Design a Mathematical Model for Performance Evaluation of Cluster of Manufacturing Plant

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Abstract—A leading cluster manufacturing plant consists of 11 sub apparel plants which are functioning at different levels due to several factors such as location of the plant, product type, customer type, no of workers etc. Annually performance comparison has been carried out among all 11 plants to select the best performed plant. However, some plants have been evaluated unfair as the method used by the company doesn't take all different factors into account. This study has selected some important parameters which directly influence to company performance and the ranking of the company is done by using AHP and DEA

Keywords—component; formatting; style; styling; insert (key words**)**

I. INTRODUCTION (*HEADING 1*)

Most of the large scale apparel industries are operating in many branches under a main arm. The selected company has 11 plants located at different areas. Those plants are characterized differently due to customers, styles, plant locations etc. Currently, they compare those plants' SMV (sewing machine value), average order quantity, product wise, lead time, and embellishment only considering the budget. This comparing methodology is not fair enough because there are significant differences among those plants. Previously, some methodologies were introduced for the above comparison but they were not fit to the requirement. This problem is a burning issue for the .company with respect of the efficiency as well as the profit of the company.
When we consider the meaning, Performance refers to output results and their outcomes obtained from processes, products, and services that permit evaluation and comparison relative to goals, standards, past results, and other organizations. Performance can be expressed in non-financial and financial terms. For measure the performance refers to numerical information that quantifies input, output, and performance dimensions of processes, products, services, and the overall organization (outcomes). Performance measures might be simple (derived from one measurement) or composite.

In below chart we categorized these factors according to product basis, process basis and service basis. To these factors affect for performance of plants are described below. Some of above factors are linking each other. Then we can represent both factors idea with one factor. Lots of facts which lead for this kind of problem could be found from a research that was done on this issue. Some manufacturing plants manufacture products that have only one customer. If we treat without any specialization for the plants which do productions for one customer, the methodology will not be fair because those kinds of companies also have to follow several different product styles for different types of products. In the other aspect, some plants have more than one customer and those kinds of plants are used for those special customer's products. .It is obvious that all plants cannot be treated similarly in account of creating a methodology for measuring efficiency.
With the product wise aspect, some products want embellishment and some product's SMV is long. Customer lead time is being reduced. In order to deliver the product in Time Company has to divide the bulk order among other manufacturing plants. As those manufacturing plants which are not initially ready status to drive this manufacturing process, and due to deviation from dedicated product which they were used for, the plant's efficiency is reduced. This unexpected change issue is also a major fact.
In the aspect of efficiency, there are two efficiency ladders for each plant. One is for new products and another for repeat product. When the plant received a previous order again, that order is considered as a repeat order. Entirely new orders are considered as new orders. The numbers of steps for repeat orders are less than comparing with that for new orders. Although the order which is assigned to the plant is a repeat order, the plant would have driving another product. In this scenario the plant cannot take the advantage of the category of repeat product as they are involving with different one. Then it will be forwarded to anther plant which has not drive the same product before. Although the numbers of steps are minimize considering against a new product the order will be considered as new efficiency ladder in this kind of situation. Company uses trial and error method to calculate this efficiency ladder. This method is not a reliable method to calculate the Efficiency.
SMV also affects for the efficiency. SMV takes account only the sewing time .SMV factor depends on the condition of the machines used. All machines don't have similar conditions. As examples, some machines are in new condition and some are in old condition .In the aspect of the easiness, easiness to operate. . Material of the product also impacts for the SMV because some materials are easy to occupy than others

according to the material type and material size. There are two types of shifts there in the process of managing the company called single shift and double shift. Two different groups of workers contribute for double shift but only one group work for single shift. That matters for preparing learning curves individually.

Among these factors we select most important factors for their performance evaluation. They are

- Total order quantity
- Number of embellishments
- Number of styles
- Standard hours
- SMV (Standard Minute Value)
- KPIs (Key Performance indicator)
  - Average of actual efficiency

About these factors and how they affect for plants performance are described below.

II. Decision parameters

A. Order Quantity

Order quantity means number of orders which received to plants. When we calculate the efficiency for one product of one plant, we use efficiency ladder which is unique for plants. Efficiency ladder is an index which shows the efficiency growth for the process in a plant which increase gradually and reaches to stable efficiency level. If the order quantity is small the plants complete producing them within short time period (two or three days). According to the efficiency ladder the average efficient is low as the efficiency is not able to reachits heist value within that short period. If we look at a plant which has large order quantity, the plant can reach the highest performance because the process time is large. Then the average efficiency takes a large value.

Order quantity α plant efficiency

B. Number of styles

Some plants have one customer and some of them have more than one customer. One customer request more than one styles sometimes. Then the product variations within the plants are very complex. They have to pay more effort for several styles than one style. It decreases plan's performance. When number of styles is increase the average order quantity also decrease

Number of Styles α 1/ plant performance

C. SMV

This stands for Standard Minute Value. This is the utilized for produce one product completely. SMV is depend in the products. When the SMV is large that indicates that product has complicated process. When we increase the SMV the efficiency also increases.

SMV α plant performance

We can clearly see the variations among these factors by below graphs. It shows parameter contribution to each plant. By it we can get clear idea about difference of plant performance measurement factors importance.

Our aim is create a mathematical model for comparing these factories fairly and simultaneously. The main requirement for our solution is give numerical value which depend on each different factors considering for each plant. It should be simple, understandable and easy to use for comparing. For find a suitable method we try apply several models and data analysis methods for this problem. They are described below chapters. The first step of the project, Select suitable performance parameters are described by this chapter. Other using methods, their procedures, uses, advantages, limitations and etc are explained by other chapters. For get a fair enough solution we have to apply these data to several mathematical models like ANOVA/MANOVA, Z value calculation method, weighted function method, AHP and DEA. Among them using Analytical Hierarchy Process (AHP) and Data Envelopment Analysis (DEA) we could be get a reasonable solutions. By solving this problem they can get a good comparison between plants and rank them fairly.

III. Methodology

AHP is developed by Thomas L. Satty in 1970.This is a multi criteria mathematical structure used for organizing and analyzing complex decisions. By this method we can priorities among criteria's and alternatives. This is not a method for find the good solution it is help to find a best decision among them.AHP can apply for various fields as government, business industry, health care, education, manufacturing etc and can apply to both qualitative and quantities data. By this method we can get only numerical representation. It is best for do our project data analysis. When apply this method we separate the problem into sub parts. By it we can construct a hierarchy. Pair wise comparison is being done here. When we do this comparison we should ask 2 questions to get a value. They are

- Which is more important with respect to the criterion?
- How strongly is important?

Because of we pair wisely comparing all data finally we can obtain an overall weight for goal

IV. Results

In this title we describe the steps with our project.

1. State the objective- Ranking the 11 manufacturing plants with considering their different p-parameters.
2. Define the criteria- These are the selected factors. For our project we select below criteria
   - Number of styles
   - Total order quantity
   - SMV

This calculation for 11 month period (2012 January-November) and done with **MS EXCEL**.

Table1: Raw Data of 2012(January-November)

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plant	no of styles	average smv	Total order qty *1000
A	3446	12.76	2431.015
B	4099	12.76	3391.425
C	6141	12.76	5033.548
D	1589	22.85	2916.167
E	2148	21.82	4607.727
F	6295	12.76	6059.888
G	3683	10.59	4775.172
H	6163	12.76	1853.118
I	2421	12.76	2397.141
J	112	5.8	71.172

3.State the Alternatives -11 plants .We named them as A,B,C,D,E,F,G,H,I,J.

4. Make the hierarchy

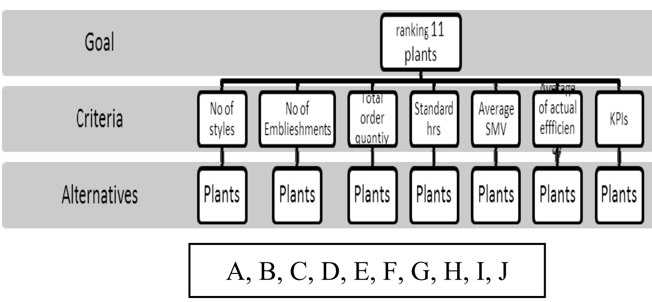

Fig1: Hierarchy of our data analysis

5. Develop the pair wise comparison matrix. For this we use a standard scale. It is

Table2: AHP pair wise comparison scale

Scale	Degree of Preference
1	Equal important
2	Between 1and 3 in scale
3	Moderate important
5	Strong important
7	Very strong important
9	Extreme important

If we give this scale values to our data we should make that data first. For this first we done below calculation

NUMBER OF STYLES

plant	no of styles	A	B	C	D	E	F	G	H	I	J
A	3446	1	1.19	1.78	0.46	0.62	1.83	1.07	1.79	0.70	0.03
B	4099	0.84	1.00	1.50	0.39	0.52	1.54	0.90	1.50	0.59	0.03
C	6141	0.56	0.67	1.00	0.26	0.35	1.03	0.60	1.00	0.39	0.02
D	1589	2.17	2.58	3.86	1.00	1.35	3.96	2.32	3.88	1.52	0.07
E	2148	1.60	1.91	2.86	0.74	1.00	2.93	1.71	2.87	1.13	0.05
F	6295	0.55	0.65	0.98	0.25	0.34	1.00	0.59	0.98	0.38	0.02
G	3683	0.94	1.11	1.67	0.43	0.58	1.71	1.00	1.67	0.66	0.03
H	6163	0.56	0.67	1.00	0.26	0.35	1.02	0.60	1.00	0.39	0.02
I	2421	1.42	1.69	2.54	0.66	0.89	2.60	1.52	2.55	1.00	0.05
J	112	30.77	36.60	54.83	14.19	19.18	56.21	32.88	55.03	21.62	1.00

Fig2: matrix construct from raw data

e.g.:- C3=B3/B3

C4=B4/B3

D3=B3/B4

Likewise we construct this matrix (fig2.10).Then we select a range foe give above AHP scale (1-9).It can be obtain by ranging them using maximum Values. For this

Table3: range values for no of styles pair wise matrix construct

RANGE	pair wise comparison value
1	1
(1.01-1.80)	2
(1.81-2.26)	3
(2.27-3.35)	5
(3.36-4.44)	7
(4.45<)	9

Likewise for construct all pair wise matrix we want crate ranges for scale values considering their maximum values.

Then we construct the pair wise comparison matrix and fill the upper triangular of it. It is shown below.

plant		A	B	C	D	E	F	G	H	I	J
A	A	1	2	2	(1/3)	(1/2)	3	2	2	(1/2)	(1/9)
B	B		1	2	(1/5)	(1/3)	2	(1/2)	2	(1/2)	(1/9)
C	C			1	(1/7)	(1/5)	2	(1/2)	1	(1/5)	(1/9)
D	D				1	2	7	5	7	2	(1/9)
E	E					1	5	2	5	2	(1/9)
F	F						1	(1/2)	(1/2)	(1/3)	(1/9)
G	G							1	2	(1/2)	(1/9)
H	H								1	(1/5)	(1/9)
I	I									1	(1/9)
J	J										1

Fig 3: Pair wise matrix for no of styles-upper triangular filled

NUMBER OF STYLES

plant	A	B	C	D	E	F	G	H	I	J
A	1	2	2	0.33333	0.5	3	2	2	0.5	0.11111
B	0.5	1	2	0.2	0.333333333	2	0.5	2	0.5	0.11111
C	0.5	0.5	1	0.14286	0.2	2	0.5	1	0.2	0.11111
D	3	5	7	1	2	7	5	7	2	0.11111
E	2	3	5	0.5	1	5	2	5	2	0.11111
F	0.333333	0.5	0.5	0.14286	0.2	1	0.5	0.5	0.33333	0.11111
G	0.5	2	2	0.2	0.5	2	1	2	0.5	0.11111
H	0.5	0.5	1	0.14286	0.2	2	0.5	1	0.2	0.11111
I	2	2	5	0.5	0.5	3	2	5	1	0.11111
J	9	9	9	9	9	9	9	9	9	1
	19.33333	25.5	34.5	12.1619	14.43333333	36	23	34.5	16.2333	2

Fig 4: Pair wise matrix for no of style

Lower triangular is fill by inverse of corresponding raw.

e.g. C16=1/D15

C17=1/E15

After filling lower triangular also we can get below matrix(figure 4).Using above procedure we should create pair wise comparison matrix for all criteria. They are shown below.

AVERAGE SMV

plant	A	B	C	D	E	F	G	H	I	J
A	1	1	1	3	3	1	0.5	1	1	0.33333
B	1	1	1	3	3	1	0.5	1	1	0.33333
C	1	1	1	3	3	1	0.5	1	1	0.33333
D	0.333333	0.333333	0.33333	1	0.5	0.33333333	0.3333333	0.33333	0.33333	0.11111
E	0.333333	0.333333	0.33333	2	1	0.33333333	0.3333333	0.33333	0.33333	0.11111
F	1	1	1	3	3	1	0.5	1	1	0.33333
G	2	2	2	3	3	2	1	2	2	0.33333
H	1	1	1	3	3	1	0.5	1	1	0.33333
I	1	1	1	3	3	1	0.5	1	1	0.33333
J	3	3	3	9	9	3	3	3	3	1
	11.66667	11.66667	11.6667	33	31.5	11.6666667	7.6666667	11.6667	11.6667	3.55556

Fig 4: Pair wise matrix for average SMV

TOTAL STANDARD HOURS

plant	A	B	C	D	E	F	G	H	I	J
A	1	3	3	0.33333	2	5	3	0.33333	0.33333	0.11111
B	0.333333	1	2	0.2	0.333333333	3	0.3333333	0.14286	0.33333	0.11111
C	0.333333	0.5	1	0.2	0.333333333	3	0.3333333	0.14286	0.2	0.11111
D	3	5	5	1	3	7	3	0.33333	3	0.11111
E	0.5	3	3	0.33333	1	5	2	0.2	0.33333	0.11111
F	0.2	0.333333	0.33333	0.14286	0.2	1	0.3333333	0.11111	0.2	0.11111
G	0.333333	3	3	0.33333	0.5	3	1	0.2	0.33333	0.11111
H	3	7	7	3	5	9	5	1	3	0.11111
I	3	3	5	0.33333	3	5	3	0.33333	1	0.11111
J	9	9	9	9	9	9	9	9	9	1
	20.7	34.83333	38.3333	14.8762	24.36666667	50	27	11.7968	17.7333	2

Fig 5: Pair wise matrix for Total standard Hours

TOTAL ORDER QUANTITY

plant	A	B	C	D	E	F	G	H	I	J
A	1	2	5	2	3	5	3	0.5	0.5	0.11111
B	0.5	1	2	0.5	2	3	2	0.33333	0.5	0.11111
C	0.2	0.5	1	0.33333	0.5	2	0.5	0.14286	0.2	0.11111
D	0.5	2	3	1	3	5	3	0.33333	0.5	0.11111
E	0.333333	0.5	2	0.33333	1	2	2	0.2	0.33333	0.11111
F	0.2	0.333333	0.5	0.2	0.5	1	0.5	0.11111	0.14286	0.11111
G	0.333333	0.5	2	0.33333	0.5	2	1	0.14286	0.33333	0.11111
H	2	3	7	3	5	9	7	1	2	0.11111
I	2	2	5	2	3	7	3	0.5	1	0.11111
J	9	9	9	9	9	9	9	9	9	1
	16.06667	20.83333	36.5	18.7	27.5	45	31	12.2635	14.5095	2

Fig 6: Pair wise matrix for Total order quantity

AVERAGE OF ACTUAL EFFICIENCY

plant	A	B	C	D	E	F	G	H	I	J
A	1	2	2	2	0.5	2	0.5	2	2	0.14286
B	0.5	1	0.5	2	0.5	2	0.5	2	0.5	0.11111
C	0.5	2	1	2	0.5	2	0.5	2	0.5	0.14286
D	0.5	0.5	0.5	1	0.5	0.5	0.5	2	0.5	0.14286
E	2	2	2	2	1	2	0.5	2	2	0.2
F	0.5	0.5	0.5	2	0.5	1	0.1111111	2	0.5	0.11111
G	2	2	2	2	2	9	1	2	2	0.11111
H	0.5	0.5	0.5	0.5	0.5	0.5	0.5	1	0.5	0.11111
I	0.5	2	2	2	0.5	2	0.5	2	1	0.14286
J	7	9	7	7	5	9	9	9	7	1
	15	21.5	18	22.5	11.5	30	13.611111	26	16.5	2.21587

Fig 7: Pair wise matrix for Average of actual efficiency

6. Construct the pair wise comparison matrix between criteria
This is most important part. By his we give a weight to each criterion with respect to another. This matrix for our project is

	no of styles	avg smv	Total Std h	Total orde	Avg actual efficiency
no of style	1	7	3	5	2
avg smv	0.142857	1	2	3	5
Total Std h	0.333333	0.5	1	5	3
Total order	0.2	0.333333	0.2	1	2
Avg actual	0.5	0.2	0.33333	0.5	1
	2.176	9.033	6.533	14.500	13.000

Fig 8: Pair wise matrix between criteria

7. Normalized the matrix
Two steps have for obtained this matrix.

i. Get the sum value of each column of all pair wise comparison matrix.

NORMALIZED VALUES-Avg SMV

plant	A	B	C	D	E	F	G	H	I	J
A	0.08571	0.08571	0.08571	0.09091	0.0952381	0.08571429	0.0652174	0.08571	0.08571	0.09375
B	0.08571	0.08571	0.08571	0.09091	0.0952381	0.08571429	0.0652174	0.08571	0.08571	0.09375
C	0.08571	0.08571	0.08571	0.09091	0.0952381	0.08571429	0.0652174	0.08571	0.08571	0.09375
D	0.02857	0.02857	0.02857	0.0303	0.01587302	0.02857143	0.0434783	0.02857	0.02857	0.03125
E	0.02857	0.02857	0.02857	0.06061	0.03174603	0.02857143	0.0434783	0.02857	0.02857	0.03125
F	0.08571	0.08571	0.08571	0.09091	0.0952381	0.08571429	0.0652174	0.08571	0.08571	0.09375
G	0.17143	0.17143	0.17143	0.09091	0.0952381	0.17142857	0.1304348	0.17143	0.17143	0.09375
H	0.08571	0.08571	0.08571	0.09091	0.0952381	0.08571429	0.0652174	0.08571	0.08571	0.09375
I	0.08571	0.08571	0.08571	0.09091	0.0952381	0.08571429	0.0652174	0.08571	0.08571	0.09375
J	0.25714	0.25714	0.25714	0.27273	0.28571429	0.25714286	0.3913043	0.25714	0.25714	0.28125

Fig 9: Normalized matrixes for no of style

ii. Divide relevant column values by corresponding sum value.

NORMALIZED VALUES-No of styles

plant	A	B	C	D	E	F	G	H	I	J
A	0.05172	0.07843	0.05797	0.02741	0.03464203	0.08333333	0.0869565	0.05797	0.0308	0.05556
B	0.02586	0.03922	0.05797	0.01644	0.02309469	0.05555556	0.0217391	0.05797	0.0308	0.05556
C	0.02586	0.01961	0.02899	0.01175	0.01385681	0.05555556	0.0217391	0.02899	0.01232	0.05556
D	0.15517	0.19608	0.2029	0.08222	0.13856813	0.19444444	0.2173913	0.2029	0.1232	0.05556
E	0.10345	0.11765	0.14493	0.04111	0.06928406	0.13888889	0.0869565	0.14493	0.1232	0.05556
F	0.01724	0.01961	0.01449	0.01175	0.01385681	0.02777778	0.0217391	0.01449	0.02053	0.05556
G	0.02586	0.07843	0.05797	0.01644	0.03464203	0.05555556	0.0434783	0.05797	0.0308	0.05556
H	0.02586	0.01961	0.02899	0.01175	0.01385681	0.05555556	0.0217391	0.02899	0.01232	0.05556
I	0.10345	0.07843	0.14493	0.04111	0.03464203	0.08333333	0.0869565	0.14493	0.0616	0.05556
J	0.46552	0.35294	0.26087	0.74002	0.62355658	0.25	0.3913043	0.26087	0.55441	0.5

Fig 10: Normalized matrixes for Average SMV

NORMALIZED VALUES- Total Standard Hrs

plant	A	B	C	D	E	F	G	H	I	J
A	0.04831	0.08612	0.07826	0.02241	0.08207934	0.1	0.1111111	0.02826	0.0188	0.05556
B	0.0161	0.02871	0.05217	0.01344	0.01367989	0.06	0.0123457	0.01211	0.0188	0.05556
C	0.0161	0.01435	0.02609	0.01344	0.01367989	0.06	0.0123457	0.01211	0.01128	0.05556
D	0.14493	0.14354	0.13043	0.06722	0.12311902	0.14	0.1111111	0.02826	0.16917	0.05556
E	0.02415	0.08612	0.07826	0.02241	0.04103967	0.1	0.0740741	0.01695	0.0188	0.05556
F	0.00966	0.00957	0.0087	0.0096	0.00820793	0.02	0.0123457	0.00942	0.01128	0.05556
G	0.0161	0.08612	0.07826	0.02241	0.02051984	0.06	0.037037	0.01695	0.0188	0.05556
H	0.14493	0.20096	0.18261	0.20166	0.20519836	0.18	0.1851852	0.08477	0.16917	0.05556
I	0.14493	0.08612	0.13043	0.02241	0.12311902	0.1	0.1111111	0.02826	0.05639	0.05556
J	0.43478	0.25837	0.23478	0.60499	0.36935705	0.18	0.3333333	0.76292	0.50752	0.5

Fig 11: Normalized matrixes for Total Standard Hours

NORMALIZED VALUES-total order quantity

plant	A	B	C	D	E	F	G	H	I	J
A	0.06224	0.096	0.13699	0.10695	0.10909091	0.11111111	0.0967742	0.04077	0.03446	0.05556
B	0.03112	0.048	0.05479	0.02674	0.07272727	0.06666667	0.0645161	0.02718	0.03446	0.05556
C	0.01245	0.024	0.0274	0.01783	0.01818182	0.04444444	0.016129	0.01165	0.01378	0.05556
D	0.5	2	3	1	3	5	3	0.33333	0.5	0.11111
E	0.02075	0.024	0.05479	0.01783	0.03636364	0.04444444	0.0645161	0.01631	0.02297	0.05556
F	0.01245	0.016	0.0137	0.0107	0.01818182	0.02222222	0.016129	0.00906	0.00985	0.05556
G	0.02075	0.024	0.05479	0.01783	0.01818182	0.04444444	0.0322581	0.01165	0.02297	0.05556
H	0.12448	0.144	0.19178	0.16043	0.18181818	0.2	0.2258065	0.08154	0.13784	0.05556
I	0.12448	0.096	0.13699	0.10695	0.10909091	0.15555556	0.0967742	0.04077	0.06892	0.05556
J	0.56017	0.432	0.24658	0.48128	0.32727273	0.2	0.2903226	0.73389	0.62028	0.5

Fig 12: Normalized matrixes for Total Order quantity

NORMALIZED VALUES-Average of actual efficiency

plant	A	B	C	D	E	F	G	H	I	J
A	0.06667	0.09302	0.11111	0.08889	0.04347826	0.06666667	0.0367347	0.07692	0.12121	0.06447
B	0.03333	0.04651	0.02778	0.08889	0.04347826	0.06666667	0.0367347	0.07692	0.0303	0.05014
C	0.03333	0.09302	0.05556	0.08889	0.04347826	0.06666667	0.0367347	0.07692	0.0303	0.06447
D	0.03333	0.02326	0.02778	0.04444	0.04347826	0.01666667	0.0367347	0.07692	0.0303	0.06447
E	0.13333	0.09302	0.11111	0.08889	0.08695652	0.06666667	0.0367347	0.07692	0.12121	0.09026
F	0.03333	0.02326	0.02778	0.08889	0.04347826	0.03333333	0.0081633	0.07692	0.0303	0.05014
G	0.13333	0.09302	0.11111	0.08889	0.17391304	0.3	0.0734694	0.07692	0.12121	0.05014
H	0.03333	0.02326	0.02778	0.02222	0.04347826	0.01666667	0.0367347	0.03846	0.0303	0.05014
I	0.03333	0.09302	0.11111	0.08889	0.04347826	0.06666667	0.0367347	0.07692	0.06061	0.06447
J	0.46667	0.4186	0.38889	0.31111	0.43478261	0.3	0.6612245	0.34615	0.42424	0.45129

Fig 13: Normalized matrixes for Average of actual efficiency

	no of style	avg smv	Total Std H	Total orde	Avg actual efficiency		Avg. Weight
no of style	0.45952	0.77491	0.45918	0.34483	0.38461538		0.4846106
avg smv	0.06565	0.1107	0.30612	0.2069	0.23076923		0.184027
Total Std H	0.15317	0.05535	0.15306	0.34483	0.38461538		0.2182055
Total orde	0.0919	0.0369	0.03061	0.06897	0.07692308		0.061061
Avg actual	0.22976	0.02214	0.05102	0.03448	0.03846154		0.0751728

Fig 14: Normalized matrixes between criteria

8. Obtain the weighted factors.
By get the average of each raw we can get weighted value for relevant plant with relevant criteria. The weighted values are summarizing below.

plant	no of styles	avg smv	Total Std hrs	Total order qty	Avg actual efficiency	priority vector
	0.4846106	0.18402697	0.218205523	0.061060986	0.236976019	
A	0.05647938	0.08594003	0.063090081	0.084994215	0.076917466	0.052999313
B	0.03842103	0.08594003	0.028291732	0.048175952	0.050076062	0.036797192
C	0.02742146	0.08594003	0.02349575	0.024141458	0.058937668	0.036383101
D	0.15684346	0.02923329	0.11133393	1.844444444	0.039738701	0.151714107
E	0.10259507	0.03385089	0.051736704	0.035752847	0.090510755	0.041150694
F	0.02170442	0.08594003	0.015433603	0.018383664	0.041560005	0.03015423
G	0.04567125	0.14389034	0.041175864	0.0302429	0.122201748	0.066270049
H	0.02742146	0.08594003	0.16100383	0.150325349	0.03223766	0.067765775
I	0.08349358	0.08594003	0.085832674	0.099108739	0.067523526	0.05659758
J	0.43994889	0.2773853	0.418605831	0.439178787	0.420296408	0.268805341

Fig 15: Priority Vector calculations

9. Calculate the priority vector
According to fig
B3, C3, D3, E3, G3 values are weighted values of criteria. Priority vector obtained by,
E.g.
I4=B3*B4+C3*C4+D3*D4+E3*E4+G3*G4
I5=B3*B5+C3*C5+D3*D5+E3*E5+G3*G5

10. Using this priority vector we can rank the plants.

plant	priority vector	
Vaanavil	0.268805341	J
Leisurelir	0.151714107	D
AITC	0.067765775	H
Asialine	0.066270049	G
Mihinthal	0.05659758	I
Shadowlii	0.052999313	A
Sleekline	0.041150694	E
Shadeline	0.036797192	B
Contourli	0.036383101	C
Synergy	0.03015423	F

Fig 16: Final Result

Fig 17: Final results graphically represent

11. Calculating and checking the Consistency Ratio (CR)
RI means Random Index. This is a standard table. According to Number of comparing values we can get RI value using this table. I value is required for finding CR value.

Table4: RI Scale

N	RI
2	
3	0.58
4	0.90
5	1.12
6	0.12
7	1.32
8	1.41
9	1.45
10	1.51

Consistency Index (CI) Calculation

CI= (α_{max}-n) / (n-1)

αmax Calculation

Sum = [pair wise comparison matrix]* [Weighted average vector]

- Weighted Sum = Sum / Avg. Weight
- α_{max} = average (Weighted Sum)
- CR=CI / RI
- For considerable acceptance CR should be 0.1 or below 0.1. Higher values should be reexamination.

e.g.

NORMALIZED VALUES-No of styles

plant	A	B	C	D	E	F	G	H	I	J	Avg. Weigh	Sum	Weighted Sum	10	
A	0.051724	0.078431	0.057971	0.027408	0.03464203	0.08333333	0.08695652	0.057971	0.030801	0.055556	0.05647938	0.593672	10.5113		
B	0.025862	0.039216	0.057971	0.016445	0.02309469	0.05555556	0.02173913	0.057971	0.030801	0.055556	0.03842103	0.398788	10.37942		
C	0.025862	0.019608	0.028986	0.011746	0.01385681	0.05555556	0.02173913	0.028986	0.01232	0.055556	0.02742146	0.277045	10.10321		
D	0.155172	0.196078	0.202899	0.082224	0.13856813	0.19444444	0.2173913	0.202899	0.123203	0.055556	0.15684346	1.703635	10.86201		
E	0.103448	0.117647	0.144928	0.041112	0.06928406	0.13888889	0.08695652	0.144928	0.123203	0.055556	0.10259507	1.099188	10.71385		
F	0.017241	0.019608	0.014493	0.011746	0.01385681	0.02777778	0.02173913	0.014493	0.020534	0.055556	0.02170442	0.229638	10.58025		
G	0.025862	0.078431	0.057971	0.016445	0.03464203	0.05555556	0.04347826	0.057971	0.030801	0.055556	0.04567125	0.477144	10.44736		
H	0.025862	0.019608	0.028986	0.011746	0.01385681	0.05555556	0.02173913	0.028986	0.01232	0.055556	0.02742146	0.277045	10.10321		
I	0.103448	0.078431	0.144928	0.041112	0.03464203	0.08333333	0.08695652	0.144928	0.061602	0.055556	0.08349358	0.882567	10.57048		
J	0.465517	0.352941	0.26087	0.740016	0.62355658	0.25	0.39130435	0.26087	0.554415	0.5	0.43994889	5.480409	12.45692	1.51	Ri
												Lambda =	10.6728	0.075	=CI
														0.049507	=CR

Fig 18: CI calculation examples

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