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Multi attribute decision making model for the evaluation of flexible manufacturing system

G. Prasanthi[1], R. Narayana Reddy[2] and S. Rama Bhupal Reddy[3]

[1]*Department of Mechanical Engineering, JNTUA College of Engineering, Anantapur - 515002, Andhra Pradesh, India*
[2]*R&B Circle Office, Sai Nagar, Andhra Pradesh, Anantapur- 515002,*
[3]*ABJ enterprises Ltd., #27, Halkingcroft, Slough , Berkshire SL37BB, U.K*

prasanthi_jntucea@yahoo.co.in; rnreddy_atp@yahoo.co.in; rama.bhupal@gmail.com

Abstract: A Multi attribute decision making model for evaluation of alternative Flexible manufacturing systems and rank them suitably when their attribute features are presented in a combination of cardinal and ordinal values is discussed. A decision supporting model which readily accepts the cardinal and ordinal data for the attribute features of the alternatives and gives out the evaluation of the alternatives in terms of ranks is developed.

Keywords: FMS evaluation, multi attribute decision making, automated model, cardinal and ordinal values.

Introduction

Evaluation of Flexible manufacturing systems (FMSs) has been a concern of researchers since the late 1970s and early 1980s. During this period the research has evolved from managerial and conceptual issues facing the justification of FMS to the development of analytical tools and models that help in evaluation of the FMS alternatives (Buzacott,1989). Due to the complexity of their evaluation, which includes combination of characteristics, FMS requires special attention. The variety of parameters and their characteristics call for models that will necessarily have to consider multiple criteria (Chuu, 2005).

Multi attribute decision making

Multi criteria decision making methods are used to take decisions when a number of multiple, usually conflicting criteria are present in any decision making scenario (Zionts, 1988). Any problem has multiple objectives or attributes. The decision maker must identify or generate the objectives or attributes for a problem (Chuu, 2004). There may be conflict among the criteria and they have incommensurable units. The Multi criteria decision making process involves designing or searching for an alternative that is the most attractive over other criteria. The alternative set may contain a finite number of elements or an infinite number of elements. The multi criteria decision making procedures are used to design the best alternatives or to select the best one among the previously specified finite number of alternatives (Santhanam & Kyparisis, 1995).

Multi criteria decision making may be broadly classified as:

1) Multi attribute decision making, and
2) Multi objective decision making.

Multi attribute decision making is best suited for selection or evaluation problems whereas multi objective decision making is best suited for operation design problems.

Flexible manufacturing systems

Flexible Manufacturing Systems (FMS) has become the most popular and useful form of automation because of its flexibility and its ability to effect changes according to changing manufacturing requirements. Compared to traditional methods, the cost of producing variety of parts simultaneously is very less in a flexible manufacturing system.

Model for the evaluation of FMS

A multi attribute decision making model is presented for evaluating alternative Flexible manufacturing systems by considering both quantitative and qualitative factors. The quantitative factors are introduced through cardinal data and qualitative factors are introduced through ordinal data. The model integrates both qualitative and quantitative data of the characteristics of the alternative flexible manufacturing systems and arrives at the relative efficiency scores or ranks for the alternative flexible Manufacturing systems. The integrated data is used for developing pair wise comparison matrices.

Problem definition

The data utilized for the illustrative analysis is after Sarkis & Talluri (1999). In their paper twelve FMS alternatives were compared. The measures, presented here, are not exhaustive but are some general quantitative and qualitative measures that should be considered in FMS evaluation. The data set for the illustrative problem is shown in Table 1.

Working of the model

The attributes 1) Capital and operating costs (C&OC), 2) Floor space requirements (FS), 3) Vendor reputation (VR), 4) Work in process (WIP), 5) Percentage of Tardy jobs (T), 6) Yield (Y) and 7) Worker approval (WA) are all given equal importance or weightages.

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Then the pairwise comparison matrix (Yardakul & Tansel ,2004) for attributes is

The normalized matrix is obtained by dividing each element with its column sum and is

A =	C&OC	FS	VR	WIP	T	Y	WA
C&CO	1	1	1	1	1	1	1
SF	1	1	1	1	1	1	1
VR	1	1	1	1	1	1	1
WIP	1	1	1	1	1	1	1
T	1	1	1	1	1	1	1
Y	1	1	1	1	1	1	1
WA	1	1	1	1	1	1	1

A_N =	C&OC	FS	VR	WIP	T	Y	WA
C&OC	0.14286	0.14286	0.14286	0.14286	0.14286	0.14286	0.14286
FS	0.14286	0.14286	0.14286	0.14286	0.14286	0.14286	0.14286
VR	0.14286	0.14286	0.14286	0.14286	0.14286	0.14286	0.14286
WIP	0.14286	0.14286	0.14286	0.14286	0.14286	0.14286	0.14286
T	0.14286	0.14286	0.14286	0.14286	0.14286	0.14286	0.14286
Y	0.14286	0.14286	0.14286	0.14286	0.14286	0.14286	0.14286
WA	0.14286	0.14286	0.14286	0.14286	0.14286	0.14286	0.14286

The weightages for the attributes are all equal and

$w_{C\&OC} = w_{FS} = w_{VR} = w_{WIP} = w_T = w_Y = w_{WA} = 0.14286$

The Capital and operating costs of the FMS1 to FMS12 are given as absolute values of individual costs in Table 1. The pairwise comparison matrix for the alternatives FMS1 to FMS12 for the attribute of Capital and operating costs is obtained by comparing each FMS cost with the rest of FMS's costs. The pairwise comparison matrix for the alternatives FMS1 to FMS12 for the attribute Capital and operating costs is shown in Fig.1.

Similarly the pairwise comparison matrices for the alternatives FMS1 to FMS12 for the attributes FS, WIP, T and Y are obtained by comparing each FMS with the rest of FMSs for each of the above attributes separately. Both Vendor reputation (VR) and Worker approval (WA) are taken as qualitative variables and are measured on an ordinal scale of 1 to 5. The pairwise comparison matrices for the alternatives FMS1 to FMS12 for the attributes VR & WA are calculated.The normalized matrices for C&OC, FS, VR, WIP, T, Y and WA are developed by dividing each element of the pairwise comparison matrices by the sum of column elements of the corresponding pairwise comparison matrix. The normalized matrix for the alternatives FMS1 to FMS12 for the attribute Capital and operating costs is shown in Fig.2.

The weightages for FMS1 to FMS12 for the attribute of C&OC are calculated by taking the average of each row of the normalized matrix $A_{N\,C\&OC}$ and are given in Table 2.

Similarly the weightages for FMS1 to FMS12 for the attributes of FS, VR, WIP, T, Y and WA are calculated by taking the average of each row of the corresponding normalized matrices.

The overall weightages for the alternatives FMS1 to FMS12 are calculated as follows.

For FMS1 the weightage w_{FMS1} is given by

$w_{FMS1} = w_{C\&OC} \times w_{C\&OC\,FMS1} + w_{FS} \times w_{FS\,FMS1} + w_{VR} \times w_{VR\,FMS1} + w_{WIP} \times w_{WIP\,FMS1} + w_T \times w_{T\,FMS1} + w_Y \times w_{Y\,FMS1} + w_{WA} \times w_{WA\,FMS1} =$

$0.14286 \times 0.12839 + 0.14286 \times 0.07225 + 0.14286 \times 0.11111 + 0.14286 \times 0.10950 + 0.14286 \times 0.11863 + 0.14286 \times 0.10528 + 0.14286 \times 0.12500 = 0.110025$

The overall weightages for other FMS alternatives FMS2 to FMS12 are calculated similarly and all the overall weightages for all the alternative FMSs are tabulated in Table 3.

Based on overall weightage for each FMS alternatives the twelve FMS alternatives are given ranking as given in Table 4.

The ranks obtained above tally with reported earlier (Sarkis & Talluri, 1999).

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Algorithm

Let n = Number of attributes

m= Number of alternatives available

Begin:

Step 1

Decide the attributes a_i to be considered for all i= 1 to n

Step 2

Find out the possible alternatives p_i available for all i = 1 to m.

Step 3

Find out the attribute features(cardinal or ordinal) a_{ij} for all i =1 to n and j =1 to m

Step 4

Convert the cardinal data into comparative ordinal data and develop pairwise comparison matrices for the alternatives for those attributes with cardinal data.

Step 5

Develop pairwise comparison matrices for the alternatives for those attributes with ordinal data.

Step 6

Develop normalized matrices for all the pairwise comparison matrices.

Step 7

Find out the weightages for the attributes and for the alternatives for each of the attributes.

Step 8

Find out the overall weightages for the alternatives with the individual weightages calculated in step 7.

Step 9

Based on the weightages rank the alternatives and select the best one with rank1.

End

Conclusions

The Multi attribute decision making model developed for evaluation of alternative FMSs which can accommodate both cardinal and ordinal values for attribute features of the alternatives is simple and effective in ranking the alternatives. With simple modification the model can accept even linguistic terms for attribute features. The model may be applied to any new area for evaluation of any multi attribute decision problem.

Fig.1. Pairwise comparison matrix for the alternatives for C & CO

$A_{C\&OC}$ =

	FMS1	FMS2	FMS3	FMS4	FMS5	FMS6	FMS7	FMS8	FMS9	FMS10	FMS11	FMS12
FMS1	1.0000	1.0340	1.4473	1.6179	1.7916	3.5532	2.7407	1.5306	4.6376	1.9059	0.9594	1.1461
FMS2	0.9671	1.0000	1.3997	1.5646	1.7326	3.4363	2.6506	1.4802	4.4850	1.8432	0.9278	1.1084
FMS3	0.6910	0.7145	1.0000	1.1179	1.2379	2.4551	1.8937	1.0576	3.2044	1.3169	0.6629	0.7919
FMS4	0.6181	0.6391	0.8946	1.0000	1.1074	2.1962	1.6940	0.9460	2.8665	1.1781	0.5930	0.7084
FMS5	0.5582	0.5772	0.8078	0.9030	1.0000	1.9833	1.5298	0.8543	2.5886	1.0638	0.5355	0.6397
FMS6	0.2814	0.2910	0.4073	0.4553	0.5042	1.0000	0.7713	0.4308	1.3052	0.5364	0.2700	0.3226
FMS7	0.3649	0.3773	0.5281	0.5903	0.6537	1.2965	1.0000	0.5585	1.6921	0.6954	0.3501	0.4182
FMS8	0.6533	0.6756	0.9456	1.0570	1.1705	2.3215	1.7907	1.0000	3.0300	1.2452	0.6268	0.7488
FMS9	0.2156	0.2230	0.3121	0.3489	0.3863	0.7662	0.5910	0.3300	1.0000	0.4110	0.2069	0.2471
FMS10	0.5247	0.5425	0.7594	0.8489	0.9400	1.8643	1.4380	0.8031	2.4332	1.0000	0.5034	0.6013
FMS11	1.0423	1.0778	1.5085	1.6863	1.8674	3.7035	2.8567	1.5953	4.8338	1.9866	1.0000	1.1946
FMS12	0.8725	0.9022	1.2628	1.4116	1.5632	3.1002	2.3913	1.3354	4.0463	1.6629	0.8371	1.0000

Fig.2. Normalised matrix for the alternatives for C & CO

$A_{N\ C\&OC}$ =

	FMS1	FMS2	FMS3	FMS4	FMS5	FMS6	FMS7	FMS8	FMS9	FMS10	FMS11	FMS12
FMS1	0.12839	0.12839	0.12839	0.12839	0.12839	0.12839	0.12839	0.12839	0.12839	0.12839	0.12839	0.12839
FMS2	0.12416	0.12416	0.12416	0.12416	0.12416	0.12416	0.12416	0.12416	0.12416	0.12416	0.12416	0.12416
FMS3	0.08871	0.08871	0.08871	0.08871	0.08871	0.08871	0.08871	0.08871	0.08871	0.08871	0.08871	0.08871
FMS4	0.07935	0.07935	0.07935	0.07935	0.07935	0.07935	0.07935	0.07935	0.07935	0.07935	0.07935	0.07935
FMS5	0.07166	0.07166	0.07166	0.07166	0.07166	0.07166	0.07166	0.07166	0.07166	0.07166	0.07166	0.07166
FMS6	0.03613	0.03613	0.03613	0.03613	0.03613	0.03613	0.03613	0.03613	0.03613	0.03613	0.03613	0.03613
FMS7	0.04684	0.04684	0.04684	0.04684	0.04684	0.04684	0.04684	0.04684	0.04684	0.04684	0.04684	0.04684
FMS8	0.08388	0.08388	0.08388	0.08388	0.08388	0.08388	0.08388	0.08388	0.08388	0.08388	0.08388	0.08388
FMS9	0.02768	0.02768	0.02768	0.02768	0.02768	0.02768	0.02768	0.02768	0.02768	0.02768	0.02768	0.02768
FMS10	0.06736	0.06736	0.06736	0.06736	0.06736	0.06736	0.06736	0.06736	0.06736	0.06736	0.06736	0.06736
FMS11	0.13382	0.13382	0.13382	0.13382	0.13382	0.13382	0.13382	0.13382	0.13382	0.13382	0.13382	0.13382
FMS12	0.11202	0.11202	0.11202	0.11202	0.11202	0.11202	0.11202	0.11202	0.11202	0.11202	0.11202	0.11202

References

1. Buzacott JA (1989) Modelling flexible manufacturing systems. Operations research models for flexible manufacturing systems. Springer – Verlag. pp: 122-134.
2. Chuu S-J (2004) Evaluating manufacturing flexibility using fuzzy multiple attribute decision making. *J. Chinese Instt. Industrial Engg*. 21 (6). 576-586.
3. Chuu S-J (2005) Fuzzy multi attribute decision making for evaluating manufacturing flexibility. *Production Planning & Control*. 16 (3) 323– 335.
4. Santhanam R and Kyparisis J (1995) Multiple criteria decision model for information system project selection. *Compu. & Operation Res*. 22 (8), 807-818.
5. Sarkis J and Talluri S (1999) A decision model for evaluation of flexible manufacturing systems in the presence of both cardinal and ordinal factors. *Intl. J. Production Res*. 37 (13), 2927-2938.
6. Yardakul M and Tansel IY (2004) AHP approach in the credit evaluation of the manufacturing firms in Turkey. *Intl. J. Prod. Econ.* 88 (3), 269-289.
7. Zionts S (1988) Multiple criteria mathematical programming: An updated overview and several approaches. *NATO ASI Series*. F48, 135-167.

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Table 1. Data set for alternate flexible manufacturing systems

	Capital & operating costs ($00000)	Floor space requirements (000sq ft)	Vendor reputation	Work in process (10)	Number of Tardy (%)	Yield (00)	Worker approval
	C&OC	FS	VR	WIP	T	Y	WA
FMS1	17.02	5.00	3	45.30	14.20	30.10	5
FMS2	16.46	4.50	2	40.10	13.00	29.80	3
FMS3	11.76	6.00	1	39.60	13.80	24.50	3
FMS4	10.52	4.00	3	36.00	11.30	25.00	4
FMS5	9.50	3.80	1	34.20	12.00	20.40	5
FMS6	4.79	5.40	4	20.10	5.00	16.50	1
FMS7	6.21	6.20	2	26.50	7.00	19.70	2
FMS8	11.12	6.00	5	35.90	9.00	24.70	1
FMS9	3.67	8.00	2	17.40	0.10	18.10	5
FMS10	8.93	7.00	1	34.30	6.50	20.60	4
FMS11	17.74	7.10	1	45.60	14.00	31.10	4
FMS12	14.85	6.20	2	38.70	13.80	25.40	3

Table 2 Weightages for FMS1 to FMS12 for C&OC

$W_{c\&ocFMS1}$	0.12839
$W_{c\&ocFMS2}$	0.12416
$W_{c\&ocFMS3}$	0.08871
$W_{c\&ocFMS4}$	0.07935
$W_{c\&ocFMS5}$	0.07166
$W_{c\&ocFMS6}$	0.03613
$W_{c\&ocFMS7}$	0.04684
$W_{c\&ocFMS8}$	0.08388
$W_{c\&ocFMS9}$	0.02768
$W_{c\&ocFMS10}$	0.06736
$W_{c\&ocFMS11}$	0.13382
$W_{c\&ocFMS12}$	0.11202

Table 3 Overall Weightages for the alternative FMS

Alternative FMS	Overall Weightage
FMS1	0.110025
FMS2	0.092576
FMS3	0.083454
FMS4	0.088162
FMS5	0.077556
FMS6	0.062199
FMS7	0.064567
FMS8	0.089879
FMS9	0.064083
FMS10	0.073548
FMS11	0.101348
FMS12	0.092627

Table 4 Ranks for the alternative FMS

Alternative FMS	Overall Weightage	Rank
FMS1	0.110025	1
FMS11	0.101348	2
FMS12	0.092627	3
FMS2	0.092576	4
FMS8	0.089879	5
FMS4	0.088162	6
FMS3	0.083454	7
FMS5	0.077556	8
FMS10	0.073548	9
FMS7	0.064567	10
FMS9	0.064083	11
FMS6	0.062199	12