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Key Performance Indicators of TQM-An Analysis by Using Analytical Hierarchy Process

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Abstract:
This paper represents extensive review of the literature on key performance indicators (KPI) of Total Quality Management (TQM) and supported by various other philosophies of TQM. This paper develops a model to conduct an empirical study in order to improve their performance based on Analytical Hierarchy Process (AHP). There are many factors which are effective in improving performance of Small and Medium Enterprise (SME) industries. In this research, a model has been developed that includes KPI of TQM and quality improvement to study their influence on the performance of the SME industries. It is hoped that this paper can provide an academic source for both academicians and managers to investigate the relationship between KPI of TQM, Quality Improvement, and Performance of TQM implementation in the SMEs. The present study will guide the researchers in selecting the reliable set of KPIs for empirical studies. Industrial sectors can benefit by adopting the results of this study for effective implementation and deployment of TQM.

Keywords: Seven key performance indicators of total quality management, TQM, quality improvement, performance measurement, analytical hierarchy process

TQM as a management philosophy joins all departments to meet and exceed customer expectations and accomplish organization goals and objectives. In the context of TQM, it is essential that the organizations identify key performance indicators, which should be given special attention for ensuring successful implementation of TQM program. KPI are internal or external factors that can seriously affect the firm for better or worse. However, there are only few research studies that discuss about factor ratings or weight-ages to be considered while deployment and evaluation of TQM.
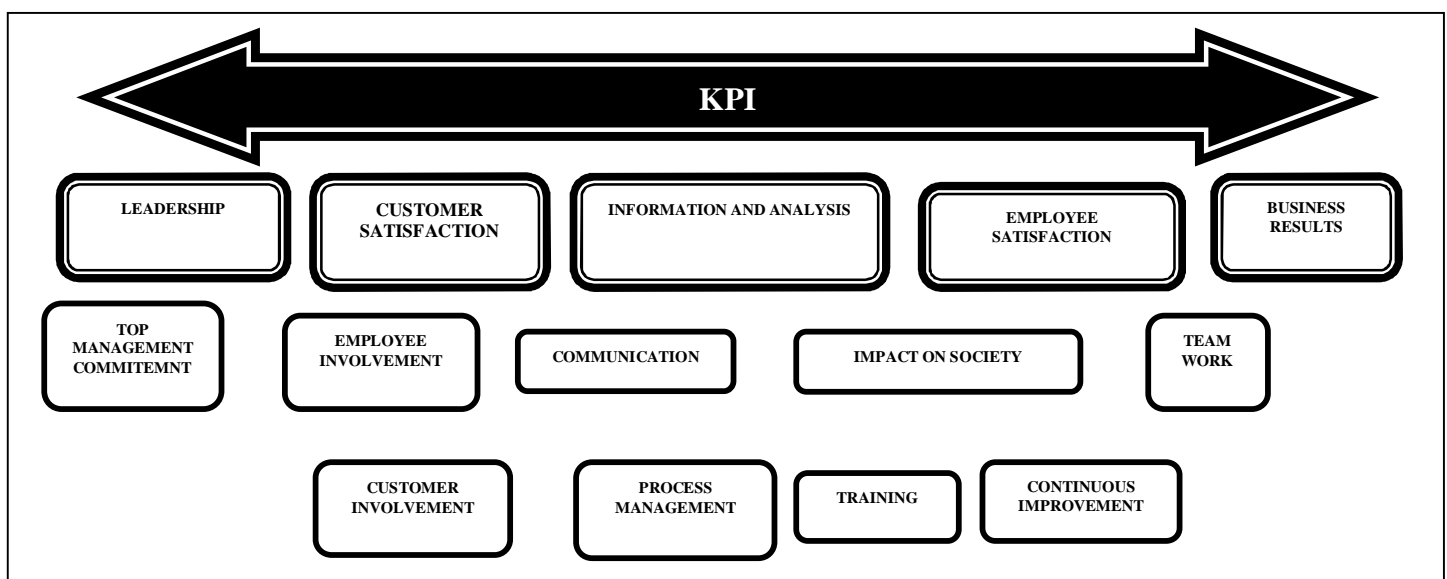

Figure 1: AHP Framework of KPI

Most of the TQM assessors take the standard weight-ages from standard models either from Malcolm Baldrige National Quality Award or Deming Quality Award or European Quality Award model for accessing all the types of businesses. The criteria chosen for the Analytical Hierarchy Process study are namely, leadership(L), customer focus(CF), information and analysis(IA), employee satisfaction(ES), business results(BR). Various alternatives influencing the factors of KPI are top management commitment (TMC), employee involvement(EI), customer involvement(CI), process management(PM), training(T), teamwork(TW), communication(C), continuous improvement(CI2), impact on society(IS)

1. Research Methodology
The research study involves collection of both primary and secondary data for analysis and interpretation. The study consists of 2 parts where part 1 involves experts' opinion and part 2 involves adding weight ages for selected factors and alternatives. The respondents include representatives from top management, consultants, employees, academicians and stakeholders. The weight ages are arrived by paired comparison of the factors of KPI. The relative importance of one criterion over another can be expressed by using paired comparison and rank them according to the following scale. 1=poor, 3=average, 5=good, 7=very good, 9=excellent
After a session of brainstorming, results in pairwise comparison are tabulated. AHP incorporated simple calculations of matrix algebra, and the weight ages are normalized by taking the averages between 0-1and the total weights are added to 1.
Using the judgments to determine the ranking of the criteria pairwise comparisons are as follows:
1. Business Results(BR) is 4 times as important as Leadership(L)
2. Leadership(L) is twice as important as Customer Satisfaction(CS)
3. Leadership(L) is 1.5 times as important as Information and Analysis(IA)
4. Leadership(L) is 1.5 times as important as Employee Satisfaction(ES)
5. Customer Satisfaction(CS) is as important as Information and Analysis(IA)
6. Customer Satisfaction(CS) is as important as Employee Satisfaction(ES)
7. Business Results(BR) is 5 times as important as Customer Satisfaction(CS)
8. Business Results(BR) is 5 times as important as Information and Analysis(IA)
9. Business Results(BR) is 5 times as important as Employee Satisfaction(ES)
10. Information and Analysis(IA) is as important as Employee Satisfaction(ES)

FACTORS i/j	L	CS	IA	ES	BR
L	1	0.5	0.6667	0.6667	0.25
CS	0.5	1	1	1	0.20
IA	1.5	1	1	1	0.20
ES	1.5	1	1	1	0.20
BR	4	5	5	5	1

Table 1: shows pairwise comparison values of KPI

Where in the matrix Kij represents factor i is most important when compared to factor j, in the next step the factors are converted into decimals and square the matrix. Eigen vectors are calculated for the resulting matrix and normalized by taking the average. Later we rank the factors by giving the highest rank for the maximum value.

FACTORS i/j	L	CS	IA	ES	BR	Eigen Vector	Normalized	Rank
L	4.251	3.584	3.751	3.751	0.8668	16.203	0.091986	4
CS	4.8	4.25	4.335	4.335	0.952	18.645	0.105844	3
IA	5.8	4.75	5.005	5.005	1.175	21.735	0.123386	2
ES	5.8	4.75	5.005	5.005	1.175	21.735	0.123386	2
BR	25.5	22	22.668	22.668	5	97.836	0.555389	1
Total	46.151	39.334	40.764	40.764	9.1418	176.1548	1	

Table 2: Calculation of weight ages for KPIs

Form the above table, the value of the eigen vectors gives us the relative ranking of our criteria, viz; Business Results ranked as 1, Information & Analysis and Employee Satisfaction is ranked 2, Customer Satisfaction is ranked 3 and finally the Leadership as 4.

	TMC	EI	CI	PM	T	TW	C	CI2	IS	Average	Normalized	Rank
TMC	1	2	0.5	2	1	1	0.25	0.5	0.2	8.45	0.06805373	8
EI	0.5	1	1	0.5	0.3333	0.25	2	1	0.5	7.0833	0.05704674	9
CI	2	1	1	0.2	0.25	0.25	0.2	5	5	14.9	0.12000006	5
PM	0.5	2	5	1	1	2	0.5	1	2	15	0.12080543	4
T	1	3	4	1	1	1	1	0.5	0.5	13	0.10469804	6
TW	1	4	4	0.5	1	1	0.25	0.25	0.5	12.5	0.10067119	7
C	4	0.5	5	2	1	4	1	0.25	0.3333	18.0833	0.14563739	2
CI2	2	1	0.2	1	2	4	4	1	0.25	15.45	0.1244296	3
IS	5	2	0.2	0.5	2	2	3	4	1	19.7	0.1586578	1
Total	17	16.5	20.9	8.7	9.5833	15.5	12.2	13.5	10.2833	124.1666	1	

Table 3: Pairwise comparison among factors with respect to Leadership(L) KPI

From the above table we have performed the pairwise comparison among factors with respect to Leadership. Ranks are been allotted by the resulting matrix and we learn that Impact on Society(IS)=1, Communication(C) =2, Continuous Improvement(CI2)=3, Process Management(PM)=4, Customer Involvement(CI)=5, Training(T)=6, Team Work(TW)=7, Top Management Commitment(TMC)=8, Employee Involvement(EI)=9

	TMC	EI	CI	PM	T	TW	C	CI2	IS	Average	Normalized	Rank
TMC	1	0.2	0.1428	0.3333	0.25	0.5	0.3333	0.25	0.1428	3.1522	0.01473929	9
EI	5	1	1	5	7	7	0.25	0.2	0.3333	26.7833	0.12523537	5
CI	7	1	1	0.111	0.111	0.111	9	0.111	1	19.444	0.09091772	7
PM	3	0.2	9	1	0.111	0.1428	0.25	0.111	0.111	13.9258	0.0651153	8
T	4	0.1428	9	9	1	0.111	0.111	0.1428	0.5	24.0076	0.11225654	6
TW	2	0.1428	9	7	9	1	0.2	0.333	1	29.6758	0.13876034	2
C	3	4	0.125	4	9	5	1	0.5	1	27.625	0.12917106	4
CI2	4	5	9	9	7	3	2	1	0.25	40.25	0.18820398	1
IS	7	3	1	9	2	1	1	4	1	29	0.13560038	3
Total	36	14.6856	39.2678	44.4443	35.472	17.8648	14.1443	6.6478	5.3371	213.8637	1	

Table 4: Pairwise comparison among factors with respect to Customer Satisfaction (CS) KPI

From the above table, we have performed the pairwise comparison among factors with respect to **Customer Satisfaction (CS)**.Ranks are been allotted by the resulting matrix and we learn that Continuous Improvement(CI2)=1, Team Work(TW)=2, Impact on Society(IS)=3, Communication(C)=4, Employee Involvement(EI)=5, Training(T)=6, Customer Involvement(CI)=7, Process Management(PM)=8, Top Management Commitment(TMC)=9

	TMC	EI	CI	PM	T	TW	C	CI2	IS	Average	Normalized	Rank
TMC	1	0.2	0.25	0.25	2	0.25	0.2	5	1	10.15	0.073634657	7
EI	5	1	3	0.25	0.3333	0.2	0.2	0.1428	1	11.1261	0.080715917	6
CI	4	0.3333	1	0.25	0.25	1	0.5	1	0.5	8.8333	0.064082465	9
PM	4	4	4	1	0.5	3	1	4	3	24.5	0.177738828	1
T	0.5	3	4	2	1	6	0.5	1	1	19	0.137838275	3
TW	4	5	1	0.3333	1.6667	1	1	0.5	1	15.5	0.112447014	5
C	5	5	2	1	2	1	1	0.25	0.5	17.75	0.128769968	4
CI2	0.2	7	1	0.25	1	2	4	1	5	21.45	0.155612158	2
IS	1	1	2	0.3333	1	1	2	0.2	1	9.5333	0.069160717	8
Total	24.7	26.5333	18.25	5.6666	9.75	15.45	10.4	13.0928	14	137.8427	1	

Table 5: Pairwise comparison among factors with respect to Information and Analysis(IA) KPI

From the above table we have performed the pairwise comparison among factors with respect to Information and Analysis(IA). Ranks are been allotted by the resulting matrix and we learn that Process Management(PM)=1, Continuous Improvement(CI2)=2, Training(T)=3, Communication(C)=4, Team Work(TW)=5, Employee Involvement(EI)=6, Top Management Commitment(TMC)=7, Impact on Society(IS)=8, Customer Involvement(CI)=9

	TMC	EI	CI	PM	T	TW	C	CI2	IS	Average	Normalized	Rank
TMC	1	3	2	0.5	1	2	0.5	0.5	3	13.5	0.12425241	4
EI	0.3333	1	2	2	1	1	3	0.3333	5	15.6666	0.14419355	3
CI	0.5	0.5	1	1	0.5	0.5	2	0.25	1	7.25	0.06672815	9
PM	2	0.5	1	1	1	1	0.5	1	0.3333	8.3333	0.07669871	7
T	1	1	2	1	1	1	0.2	0.25	0.3333	7.7833	0.07163658	8
TW	0.5	1	2	1	1	1	0.25	1	1	8.75	0.08053397	6
C	2	0.3333	0.5	2	5	4	1	0.5	1	16.3333	0.15032978	2
CI2	2	3	4	1	4	1	2	1	0.5	18.5	0.17027183	1
IS	0.3333	0.2	1	3	3	1	1	2	1	12.5333	0.11535502	5
Total	9.6666	10.5333	15.5	12.5	17.5	12.5	10.45	6.8333	13.1666	108.6498	1	

Table 6: Pairwise comparison among factors with respect to Employee Satisfaction (ES) KPI

From the above table we have performed the pairwise comparison among factors with respect to Employee Satisfaction (ES). Ranks are been allotted by the resulting matrix and we learn that Continuous Improvement(CI2)=1, Communication(C)=2, Employee Involvement(EI)=3, Top Management Commitment(TMC)=4, Impact on Society(IS)=5, Team Work(TW)=6, Process Management(PM)=7, Training(T)=8, Customer Involvement(CI)=9

	TMC	EI	CI	PM	T	TW	C	CI2	IS	Average	Normalized	Rank
TMC	1	3	2	1	1	2	2	2	5	19	0.16615683	2
EI	0.3333	1	0.5	1	1	1	2	0.5	2	9.3333	0.08162061	6
CI	0.5	2	1	5	3	3	3	0.2	5	22.7	0.19851368	1
PM	1	1	0.2	1	2	2	2	0.5	3	12.7	0.11106272	4
T	1	1	0.3333	0.5	1	0.5	2	0.3	4	10.6333	0.09298923	5
TW	0.5	1	0.3333	0.5	2	1	1	0.5	2	8.8333	0.07724806	7
C	0.5	0.5	0.3333	0.5	0.5	1	1	0.5	0.5	5.3333	0.04664022	9
CI2	0.5	2	5	2	3	2	2	1	0.3333	17.8333	0.15595392	3
IS	0.2	0.5	0.2	0.3333	0.25	0.5	2	3	1	7.9833	0.06981473	8
Total	5.5333	12	9.8999	11.8333	13.75	13	17	8.5	22.8333	114.3498	1	

Table 7: Pairwise comparison among factors with respect to Business Results(BR) KPI

From the above table we have performed the pairwise comparison among factors with respect to Business Results(BR). Ranks are been allotted by the resulting matrix and we learn that Customer Involvement(CI)=1, Top Management Commitment(TMC)=2, Continuous Improvement(CI2)=3, Process Management(PM)=4, Training(T)=5, Employee Involvement(EI)=6, Team Work(TW)=7, Impact on Society(IS)=8, Communication(C)=9

2. Discussion & Conclusion

	L	CS	IA	ES	BR		For 100 point Scale	For 1000 Point Scale	Rounded Values for 1000	Rank
KPIs	0.091986	0.105844	0.123386	0.123386	0.555389					
TMC	0.068053	0.014739	0.073634	0.124252	0.166156	0.12451	12.4518	124.518	125	**3**
EI	0.057046	0.125235	0.080715	0.144193	0.081620	0.09158	9.15847	91.5847	92	**6**
CI	0.120000	0.090917	0.064082	0.066728	0.198513	0.14705	14.7053	147.053	147	**2**
PM	0.120805	0.065115	0.177738	0.076698	0.111062	0.11108	11.1081	111.081	111	**4**
T	0.104698	0.112256	0.137838	0.071636	0.092989	0.09900	9.90039	99.0039	99	**5**
TW	0.100671	0.138760	0.112447	0.080534	0.077248	0.09066	9.06611	90.6611	91	**8**
C	0.145637	0.129171	0.12877	0.150329	0.046640	0.08740	8.74090	87.4090	87	**9**
CI2	0.124429	0.188204	0.155612	0.170271	0.155953	0.15819	15.8190	158.190	158	**1**
IS	0.158657	0.135600	0.0691607	0.115355	0.069814	0.09048	9.04877	90.4877	90	**7**

Table 8: Overall weight ages for the all KPI taking together

From the above table of overall weight ages for all KPI is calculated by taking all the normalized values of the alternatives with respect to factors influencing KPIs. Viz., TMC=(Normalized value of TMC*Eigen Vector of LeadershipKPI)+(Normalized value of TMC*Eigen Vector of Customer Satisfaction)+(Normalized value of TMC*Eigen Vector of Information and Analysis)+(Normalized value of TMC*Eigen Vector of Employee Satisfaction)+(Normalized value of TMC*Eigen Vector of Business Results)

TMC=(0.0680537*0.091986)+(0.0147393*0.105844)+(0.0736347*0.123386)+(0.1242524*0.123386)+(0.1661568*0.555389)
TMC=0.124518 which is multiplied by 100 for 100 point scale and multiplied by 1000 for 1000 point scale and the values obtained are been rounded off to the next decimal. From the results obtained it is ranked according to the descending order for which the highest value gets rank 1 and the least value gets rank 9. Viz.,Continuous Improvement(CI2)=1, Customer Involvement(CI)=2, Top Management Commitment(TMC)=3, Process management(PM)=4, Training(T)=5, Employee Involvement(EI)=6, Impact on Society(IS)=7, Team Work(TW)=8, Communication(C)=9.

It is clear that Continuous Improvement has scored 158 points and it's the main factor which has influenced the key performance indicators following to which, Customer Involvement with 147 points stands second and then comes the top management commitment with 125 points. These are the important KPIs for the successful implementation of TQM in SME Organizations.

3. Implications

In various businesses it is very much important to identify the KPIs for successful implementation of TQM in organizations, the results may be helpful for the organizational executives and quality engineers to successfully deploy TQM and focus on the development. In the paper we have used AHP technique which is helpful for acumen in decision making and the specific factors chosen will help organizations to build a framework to deploy.

The study has some limitations as its output and analysis is purely based on AHP technique and is performed without cross validation mainly due to time constraints. Some of the factors can be considered for extensive study as we can see in table 8, there is no much difference and very closely related to the values pertaining to the scores of the factors influencing the KPIs.

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