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Application of knowledge management in R & D organizations of Pakistan

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Abstract: This research intends to determine the existing level of knowledge management best practices in R & D organizations of Pakistan. The results have been transformed into an index for inter comparison of organizations in terms of knowledge management maturity. Furthermore, this identifies the extent of problems being faced by the R & D organizations. The level of problems has also been converted into index for analysis of the gaps so as to improve their performance. Finally, a problem solving model has been proposed for enhancing the performance of R & D by solving problems through knowledge management philosophy. The hypothesis has been tested and results indicate that knowledge management meets the essential requirements of problem solving, generation of new ideas and productivity enhancement activities of R & D organizations. The results are certainly beneficial for R & D Managers in achieving their ever increasing and focused objectives.
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1. Introduction

Knowledge will be the only competitive resource for companies in the future (Drucker, 1993). The organization learns with the passage of time and knowledge management accelerates the leaning process; thus, further leading to enhanced performance (Kontour, 1997; Alavi et al., 2010). In order to survive today's challenging and uncertain environment, management of knowledge assets is a prerequisite (Chang et al., 2007). Zack et al. (2009) conclude that knowledge management practices increase organizational performance directly and further improve financial performance. Zheng et al. (2010) suggest that knowledge management is intervening mechanism for organizational effectiveness. Yang (2010) found that the strategic performance is significantly related to knowledge management strategy and the relationship is positively moderated by reward systems, process innovation and intra organizational knowledge sharing. Various other researchers (Parikh, 2001; Wong et al., 2006; Ansari et al., 2009; Alipour et al., 2010) have also concluded that knowledge management is advantageous for organizations in many aspects like enhanced decision making, increasing efficiency, greater productivity, sustained competitive advantage, customer satisfaction, product variety, lesser warranty issues, reduced lead time.

The intellectual capital has replaced tangible assets and knowledge and is the most important or rather, the only precious asset of any organization, especially in research and development (R & D) organizations. In today's volatile and changing environment, any R & D program cannot be started from scratch especially in developing countries due to lack of resources. R & D is important but it is risky and costly. Although, passing through logical steps and doing design iterations help building concrete footings but funding constraints do not allow this luxury. Researchers have to take lead from current practices being adapted in advanced countries. With every passing day, the knowledge is getting multiplied and accordingly needs more attention for proper management. Moreover, knowledge acquired during past projects has to be well integrated and utilized in the current as well as future projects. Linlin et al. (2008) and Wenyong et al. (2009) concluded that knowledge management plays a mediating role in creating and managing R & D knowledge. The initiative of knowledge management in R & D has been experienced by researchers in advanced countries. Since knowledge management is widely believed to be helping in identifying knowledge gaps along with requirements, bridging knowledge gaps, creation of new knowledge, managing existing knowledge and sharing of knowledge leading to improved R & D performance. However, the R & D organizations of Pakistan are still not fully conversant with the best practices of knowledge management.

Now, there is need to extend the research to benefit R & D organizations of developing countries as well.

2. Methodology

This research was conducted with the aim to familiarize R & D organizations of Pakistan with the best practices of knowledge management for subsequent implementation and harvesting benefits. The forthcoming research is based on the interviews of R & D professionals and survey on predefined parameters conducted in R & D organizations located in Pakistan to determine awareness status of knowledge management and its benefits. Multiple case research methodology was adopted because it gives in depth details and allows cross examination. The first survey and interaction builds the need for launching knowledge management initiative whereas the second survey and interviews cater for identifying the potential areas of improvement in terms of measuring the severity of problems being faced by R & D organizations of Pakistan. Finally the R & D managers have been proposed with the problem solving perspective of knowledge management which is validated by third survey, which involved many professionals of all case study R & D organizations.

3. Current Awareness Level of Knowledge Management Best Practices in R & D Organizations of Pakistan

One professional each from sixteen in number R & D organizations of Pakistan were interviewed to identify existence of awareness about knowledge management and its potential benefits. All the interviewees were a part of middle management and the reason behind approaching middle management slot is their insight about functioning of organization as well as regarding future intentions and commitment of higher management towards a certain strategy. Each of the interviews lasted for an hour. After the interviews, the following are questions whose response was obtained according to five point Likert scale with 1 being the lowest and 5 being the highest level of existence of the said practice or awareness level:

1. Awareness about importance of intangible assets.
2. Awareness level regarding Knowledge Management best practices
3. Knowledge sharing culture.
4. Conduct of Joint meetings and sessions
5. Management commitment for knowledge sharing.
6. Reward system against sharing knowledge
7. Sharing of resources
8. Usage of Information Technology tools like Intranet, central database etc
9. Involvement of Customer in R & D activities.

Reliability Test: The structured questions were developed to assess the direct or indirect existence of present situation of practices related to knowledge management. In order to determine the reliability of the questionnaire, Cronbach's Alpha was calculated by using SPSS 19 software and its value is 0.905. The said value comes in the "Excellent" range and gives confidence that the same results can be expected from the other similar professionals of R & D organizations.

Results and Analysis: The response received against the above enlisted variables was statistically analyzed to get holistic picture. The mean and standard deviation of response received against each variable is given in Table 1.

Table 1 Descriptive statistics of awareness level of knowledge management in R & D organizations

Variables	Mean	Std. Deviation
Awareness about Intangible Asset	2.56	1.365
Awareness about Knowledge Management Practices	2.13	1.147
Knowledge Sharing Culture	2.75	1.125
Joint Meetings	3.50	1.155
Management Commitment for knowledge sharing	2.75	1.342
Reward System	2.06	1.181
Resource Sharing	2.88	1.258
Information Technology Tools	3.19	1.424
Customer Involvement	2.88	1.500
Valid N (list wise) = 16		

The results clearly depict that R & D organization of Pakistan lack awareness about knowledge management and its benefits. Higher management's commitment for knowledge sharing is not up to the mark followed by lack of reward system for sharing knowledge and best practices. However, the intranet and joint meetings are in practice, which establishes the required baseline for knowledge

management initiative. Mostly, there is no specific parameter for measuring performance of R & D activities. Only, one organization is utilizing the number of published research papers over the period of a year as an indicator to measure R & D performance of the personnel. The comparative overall performance of R & D organizations on the basis of total score obtained against all selected variables of knowledge management is also given in Figure 1. The results reflect that organization 'C' lies at highest position and organization 'J' falls at the lowest level. Although, no formal knowledge management has been adapted in any organization but the organization 'C' has been found with greater inclination and potential for success of launching knowledge management initiative.

Knowledge Management Index: The results of the survey have also been transformed into a knowledge management index ranging from 0 to 1, tabulated in Table 2, which gives clearer picture of the existence of knowledge management practices in the R & D organizations of Pakistan. The index has been calculated by obtaining the percentage of received score against cumulative ideal score. For example, the sum of response received against all nine questions from organization 'A' is 16 against total score of 45, which leads the percentage of 0.35 i.e. index of existence of knowledge management. It is pertinent to mention here that this index is based on limited aspects of knowledge management. However, it can be augmented and stretched to more comprehensive index for ratification of the organizations.

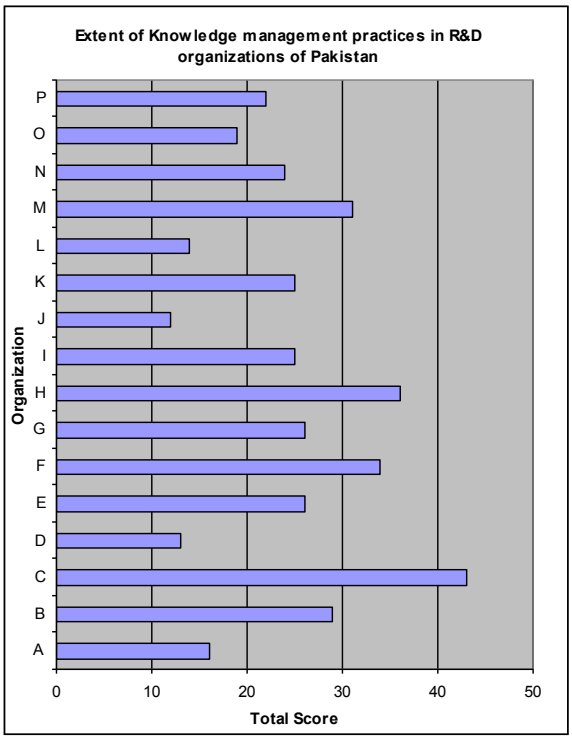

Figure 1 Comparative level of knowledge management practices

Table 2 Extent of existence of knowledge management practices in R & D organizations

S/N	Organization	Knowledge Management Index
1	A	0.35
2	B	0.64
3	C	0.95
4	D	0.29
5	E	0.58
6	F	0.75
7	G	0.58
8	H	0.80
9	I	0.55
10	J	0.27
11	K	0.55
12	L	0.31
13	M	0.69
14	N	0.53
15	O	0.42
16	P	0.49

4. Problems of R & D organizations of Pakistan

In order to identify the problems being faced by R & D organizations of Pakistan, another survey was conducted in the same organizations and response on following questions was obtained:

1. Lack of funds allocated for R & D within organization
2. Lack of funds from outside sources like government, customer etc

3. Lack of R & D infrastructure e.g. equipment, software, etc.
4. Lack of qualified personnel within the organization
5. Lack of qualified personnel in market
6. Lack of information of market
7. Lack of knowledge sharing culture
8. Lack of rewards
9. R & D costs too high
10. Risk factor is high
11. Rigid organizational structure
12. Poor coordination/communication among the departments within the organization
13. Insufficient Government Support
14. Strong competitors in market
15. Demanding customer
16. Environmental issues
17. Short timelines
18. Unclear objectives
19. Lack of well defined strategy
20. Political instability
21. Marketing/commercialization failures
22. International sanctions / policies etc
23. Law and Order situation
24. Problems in measurement of performance
25. Low rate of return on investment

Reliability Test: The structured questions were developed to assess the extent of problems being faced by R & D organizations of Pakistan. In order to determine the reliability of the questionnaire, Cronbach's Alpha was calculated and its value is 0.881. The said value comes in the good range and gives confidence that the same results can be expected from the other similar professionals of R & D organizations.

Results and Analysis:

The response received against the above enlisted variables was statistically analyzed to get holistic picture. The mean and standard deviation of response received against each variable is given in Table 3.

Table 3 Descriptive statistics of problems of R & D organizations of Pakistan

Variables	Mean	Std. Deviation
Lack of Funds allocated by the firm	3.19	1.223
Lack of Funds available from outsourcers like government, customer etc	3.56	1.031
Lack of Infrastructure, equipment etc	2.44	.964
Lack of qualified Researchers within the firm	2.31	1.014
Lack of Researchers available in the market	3.50	1.211
Lack of Market Information	3.06	.929
Lack of knowledge Sharing Culture	4.19	.834
Lack of Rewards	4.12	1.088
High R & D Costs	3.81	1.109
High R & D Risk	3.44	1.031
Rigid Organizational Structure	3.50	1.211
Poor Communication / coordination among departments of organization	3.69	.946
Lack of Government Support	3.19	1.223
Strong Competitor in the market	3.75	1.342
Demanding Customer	3.06	1.063
Environment issues	2.75	1.183
Shorter Timelines	3.44	1.153
Unclear Objective	3.00	1.211
Lack of well defined Strategy	3.94	.772
Political Instability	3.81	.834
Commercialization failures	3.69	1.078
International Policies, sanctions etc	4.19	.750
Poor Law and Order situation	4.13	.957
Lack of or improper Performance Measurement of R & D activities	4.06	1.063
Low Return On Investment	3.50	1.265
Valid N (list wise) = 16		

The comparative overall problems of R & D organizations on the basis of total score obtained against all selected variables are also given in Figure 2. The results reflect that organization 'J' lies at highest position and organization 'F' falls at the lowest level.

The results clearly show that culture is the worst problem being faced by R & D organizations of Pakistan. Higher management may be actively

involved in cultivating moral values and inculcate knowledge sharing culture. R & D organizations may focus on enhancing capabilities of its researchers and have to adapt methodologies for training in relevant areas and retaining expert employees. Organizational structure of R & D organizations is also very important and should facilitate flow of information in contrary to conventional organizations. Presently, no uniform or specific organizational structure is defined in R & D organizations of Pakistan. Some organizations have adapted the functional organizational structure i.e. different departments exist as per their functions like design, manufacturing, procurement, etc. While in some cases the divisional structure also exists in the organizations operating in different areas like north wing and south wing of the country. Keeping in view of the problems being faced especially funds and human resource constraint, it is recommended that organizations may divide their groups on the basis of technologies like design of mechanical structure, mechanical workshop, testing and calibration facility etc. When ever a project is to be worked out, its different sub systems may be assigned to the group head of a specific technology area followed by its subsequent tasking and implementation. The core team of the project and project manager shall continuously interact with all teams working on sub systems for its correct integration thus leading to successful product.

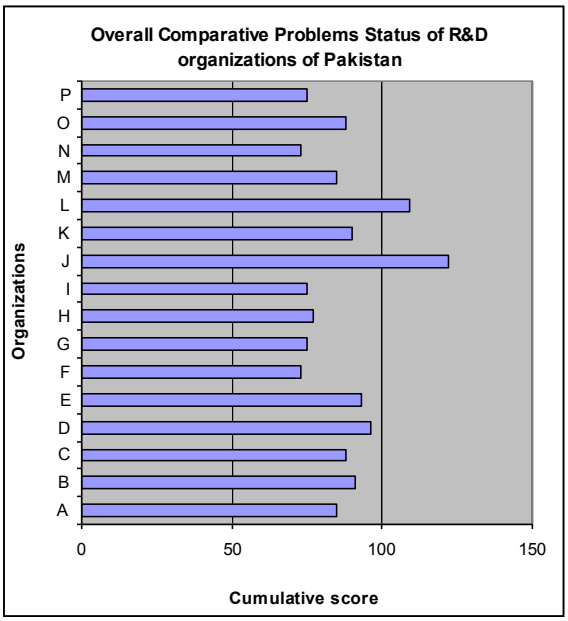

Figure 2 Comparative levels of problems of R & D organizations

Employees think of sharing knowledge and personal experiences when this is properly acknowledged by higher management and it leads by example. Different departments working under different heads are not cooperative with each other, inter departmental rifts exist very often. Duplication of facilities is also attributed due to lack of trust, confidence and mutual cooperation. Incentive programs may be planned to reward employees for sharing knowledge and performing well. Customer being another important factor is more choosy and difficult to attract and nearly impossible to retain. Customers are hindered by less purchasing power, yet aroused and seduced by a variety of products. Customer feedback on products of competitors helps understanding regarding any problems being faced and customer's desires. Moreover, customer feedback helps to accurately forecast market demand and design a product with better features to gain competitive edge.

Various other stakeholders like government and regulatory authorities are also creating problems for R & D programs. Political instability and frequent changing of government policies, public's urging for rapid and quick solutions at less cost, funding constraints, interrupted investment and environmental friendly products are also boundary limits for researchers. Since higher management is reluctant to further invest in R & D programs, so it is inevitable to present some concrete evidences that may reflect improved performance. This century is going to see worst disasters related to environment. R & D processes along with products have to be environment friendly and comply with concerned rules and regulations, which are going to be strict with every passing day.

R & D Problems Index: The results of the survey have also been transformed into a R & D Problems index ranging from 0 to 1, tabulated in Table 4 below, which gives clearer picture of the severity of problems of R & D organizations of Pakistan. The index has been calculated by obtaining the percentage of received score against cumulative ideal score. For example, the sum of response received against all twenty five variables from organization 'A' is 85 against total score of 125, which leads the percentage of 0.68 i.e. index of severity of R & D problems. It is pertinent to mention here that this index is based on specific identified problems of R & D organizations. However, it can be augmented and stretched to more comprehensive index for ratification of the other R & D organizations as well.

Table 4 Extent of Problems of R & D Organizations

S/N	Organization	R & D Organizations Problems Index
1	A	0.68
2	B	0.73
3	C	0.70
4	D	0.77
5	E	0.74
6	F	0.58
7	G	0.60
8	H	0.61
9	I	0.60
10	J	0.98
11	K	0.72
12	L	0.87
13	M	0.68
14	N	0.58
15	O	0.70
16	P	0.60

5. Problem Solving Model of Knowledge Management for R & D Organizations

R & D processes are different from typical organizational processes with well-defined procedures and instructions. In R & D, knowledge creation, capturing, organizing, storing and its utilization, all are going in parallel and require utmost care for maximizing benefits. However, the ultimate objective of any R & D process is to generate more return on investment. All activities of R & D process are influenced by various internal and external problems; thus affecting ultimate objective i.e. new products, new knowledge and return on investment. Some problems are in control of the organizations called internal problems and some other are beyond control of organization being external problems.

In author's opinion, all problems affecting R & D process are covered under the scope of knowledge management which is depicted in problem solving model given in Figure 3. Knowledge management system by virtue of its holistic approach encircles all internal and external problems. There are many pressures on R & D process but knowledge management turns all barriers to useful inputs, further boosting R & D outcomes, which lie at core of the model and ultimate goal. Whenever a problem exists, its solution also lies. The key to solution is in proper understanding of the problem, assigning it due weight age and priority followed by take up of solution by relevant person. All problems can be solved, if relevant 'knowledge' is available. Knowledge management incorporates 'knowledge' of all affecting factors and if properly managed, gives solution to every one's problems and needs.

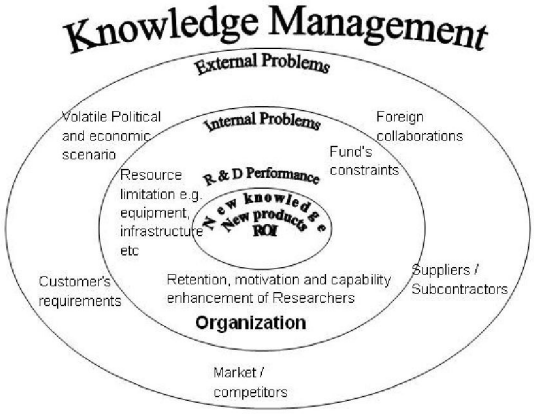

Figure 3 Problem solving model of knowledge management for R & D Organizations

Various types of knowledge exist in an organization and different people use it according to their tasks. For example customer knowledge and market knowledge is to be obtained by marketing people by adapting suitable means. This will help in decision making about which area to target and with which product so as to generate some revenue. Customer is not fully satisfied because its requirements are not understood, while knowledge management caters for this. Similarly government policies, standards, environmental issues, investor's desire for performance, cultural issues, suitable information technology infrastructure and selection of right experts for some problems; all are managed if knowledge management initiative functions properly. In knowledge management, customer requirements are also studied and it gives reliability / assurance that product will be as per customer's requirement. The argument can be deduced that if knowledge

management techniques are implemented in R & D organization, it is strongly believed that it will give due importance to all parties and ultimately generates more return on investment.

It is pertinent to mention here that R & D organizations of Pakistan especially and nearly every R & D organizations is engaged in R & D activities in collaboration with some partners. It is very important to remember that the success can only be achieved if focus of such collaboration remains consistent on knowledge. R & D organizations of Pakistan often engage in Transfer of Technology contracts with overseas firms but have been never able to replicate the products. The major reason of failure is focus on tangible deliverables and no or little attention is given to obtain knowledge i.e. learn design and manufacturing methodologies etc. In order to excel in the field it is mandatory to go through the design, manufacturing etc iterations the supplier R & D organization has gone through over period of time. Knowledge management approach of the R & D organizations will definitely maximize the outcome of such collaborations.

Research Hypothesis:

Following hypothesis has been developed on the problem solving ability of the knowledge management i.e. model proposed in Figure 3:

a. Knowledge Management best practices resolve internal problems of R & D organizations.

b. Knowledge management system helps R & D organizations in addressing external issues.

c. Knowledge Management initiative optimizes R & D performance.

In order to verify the above hypothesis both qualitative and quantitative approaches can be adopted. In quantitative approach a baseline survey needs to be carried out before launching knowledge management initiative and agreed parameters between researchers and investors / monitoring agencies are to be defined like customer satisfaction, reduced cost and time etc. These parameters may cover essential things like reduction in development time and cost, number of published research papers and number of patents etc. Subsequently, after adapting knowledge management, survey on agreed parameters may be again carried out reflecting enhanced performance. Since presently none of the R & D organizations of Pakistan is employing knowledge management therefore, quantitative approach cannot be utilized. However, qualitative approach i.e. perception and conformance level of professionals can be obtained to validate the model and same practice has been carried out in this research.

Survey Parameters:

A survey of R & D organizations was conducted seeking response on following questions to validate the hypothesis given above:

1. Knowledge management best practices resolve internal problems of R & D organization i.e.:

a. Facilitates in sharing of resources e.g. equipment, infrastructure etc

b. Helps in retention, motivation and capability enhancement of researchers

c. Reduces R & D expenses

2. Knowledge management system helps R & D organizations in addressing external issues i.e.:

a. Better understanding of customer and market requirements

b. Ensuring acquisition of knowledge through foreign collaborations and proper liaison with suppliers, subcontractors etc

c. Adjustment with volatile economic & political scenario

3. Knowledge management initiative optimizes R & D performance i.e.:

a. Creates new knowledge

b. Fosters new product development

c. Generates greater return on investment

Reliability Test: In order to determine the reliability of the scale, Cronbach's Alpha was calculated and its value is 0.880. The said value falls in the good range and gives confidence that the same results can be expected from the other similar professionals of R & D organizations.

Analysis and Results:

The results for survey conducted to verify the hypothesis have been analyzed for descriptive statistics which is given in Table 5. The results clearly indicate that professionals of R & D organizations of Pakistan strongly believe about the benefits and problem solving ability of knowledge management. The mean obtained for all the questions is around or above four out of five which is approximately eighty percent conformance level. The two aspects where respondents were found to be little uncertain are:

a. Helps in retention, motivation and capability enhancement of researchers

b. Adjustment with volatile economic & political scenario

The reason envisaged behind lesser confidence in argument i.e. knowledge management helps in retention, motivation and capability enhancement of researchers, is due to the fact that in Pakistan monetary / tangible rewards are more attractive than the one's desire to enhance his capabilities. For a shorter period one may stay in an organization to quench the thirst of knowledge but in longer time people will prefer to serve the organization with better monetary benefits irrespective of the intangible motivators. On the other hand it is predicted that the

philosophy behind the adjustment capability of organization with volatile economic and political scenario, has been less understood by the respondents. Since R & D Organizations of Pakistan which are being run in typical old fashion are least concerned with the global economic and political environment, therefore, the employees are also less concerned. However in future R & D organizations will have to adapt / modify the portfolio according to the changing environment in order to survive. The available options can be multiple and not limited to change of the product range and interaction with other potential partners.

Table 5 Descriptive statistics of hypothesis related to problem solving perspective of knowledge management

Variables	Mean	Std. Deviation
Knowledge management facilitates in resource sharing	4.33	0.656
Knowledge management enhances expertise of researchers	3.41	0.857
Knowledge management reduces R & D expense	4.07	0.730
Knowledge management ensures better understanding of customer and market	3.79	0.858
Knowledge management maximizes benefits from foreign collaborations	3.66	0.824
Knowledge management helps organization in addressing volatile political and economic scenario	3.28	0.909
Knowledge management practices generate new knowledge	4.23	0.721
Knowledge management fosters new product development	3.90	0.764
Knowledge management increases return on investment	4.03	0.770
Valid N (list wise) = 107		

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	21.920	1	21.920	106.028	.000[b]
	Residual	21.708	105	.207		
	Total	43.628	106			

a. Predictors: (Constant), KM
b. Dependent Variable: Performance

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	1.170	.283		4.138	.000	.609	1.731
	KM	.767	.075	.709	10.297	.000	.620	.915

a. Dependent Variable: Performance

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.709[a]	.502	.498	.45469

a. Predictors: (Constant), KM

Correlations

		KM	Performance
KM	Pearson Correlation	1	.709**
	Sig. (2-tailed)		.000
	N	107	107
Performance	Pearson Correlation	.709**	1
	Sig. (2-tailed)	.000	
	N	107	107

**. Correlation is significant at the 0.01 level (2-tailed).

Regression Analysis: The extent of linear relationship between dependent variable i.e. R & D performance and independent variable i.e. Knowledge management practices, was also determined by using linear regression. The value of Pearson Correlation between Knowledge management best practices and R & D performance is 0.709 which shows a good positive relationship. The value of R-Square (coefficient of determination) is 0.502 which means that 50.2 % variation in R & D performance i.e. dependent variable can be attributed to the independent variable i.e. knowledge management best practices. ANOVA shows that significance is 100%. Coefficient analysis was carried out which results in the following equation for linear regression:

R & D Performance = 0.767 (Knowledge Management) + 1.170

6. Conclusion

Knowledge management is a useful tool in the efficient utilization of resources. It enhances customer satisfaction, stimulates elements of R & D process and has potential to improve the organization's return on investment. Knowledge management helps R & D organizations in managing the key asset i.e. knowledge which serves the purpose of stock for future projects as well.

In developing countries and especially in Pakistan, consistent focus on R & D is required to facilitate in country development for subsequent lifting up the social and economic status of people. The concerns in developing countries regarding brain drain, scarcity of resources and lagging behind other nations in technology are driving R & D organizations to adapt knowledge management initiative for fostering performance. In order to excel and cope with future requirements, adaptation of knowledge management practices will be a wise step and worthwhile investment. Improved performance will certainly attract more investment and result in expansion of R & D organizations.

In order to meet the ultimate objective i.e. provision of quick and affordable solutions, the knowledge management must be implemented in R & D organizations. This research will certainly help decision makers in launching knowledge management initiative in R & D organizations thus further leading to enhanced performance and adding benefits to national economy.

R & D Managers can definitely benefit from this research to learn the issues and benefits involved in the application of knowledge management for subsequent decision making and gaining sustainable competitive advantage. Knowledge management, if implemented in the organization in letter and spirit, provides identification and sharing of available information technology tools, equipment, expertise of researchers and provides a platform conducive for knowledge sharing culture resulting in improved performance.

7. Validity of the research

The result concluded and argument verified in this research i.e. R & D performance can be enhanced by using knowledge management initiative is also in line with the similar conclusions deduced by Darroch (2005) for various sector organizations of New Zealand, Marques and Simon (2006) for Spanish Biotechnology and Telecommunication industries, Linlin and Hui (2008) for Chinese University Teams and Zaaimuddin et al., (2009) for single R & D organization of Malaysia. As knowledge management system in an organization is matured, it will lead to continuous increased performance over the time.

8. Limitations of the Research

In Pakistan there are limited numbers of R & D organizations in totality and almost all the engineering organizations engaged in active R & D are under direct control of Ministry of Defense and funded accordingly. A few organizations are working for Public Sector Development Projects under control of ministries of science and technology and industries. The public sector development projects have always been facing administrative and financial constraints thus not performing a significant role. The case studies selected were the defense sector R & D organizations. However, the findings of the research are equally beneficial for the other R & D organizations of Pakistan as well.

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