub-factors and their interdependencies among the potential alternatives.

Step 3: Graph representation of the attributes as nodes and their relative importance as edges. The digraph consists of a set of nodes  $N = \{n_i\}$  with  $i=1,2,3,\dots,M$  and a set of directed edges  $E=\{e_{ij}\}$ . A node  $n_i$  represents  $i$ -th alternative. The number of nodes  $M$  is equal to the number of alternatives considered. If a node 'i' has relative importance over another node 'j', a directed edge is drawn from node  $i$  to node  $j$  ( $e_{ij}$ ). If node 'j' has relative importance over node 'i', a directed edge is drawn from node  $j$  to node  $i$  ( $e_{ji}$ ).

Step 4: Representation of digraph as selection criteria matrix. Matrix representation of selection criteria digraph gives one-to-one representation. This selection criteria matrix is a  $M \times M$  matrix and considers all of the criteria ( $A_i$ ) and their relative importance ( $a_{ij}$ ). Where  $A_i$  is the value of the  $i$ -th criteria represented by node  $n_i$  and  $a_{ij}$  is the relative importance of the  $i$ -th criteria over the  $j$ -th criteria, represented by the edge  $e_{ij}$ . The values of  $A_i$  should preferably be obtained from the experimental results and are normalized on the same scale. The values of  $a_{ij}$  may be obtained from the suitable scale proposed by Rao18(2007) or on a Fuzzy scale.

Step 5: The selection criteria function for the matrix is obtained. The permanent of this matrix is defined as the alternative selection criteria function. Application of the concept of permanent function leads to a better

appreciation of selection attributes, as there is no negative sign in expression, no information is lost.

Step 6: Evaluation and ranking of the alternatives. The permanent function(Per) values for all alternatives are evaluated and ranked as shown in Eq. 6.1

$$\begin{aligned} \text{Per(A)} = & (\prod_{i=1}^M S_i + \\ & \sum_i \sum_j \sum_k \dots \sum_m (a_i a_j) R_i R_j \dots R_m + \sum_i \sum_j \sum_k \dots \sum_m (a_{ij} a_{ki} a_{jk} + \\ & a_{ij} a_{jk} a_{ji}) R_i R_j \dots R_m) + \\ & (\sum \sum \sum \dots \sum (a_{ij} a_{ji}) (a_{ki} a_{ik}) R_i R_j \dots R_m + \\ & \sum_i \sum_j \sum_k \dots \sum_m (a_{ki} a_{ij} a_{jk} a_{ik} + \\ & a_{ik} a_{jk} a_{kj} a_{ji}) R_i R_n \dots R_m) + \\ & (\sum_i \sum_j \sum_k \dots \sum_m (a_{ij} a_{ji}) (a_{ki} a_{im} a_{mk} + \\ & a_{im} a_{jk} a_{ik}) R_j R_i \dots R_m + \\ & \sum_i \sum_j \sum_k \dots \sum_m (a_{ij} a_{jk} a_{ki} a_{im} a_{mi} + \\ & a_{ik} a_{im} a_{mi} a_{kj} a_{ji}) R_i R_j \dots R_m + \dots) \end{aligned} \quad (6.1)$$

The values of  $R_i$  are taken from the Rotated component matrix table which are based on the calculation using factor analysis. The relative importance the relative importance ( $a_{ij}$ ) between attributes can also be assigned a value between 0 and 1 on scale shown in Table 6.1 proposed by Adil Baykasoglu.

The values of  $a_{ji}$  are calculated using the following Eq.  $a_{ji} = 1 - a_{ij}$ .

The following text explains the the relative importance of the attributes with one other.

Two	attributes	are	equally	important				
0.5	0.5							
One	attribute	is	slightly	more	important	over	the	other
0.6	0.4							
One	attribute	is	strongly	more	important	over	the	other
0.7	0.3							
One	attribute	is	very	strongly	important	over	the	other
0.8	0.2							
One	attribute	is	extremely	important	over	the	other	
0.9	0.1							
One	attribute	is	exceptionally	more	important	over	the	other
1.0	0.0							

**Application of GTMA**

Step 1: To identify the factors involved in the Retail Supply Chain.

Following are the factors that were identified in the process from the literature review and the feedback from the people of the industry.

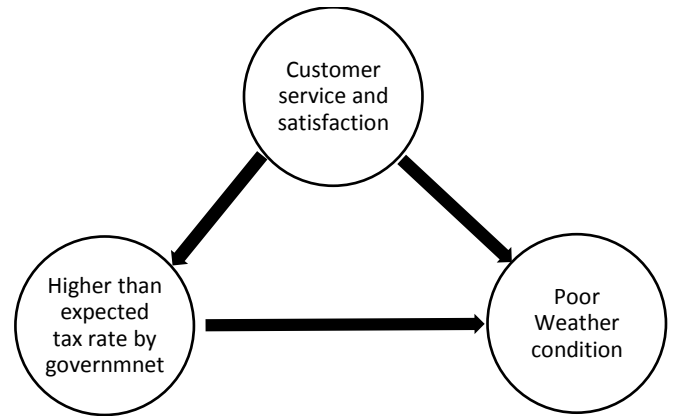
1. Higher than expected tax rates by governments
2. Economically challenged consumer base
3. Poor weather conditions
4. Out of stock problems due mismanagement in backrooms
5. Higher delivery costs of transportation of goods
6. Demand forecasting
7. Variable lead times for order
8. Government regulations and Political environment
9. Price fluctuations of raw materials on the supplier end
10. Warehouse capacity
11. Customer Loyalty
12. Training of an Employee
13. Planning tools like ERP, MRPM
14. Communication flow and Communication tools
15. Order Inflation Rise in no. of Orders
16. Globalization
17. Quality Control
18. Flexibility
19. Material Sourcing
20. Supply chain relationships
21. Innovation
22. Business Management Practices like Process Strategies Marketing
23. Late Deliveries
24. Incomplete Shipments
25. Customer Service and Satisfaction

Step 2: Identifying the latent factors and their interdependencies using factor analysis.

1. Quality to cost
2. Customer experience
3. Product acquisition
4. Market share
5. Planning Development
6. Flexibility
7. Supply consistency
8. Demand fulfilment
9. Economical and geographical scenario
10. Supply chain innovation

Step 3: Di-Graph Representation of the attribute as nodes and their relative importance as edges.

If a node i has relative importance over another node j, a directed edge is drawn from node i to node j. If a node j has relative importance over another node i, a directed edge is drawn from node j to node i..



Step 4: Matrix representation of selection criteria diagram to give one to one representation.

$$A = \begin{matrix} R_1 & a_{12} & a_{13} \\ a_{21} & R_2 & a_{23} \\ a_{31} & a_{32} & R_3 \end{matrix}$$

Step 5: Calculation of permanent of the matrix using the formula

$$\text{Per}(A) = \prod_{i=1}^3 R_i + \sum_{ijk} (a_{ij} * a_{ji}) R_k + \sum_{ijk} (a_{ij} * a_{jk} * a_{ki} + a_{ik} * a_{ij} * a_{ji})$$

Step 6: Decision making. The alternative with highest value of permanent function is the optimal combination of the process or system.

**4. CALCULATION OF GTMA**

To calculate the permanent of a matrix, the values of R\_1, R\_2 and R\_3 from Table 5.6. The values of a\_ij are taken from Table 6.1. The following matrix is taken for the factor market share,

$$A = \begin{vmatrix} 0.845 & 0.1 & 0 \\ 0.9 & 0.753 & 0 \\ 1 & 1 & 0.593 \end{vmatrix}$$

Using equation 6.2,

$$\text{Per}(A) = 0.845*0.753*0.593 + 0.1*0.9*0 + 0*1*0.845 + 0.753*0*1 + 0.1*0*1 + 0.593*0.9*1 = 0.430687$$

Similarly, calculating the permanent of other factors. The following table is obtained

Serial no.	Factor	Per(A)	Rank
1	Quality to cost	3.994	1
3	Product Acquisition	3.84593	2
2	Customer Experience	3.48652	3
5	Planning Development	1.645	4

6	Flexibility	0.922	5
7	Supply Consistency	0.751	6
8	Demand Fulfilment	0.71135	7
10	Supply Chain Innovation	0.6368	8
9	Economical and Geographical Scenario	0.489	9
4	Market Share	0.430687	10

## 5. RESULT

A study was done on retail supply chain management and subsequently factors affecting supply chain were identified. A questionnaire was formed and sent to the industry experts. This questionnaire was formed on the basis of a Likert scale (1-5 where 1 depicted the least effect of the factor on retail supply chain and 5 depicted the most effect of the factor on retail supply chain). The factors affecting a Retail Supply Chain were condensed using factor analysis on a SPSS statistics software which reduced the factors from 25 to 10. To test the internal consistency of the data, reliability analysis was done using the split half reliability technique. The split half reliability of these variables is depicted by the Cronbach alpha value whose value should be greater than 0.7 for the data to be acceptable. The Cronbach alpha value was 0.769 so the data is acceptable. The following latent factors were identified:

Quality to cost  
Customer experience  
Product acquisition  
Market share  
Planning Development  
Flexibility  
Supply consistency  
Demand fulfilment  
Economical and geographical scenario  
Supply chain innovation

Further in order to identify the relationship between these 10 factors and to rank these factors on the basis of their ability to affect a retail supply chain. Graph Theory Matrix approach methodology is applied on the 10 factors. Base on the value of the permanent 'P' obtained for each matrix associated with a factor, the ranking of factors is as follows:

1. Quality to cost  
2. Product Acquisition  
3. Customer Experience  
4. Planning Development  
5. Flexibility  
6. Supply Consistency  
7. Demand Fulfilment  
8. Supply chain innovation  
9. Economical and Geographical Scenario

## 10. Market Share

quality, and professional-looking. Following are two examples of an author's biography.

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