DEVELOPMENT OF SUPPLY CHAIN ASSESSMENT MODEL USING FAHP FOR AGRO IMPLEMENT MANUFACTURING INDUSTRIES

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Abstract

The purpose of this paper is to provide a good insight into the use of fuzzy Analytical Hierarchy Process (fuzzy AHP) approach that is a multi criteria decision making methodology in evaluating the benefits of information sharing decision problems. In this study, the integration of AHP with the fuzzy synthetic extent analysis method (fuzzy AHP) is proposed in evaluating the benefits of information sharing decision problems as a framework to guide managers. Findings demonstrate that the customer requirement and operational information alternatives are the preferred key decisions, which all supply chain partners might agree to share with one another. Further, it can also be concluded that the planning and financial information alternatives have almost the same importance.

Keywords: Fuzzy Analytic hierarchy process; Multi-criteria decision-making methods; Supply chain; Agro Manufacturing industries, Eigen Vector, Consistency Index, consistency Ratio. Expert Judgment Matrix

1. Introduction

Supply chain management is an important subject among researchers as many studies focus on the integration of the supply chain that consists of information and material flows [1].

An analytical way to reach the best decision is more preferable in many business platforms. When variables are quantitative and number of criteria is not high, then one can use several analysis tools and make his/her decision and solve the problem. However, many times beside the measurable variables, there exist qualitative variables, or people are supposed to prefer the best among the many choices, thus, an analytical way to make a successful decision is needed. Analytical Hierarchy Process (AHP) is one of the best ways for deciding among the complex criteria structure in different levels. Fuzzy AHP is a synthetic extension of classical AHP method when the fuzziness of the decision makers is considered. In this paper, the comparison of classical AHP and fuzzy AHP on a case study that is constructed for the same hierarchy structure and criteria set.The analytic hierarchy process (AHP) is a structured technique for organizing and analyzing complex decisions, based on mathematics and psychology. It was developed by Thomas L. Saaty in the 1970s and has been extensively studied and refined since then. It has particular application in group decision making and is used around the world in a wide variety of decision situations in fields such as government, business, industry, healthcare, shipbuilding and education. Fuzzy Analytic Hierarchy Process (FAHP) proves to be a very useful methodology for multiple criteria decision-making in fuzzy environments, which has found substantial applications in recent years. Supplier selection is one of the most important functions of a purchasing department. Since by deciding the best supplier, companies can save material costs and increase competitive advantage. However this decision becomes complicated in case of multiple suppliers, multiple conflicting criteria, and imprecise parameters.

In addition the uncertainty and vagueness of the experts' opinion is the prominent characteristic of the problem. Therefore an extensively used multi criteria decision making tool Fuzzy AHP can be utilized as an approach for supplier selection problem. Fuzzy analytic hierarchy process (FAHP) proves to be a very useful methodology for multiple criteria decision-making in fuzzy environments, which has found substantial applications in recent years. The vast

majority of the applications use a crisp point estimate method such as the extent analysis or the fuzzy preference programming (FPP) based nonlinear method for fuzzy AHP priority derivation.

2. Supply Chain Model

More than one criterion is usually needed to reach a decision, therefore making it more complex. Hence, it is important to decompose the problem and to explicitly assess relevant criteria before come out for a decision. Many methods have been developed to solve problems, and, common too many of them is the idea that most decision-making can be improved by breaking down the general evaluation of alternatives into evaluations on a number of relevant criteria. The methods differ on how they assess each criterion and on how they combine the evaluation of criteria to achieve a general evaluation.

We have given visits to more than 50 agro manufacturing industries in vidarbh region and outside region also. Out of 50 participants, 40 were given active feedback to our questionnaires and 10 were responded little bit. Collected data samples include 7 major factors and 34 sub factors. Factures are chosen by proper expert opinion and their experience in agro manufacturing sectors. Below is a list of factors and sub factors that are considered for data analysis.

Hierarchical structure of data factors and its sub factor are as follows

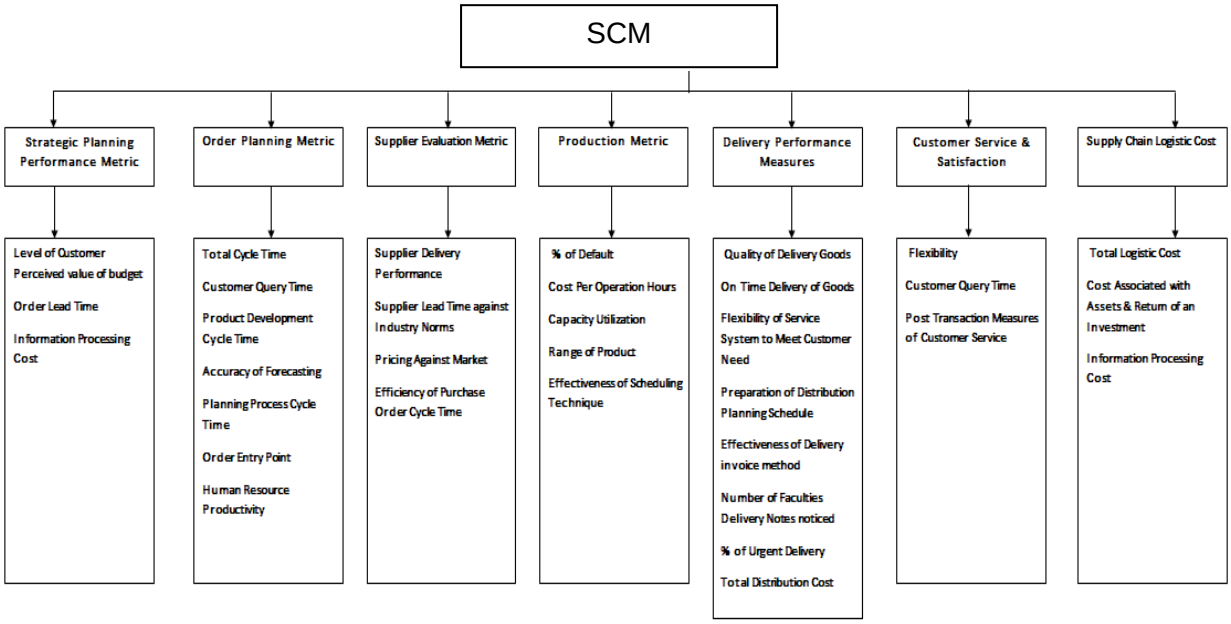


Fig 2.1: Proposed SCM Model

3. Methodology

Data Analysis is a step where all collected sample data are examined and from it, a decision has to be taken. We proposed Fuzzy analytical hierarchical process model for data analysis. FAHP model is a decision support model that gives a significance of factors in supply chain management process. Higher the value of factor more is a significance of factors/sub factors.

4. FAHP

From score factors, an expert judgment matrix has been calculated for all factors and sub factors. We were collected data from Agro Manufacturing Industries with based on 5 different experts opinions. Eigen vectors matrix created for major factors is as below

	SPPM	OPM	SEM	PM	DPM	CSS	SCLC	Total	AVG	r	w	M	N
SPPM	1.000	5.000	0.110	0.110	7.000	3.000	5.000	20.220	3.031	1.537	16.213	2.316	0.156
OPM	0.200	1.000	1.000	7.000	1.000	1.000	1.000	12.000	1.743	1.426	15.049	2.150	0.145
SEM	7.000	1.000	1.000	5.000	1.000	3.000	1.000	12.000	2.714	1.426	15.049	2.150	0.145
PM	5.000	0.143	0.200	1.000	5.000	7.000	5.000	18.343	3.335	1.515	15.989	2.284	0.154
DPM	0.143	1.000	1.000	0.200	1.000	3.000	1.000	7.200	1.049	1.326	13.990	1.999	0.135
CSS	0.333	1.000	0.333	0.143	3.000	1.000	3.000	8.476	1.259	1.357	14.320	2.046	0.138
SCLC	0.200	1.000	1.000	0.200	1.000	0.333	1.000	4.533	0.676	1.241	13.095	1.871	0.126

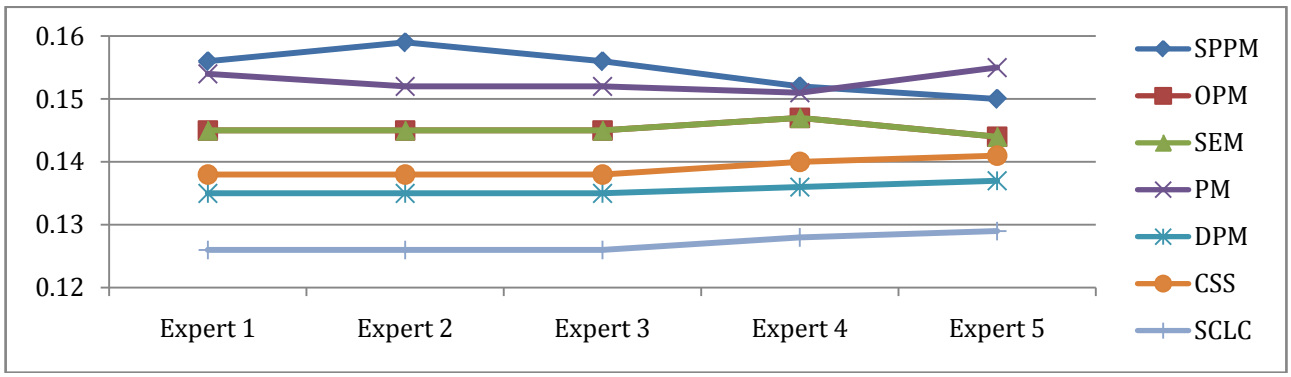
Table 1. FAHP model calculation for overall major factors

Where
r = Geometric mean of fuzzy comparison = =POWER(average(i),1/(Total Factors))
w = Weight = =r/(Power(Multiply[Average],-1)
M = Non fuzzy number = =w(i)/Total Factors
N = Scores = =M(i)/∑M
i = index = 1,2,3…n

Value N is directly proportional to importance of factor in supply chain management. Sum of judgment matrix specifies an impact of factors over others factors considered in performance measurement. Likewise an opinion from 5 different expert were collected of their Eigen Values are listed

Fuzzy AHP (Major Factors)

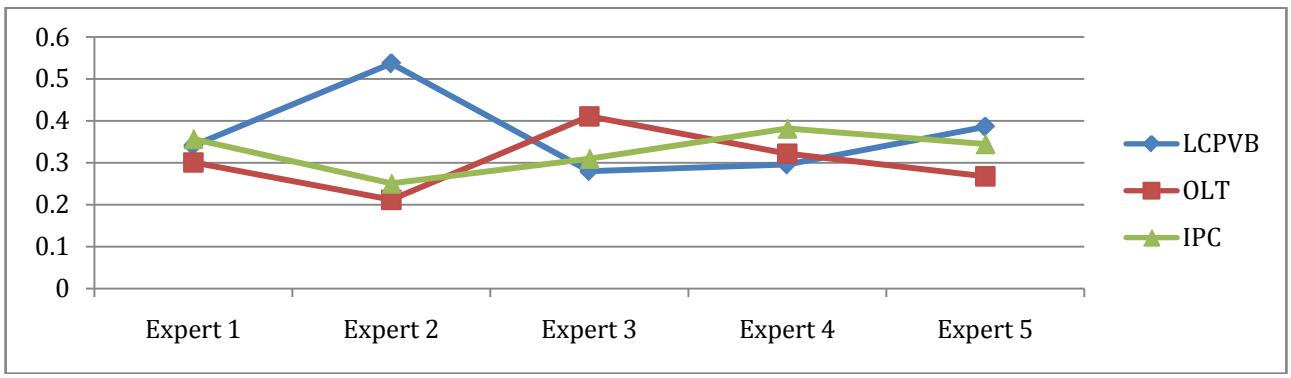
Factors	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Average
SPP	0.156	0.159	0.156	0.152	0.150	0.155
OPM	0.145	0.145	0.145	0.147	0.144	0.145
SEM	0.145	0.145	0.145	0.147	0.144	0.145
PM	0.154	0.152	0.152	0.151	0.155	0.153
DPM	0.135	0.135	0.135	0.136	0.137	0.136
CSS	0.138	0.138	0.138	0.140	0.141	0.139
SCLC	0.126	0.126	0.126	0.128	0.129	0.127



Graph 4.1: Major FAHP Factors

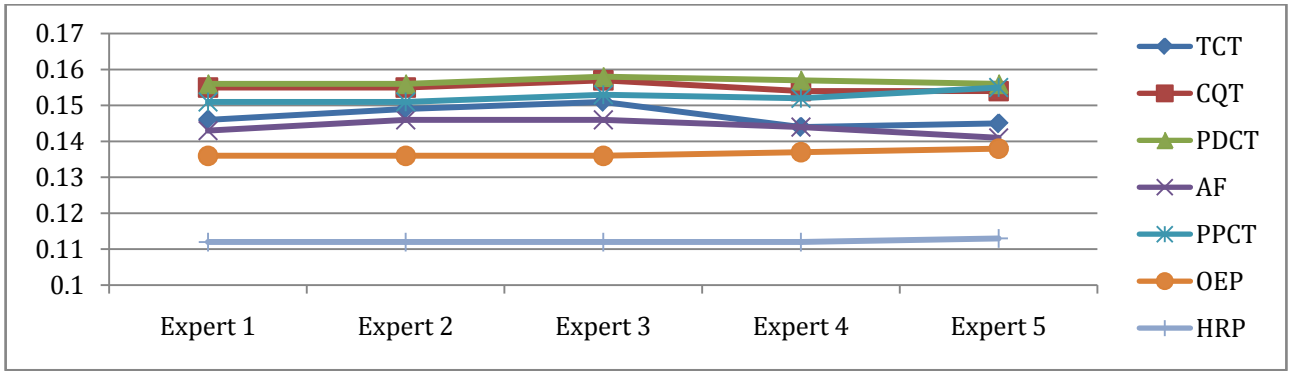
FAHP calculations for Strategic Planning Performance Metric

Sub Factors	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Average
LCPVB	0.341	0.537	0.280	0.296	0.386	0.368
OLT	0.301	0.212	0.411	0.322	0.268	0.303
IPC	0.357	0.251	0.310	0.382	0.345	0.329



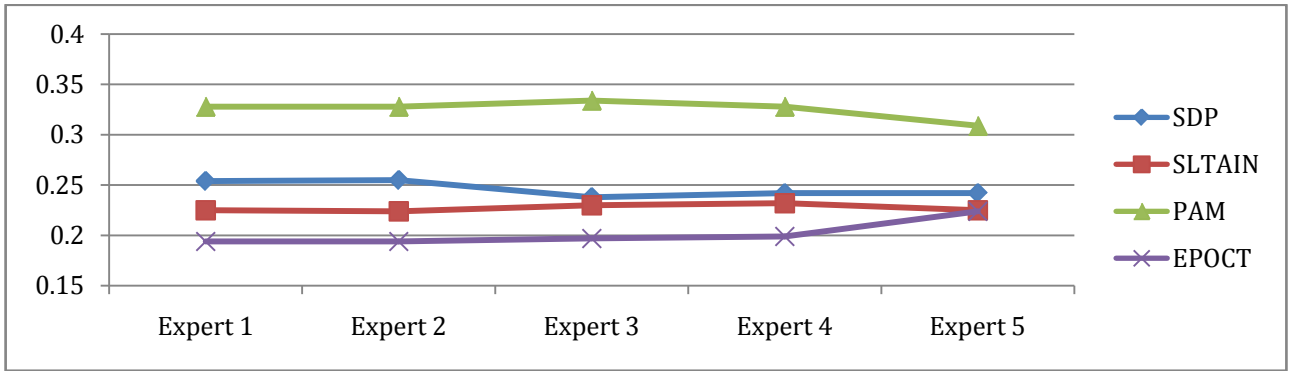
Graph 4.2 Strategic Planning Performance Metric

FAHP calculations for Order Planning Metric						
Sub Factors	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Average
TCT	0.146	0.149	0.151	0.144	0.145	0.147
CQT	0.155	0.155	0.157	0.154	0.154	0.155
PDCT	0.156	0.156	0.158	0.157	0.156	0.157
AF	0.143	0.146	0.146	0.144	0.141	0.144
PPCT	0.151	0.151	0.153	0.152	0.155	0.153
OEP	0.136	0.136	0.136	0.137	0.138	0.136
HRP	0.112	0.112	0.112	0.112	0.113	0.112



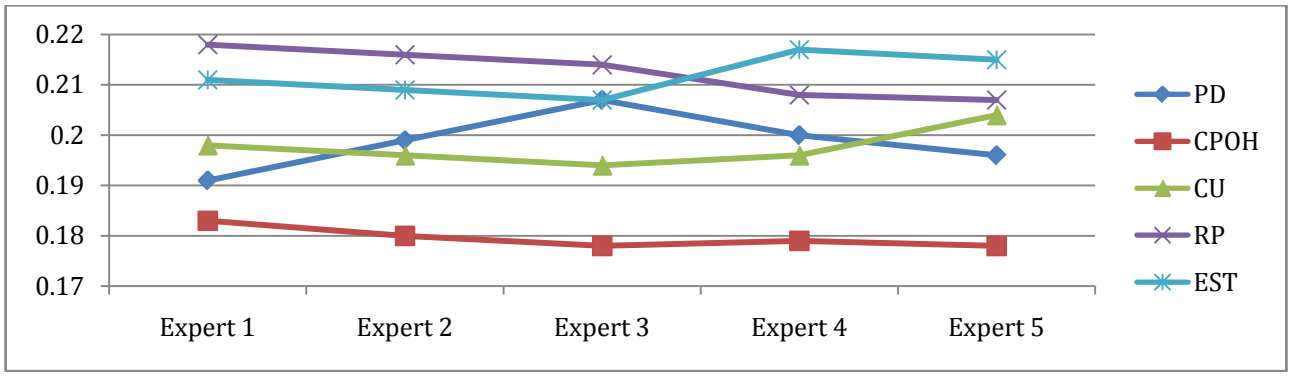
Graph 4.3 Order Planning Matric

FAHP calculations for Supplier Evaluation Metric						
Sub Factors	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Average
SDP	0.254	0.255	0.238	0.242	0.242	0.246
SLTAIN	0.225	0.224	0.230	0.232	0.225	0.227
PAM	0.328	0.328	0.334	0.328	0.309	0.325
EPOCT	0.194	0.194	0.197	0.199	0.224	0.202



Graph 4.4 Supplier Evaluation Metric

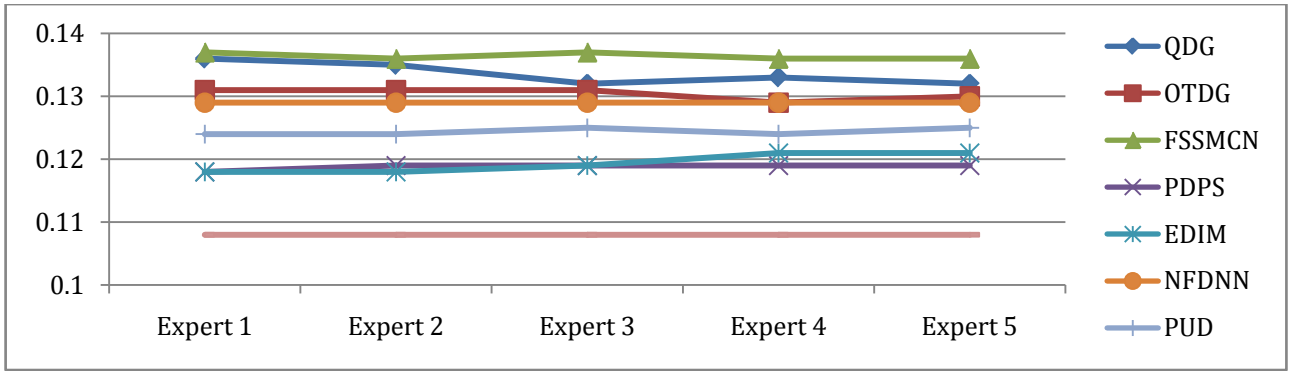
FAHP calculations for Production Metric						
Sub Factors	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Average
PD	0.191	0.199	0.207	0.200	0.196	0.199
CPOH	0.183	0.180	0.178	0.179	0.178	0.179
CU	0.198	0.196	0.194	0.196	0.204	0.198
RP	0.218	0.216	0.214	0.208	0.207	0.213
EST	0.211	0.209	0.207	0.217	0.215	0.212



Graph 4.5 Production Metric

FAHP calculations for Delivery Performance Measures

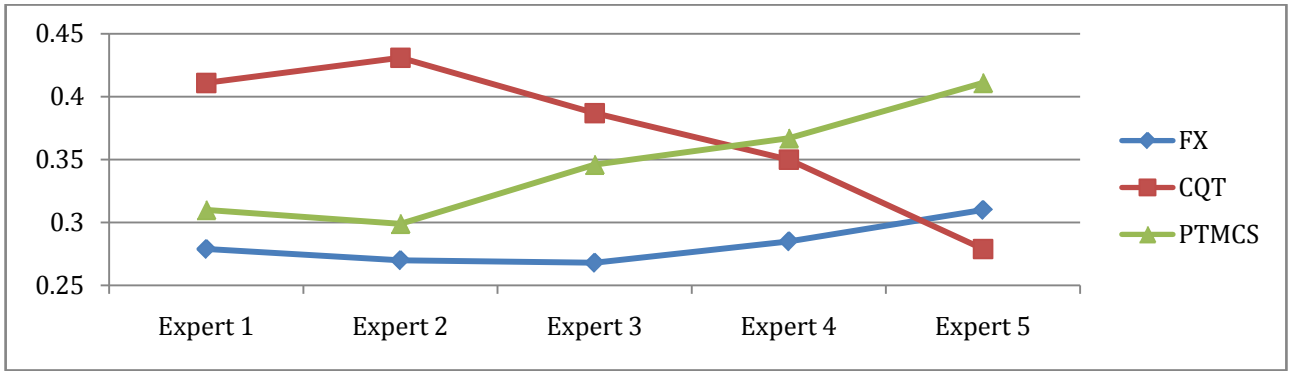
Sub Factors	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Average
QDG	0.136	0.135	0.132	0.133	0.132	0.134
OTDG	0.131	0.131	0.131	0.129	0.130	0.130
FSSMCN	0.137	0.136	0.137	0.136	0.136	0.137
PDPS	0.118	0.119	0.119	0.119	0.119	0.119
EDIM	0.118	0.118	0.119	0.121	0.121	0.119
NFDNN	0.129	0.129	0.129	0.129	0.129	0.129
PUD	0.124	0.124	0.125	0.124	0.125	0.124
TDC	0.108	0.108	0.108	0.108	0.108	0.108



Graph 4.6 Delivery Performance Measures

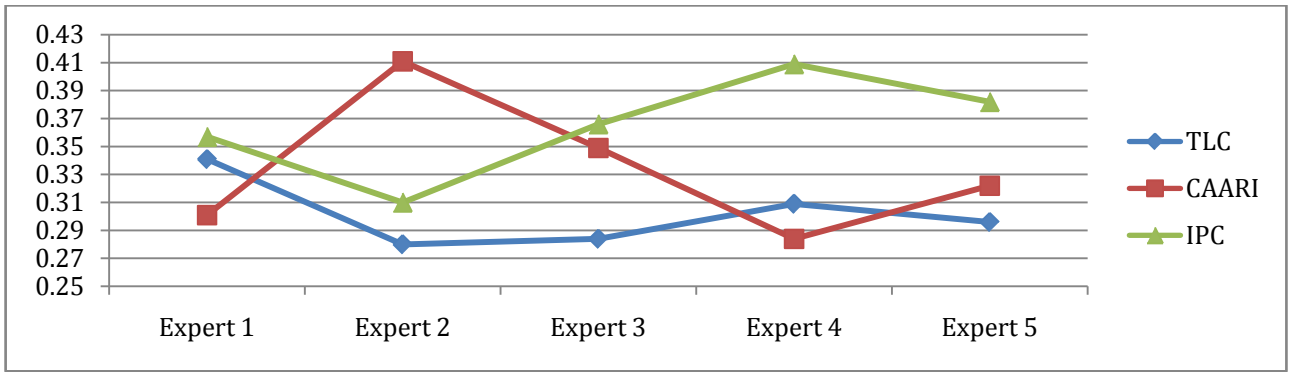
FAHP calculations for Customer Service & Satisfaction

Sub Factors	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Average
FX	0.279	0.270	0.268	0.285	0.310	0.282
CQT	0.411	0.431	0.387	0.350	0.279	0.372
PTMCS	0.310	0.299	0.346	0.367	0.411	0.347



Graph 4.7Customer Service & Satisfaction

FAHP calculations for Supply Chain Logistic Cost						
Sub Factors	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Average
TLC	0.341	0.280	0.284	0.309	0.296	0.302
CAARI	0.301	0.411	0.349	0.284	0.322	0.333
IPC	0.357	0.310	0.366	0.409	0.382	0.365



Graph 4.8 Supply Chain Logistic Cost

From above graphs in section 4, One can Conclude that, all experts have their views similar to each other for factors& sub factor. Strategic Planning Performance Metric has highest significance and Supply Chain Logistic Cost have lowest significance in supply chain management process. This shows that , there is need to enhance attention for factors like SCLC, CSS DPM etc

1. FAHP Model

Factors	Weight	Sub- Factors	Weight
Strategic Planning Performance (SPP)	0.155	LCP	0.368
		OLT	0.303
		IPC	0.329
Order Planning Metric (OPM)	0.145	TCT	0.147
		CQT	0.155
		PDC	0.157
		AF	0.144
		PPC	0.153
		OEP	0.136
		HRP	0.112
Supplier Evaluation Metric (SEM)	0.145	SDP	0.246
		SLT	0.227
		PAM	0.325
		EPO	0.202
Production Metric (PM)	0.153	PD	0.199
		COH	0.179
		CU	0.198
		RP	0.213
		EST	0.212
Delivery Performance Measures (DPM)	0.136	QDG	0.134
		OTDG	0.130
		FSS	0.137
		PDPS	0.119
		EDIM	0.119
		NFD	0.129
		PUD	0.124
		TDC	0.108
Customer Service & Satisfaction (CSS)	0.139	FX	0.282
		CQT	0.372
		PTM	0.347
Supply Chain Logistic Cost (SCLC)	0.127	TLC	0.302
		CAA	0.333
		IPC	0.365

7. Observation

Observations are analytical conclusion made by researcher based on analysis. From above analysis, we can have a below observation

Factors like Strategic Planning Performance Metric, Order Planning Metric etc are strong in supply chain management process.

Data Collection and Analysis process done with properly identified factors/sub factors.

Very Few factors like logistic SCLC & DPM etc have low significance value values. There is a great scope of improvement in these factors.

All Experts have their views closer to each other's.

Data Collected from 50 industries and 5 experts opinions are good enough to have a decision making process.

Values predicted by FAHP model are closer to expert opinion values. That's why FAHP model can be validated and considered as ideal model for data prediction and analysis.

8. Conclusion

Validation of any data is dependent on model chosen for analysis. Applied Fuzzy Analytical Hierarchical model is good enough to put a conclusion for Agro manufacturing industries future. Experts decision should be enhance to more so that other factors will also be considered for evaluation. Further study will compare this applied AHP model with Fussy AHP

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APPENDIX

1. STRATEGIC PLANNING PERFORMANCE METRIC

SN	Parameter	Meaning
1	**Level of Customer Perceived value of budget**	**Perceived value pricing is that value which customers are willing to pay for a particular product or service based on their perception about the product.**
2	**Order Lead time**	**A lead time is the latency between the initiation and execution of a process.**
3	**Information Processing Cost**	**Information processing cost refers to the cost of manipulation of digitized information by computers and other digital electronic equipment.**
4	**Total Cycle Time**	**The period required to complete one cycle of an operation; or to complete a function, job, or task from start to finish. Cycle time is used in differentiating total duration of a process from its run time.**

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2. ORDER PLANNING METRIC

SN	Parameter	Meaning
1	Customer Query Time	Customer query time refers to a time for a firm to respond to customer enquiry with required information.
2	Product Development Cycle Time	the various stages that a new or improved product or service goes through from design, through developing, testing, and marketing it
3	Accuracy of Forecasting	Calculating the accuracy of supply chain forecasts. Forecast accuracy in the supply chain is typically measured using the Mean Absolute Percent Error or MAPE. Statistically MAPE is defined as the average of percentage errors.
4	Planning Barrier Cycle Time	A fence or other obstacle that prevents movement or access
5	Order Entry Method	Order entry method, sometimes referred to as computerized provider order entry or computerized provider order management, is a process of electronic entry of product.
6	Human Resource Productivity	Human Resource Productivity is an assessment of the efficiency of a worker or group of workers. ... Typically, the productivity of a given worker will be assessed relative to an average for employees doing similar work.

3. SUPPLIER EVALUATION METRIC

SN	Parameter	Meaning
1	Supplier Delivery Performance	Supplier Delivery Performance (SDP) is a broadly used standard key performance indicator measurement in supply chains to measure the fulfillment of a customers demand to the wish date.
2	Supplier Lead Time against Industry Norms	A lead time is the latency between the initiation and execution of a process.
3	Pricing against Market	In economics, market price is the economic price for which a good or service is offered in the marketplace. It is of interest mainly in the study of microeconomics. Market value and market price are equal only under conditions of market efficiency, equilibrium, and rational expectations.
4	Efficiency of Purchase order Cycle Time	Purchase order Cycle time can have a significant impact on a industry's bottom line. It is a key component of delivery cycle time, along with the time it takes to make the product and the time it takes to deliver the product.

4. PRODUCTION METRIC

SN	Parameter	Meaning
1	% of Defaults	Failure to appear at the required time in a legal proceeding
2	Cost of Operation Hours	Operating cost. Operating (Operational) costs are the expenses which are related to the operation of a business, or to the operation of a device, component, and piece of equipment or facility. They are the cost of resources used by an organization just to maintain its existence.
3	Capacity Utilization	Capacity utilization is a measure of the extent to which the productive capacity of a business is being used. It can be defined as: The percentage of total capacity that is actually being achieved in a given period.
4	Range of Products & Services	A set of variations of the same product platform that appeal to different market segments.
5	Effectiveness of Scheduling Techniques	Scheduling is the art of planning your activities so that you can achieve your goals and priorities in the time you have available.

5. DELIVERY PERFORMANCE MEASURES

SN	Parameter	Meaning
1	Quality of Delivery Goods	An assessment of how well a delivered service conforms to the client's expectations. Service business operators often assess the service quality provided to their customers in order to improve their service, to quickly identify problems, and to better assess client satisfaction.
2	On Time Delivery of Goods	On-time delivery (OTD) is one of contract manufacturing's most common measurements
3	Flexibility of Service System to Meet customer Need	The ability to move the products within a manufacturing facility.
4	Effectiveness of Distribution Planning Schedule	Distribution resource planning (DRP) is a method used in business administration for planning orders within a supply chain. DRP enables the user to set certain inventory control parameters and calculate the time-phased inventory requirements.

5	Effectiveness of Delivery invoice method	An invoice, bill or tab is a commercial document issued by a seller to a buyer, relating to a sale transaction and indicating the products, quantities, and agreed prices for products or services the seller had provided the buyer.
6	Numbers of Faultiness delivery notes noticed	The inaccuracy associated with a given product system resulting in a dispersion.
7	% of Urgent deliveries	Requiring or compelling speedy action or attention
8	Information richness in carrying out delivery	Media Richness Theory, sometimes referred to as information richness theory or MRT, is a framework used to describe a communication medium's ability to reproduce the information sent over it.
9	Total Distribution Cost	Cost incurred by a producer incident to activities connected with placing a finished product in the hands of a customer

6. CUSTOMER SERVICE & SATISFACTION

SN	Parameter	Meaning
1	Flexibility	The ability to be easily modified.
2	Customers Query Time	Customer query time refers to a time for a firm to respond to customer enquiry with required information.
3	Post Transaction Measures of Customer Service	Post-transaction marketing is a deceptive marketing practice used by many companies, which have then been subject to investigation, charges from state attorneys general, and class action lawsuits.

7. SUPPLY CHAIN & LOGISTIC COST

SN	Parameter	Meaning
1	Total Logistic Cost	Total Logistics Costs Tradeoff Total logistics costs consider the whole range of costs associated with logistics, which includes transport and warehousing costs, but also inventory carrying, administration and order processing costs.
2	Cost Associated with assets & return of innovation	The original cost of an asset takes into consideration all of the costs that can be attributed to its purchase and to putting the asset to use. These costs can include such factors as the purchase price, commissions, transportation, appraisals, warranties and installation
3	Information Cost	Information costs. Transactions costs that include the assessment of the investment merits of a financial asset.

All these prominent agro manufacturing industries are belong to vidharbh region, Maharashtra. While mapping each factor and its sub factors, rating given based an expert views

1 – Not at all important

2 – Slightly Important

3 - Important

4 – Very Important

5 – Most Important

0 - No Opinion