Empirical study of the impact of software quality practices on product performance in engineering firms in Pakistan

Muhammad Tasleem, Nawar Khan, Syed Tasweer Hussain
Department of Engineering Management
National University of Sciences and Technology
Islamabad, Pakistan
m.tasleem@ceme.nust.edu.pk

Syed Athar Masood
Department of Mechanical Engineering
International Islamic University
Islamabad, Pakistan
athar.masood@iiu.edu.pk

***Abstract*—In the growing race of technology and innovation users and engineering firms, particularly in developing countries like Pakistan, are perturbed by software related issues in the build products that impede customer satisfaction, timely product development and delivery. Software quality practices have become important to tackle such impediments as reveals in literature review. This paper identifies a research framework and investigates the impact of Software Quality Practices composed of three factors Software Quality Standards, Software Configuration Management and Software Tools on Product Performance composed of other three factors Customer Satisfaction, Product Safety and Product Development Time once software quality practices were introduced and implemented in four engineering firms in Pakistan. The research is administered with survey questionnaire and primary data collected from the customers of these firms. Statistical analysis is performed and the results show that product performance increased after the implementation of software quality practices. Recommendations are proposed to deal with implementation challenges and reducing product development and delivery time. The study contributes to determine and align the practical solutions related to software quality practices in engineering firms in Pakistan.**

Keywords—Software quality; product performance; customer satisfaction; product development

I. INTRODUCTION

Since the inception of software industry, it has never been easy to predict rightly the performance and results of developing softwares. The probability of malfunctioning can never be eliminated. Balzer explicitly mentioned that "software is unreliable, delivered late, unresponsive to change, inefficient, and expensive" [1]. It is true when dealing with development and delivery of softwares for complex systems. Kraut and Streeter shared the results of a survey and highlighted common issues of cost and time overrun, code changes till the application of softwares and presence of undetected errors while delivering of softwares [2]. Even today, problems with software systems are common and highly-publicized occurrences.

In the growing race of technology and innovation users and engineering firms are perturbed by software related issues in the build products that impede customer satisfaction, timely product development and delivery. Software quality practices have become important to tackle such impediments. Martin [3] and Highsmith et al. [4] have proposed the concept of agile software development through efficient techniques and practices. It is now emphasized that in order to enhance quality level of products the software development should be more efficient to meet system requirements and to be mission successful. Otherwise the impact of poor quality is much more adverse and significant [5].

This paper investigates the importance of software quality practices (SQP) and its effect on product performance through empirical study. The study is longitudinal and takes four engineering firms in Pakistan for the evaluation of the effect of introduction of software quality standards, software configuration management and software tools in the ongoing development of engineering and complex products. The effect on product performance is determined through pre and post SQP comparison administered through survey questionnaire duly completed by users of the software.

Given a brief introduction of the study in section 1, literature insight on software quality standard, software configuration management and software tools is provided in section 2. Research framework and methodology is presented in section 3, and the results and analysis are discussed in section 4. Finally, the study is concluded with final comments and future dimension in section 5.

II. LITERAURE REVIEW

A. Software Quality Standard

Standard can be defined as a set of rules and guidelines, provided and approved by a recognized body, for accomplishment with a valid service as a minimum acceptable objective. There is wide range of standards starting from simple measurements to comprehensive standards of software analysis and code optimization. The only effective way to develop software based system or a product is through the use of suitable software quality standard that can provide guidelines to software professionals to write a logical code. An effective standard is one that should help developers, assessors and users of such systems [6].

The objective of standard is to control the development process of software. The specifications, requirements, designing, coding, reviews, audits and testing methodologies are all part of the "Software Standard" [7]. Advantages of software standards are following.

- It guides the software engineers/designers to establish the software development processes which impacts on time required to rewrite the logic. Software can easily adopt the upcoming changes as the time passes.
- Products can be developed more rapidly because most of the logic (code) is written and tested on some standard, by the software group.

Another important aspect of using software quality standards is the 'organization wide reusability'. These benefits decrease the risks and increase the software developmental and maintenance productivity. Standards incorporate the quality in software development throughout the organization. Through the effective use of Quality procedures, a firm can analyze and ensure that its products and processes meet customers' needs [8].

B. Software Configuration Management

Configuration management is the physical and functional characteristics of a product as achieved and defined in relevant technical documents. Configuration management practices place methodical and traceable development process and ensure that a system or product is in a well-defined state with right specifications and verified quality characteristics at all times [9]. Configuration management is an integral part of the software development process across all phases of the life cycle.

Software configuration management (SCM) is the technical and administrative direction of identifying and organizing software items, controlling changes to the software, and monitoring the software development and release status throughout the life-cycle. It is one of the software engineering disciplines concerned with managing and controlling the changes [10]. SCM comprises methods and techniques of initiating, reviewing, and controlling changes to software codes or products during the software development life cycle. The purpose of implementing SCM is to prevent failures in the products caused by the numerous corrections, changes, and modifications that are applied during the product life cycle.

Westfechtel and Conradi have presented core life cycle model of software process [11]. They discussed that requirement engineering is the 'problem domain' and programming-in-the-large is the 'solution domain'. Programming-in-the-small is module level design and coding activities. SCM is concerning to software objects developed throughout in its life cycle. Project management is the management function to deliver the project objectives. Quality assurance associates verification and testing activities and documentation process specifies generation of technical and user related documents. The core life cycle model of software process is shown as Fig. 1.

SCM is a professional discipline in software development and maintenance. The importance of SCM has increased as programs have become larger, more long lasting, and more mission and life critical [12].

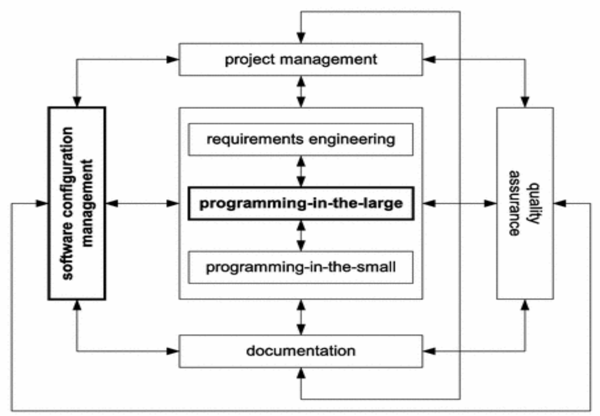

Fig. 1. Core life cycle model of software process; prsented by Westfechtel and Conradi (2003)

The scope and implementation of SCM remains extended over the life of the product therefore organizations and developers use SCM data system modules for efficient control. The modules consider all aspects of software configuration process including identification of software configuration items, change evaluation and reporting, bug reporting and corrections, execution, version control and extensions.

In literature various database and modules systems have been presented that support software development. For example, EPOS system [13] is a database that stores the entire software process model with entities and relationships expressed through schemes, modules and sub-modules. The system is potentially helpful in chalking and controlling configurations and much related to entire process of software development. Similarly an another system that describes the environment evolution of changes is the Prism model [14]. It uses a dependency structure in data description related to changes and a change structure in classifying, recording, and analyzing change related data.

1) Elements of configuration management: Four elements of configuration management can be identified; configuration identification, configuration change control, configuration status accounting and configuration audits. The same elements can be performed in software configuration management [9]. The four elements can also be called as functions of SCM.

2) Software Configuration Items (SCIs): Configuration item is the designed single entity, hardware or software or both, in the configuration management process. There could be numerous SCIs or critical software configuration items (CSCIs) in the system development. Examples include SCM plan, software requirement specification (SRS), system design document (SDD), system test specifications, test plan, source code, database description etc.

C. Software Tools

In hardware manufacturing there are three major phases; design & development, qualification and production. In software cycle the software development is the production phase. Therefore software development and qualification phases need directed efforts and attention for quality software. The software development cycle can be made effective and agile with the assistance and utilization of software development tools as available with multiple applications.

The software tools can mainly be classified in two categories; software development tools and automated software testing tools. Software development tools are those that assist in software development ranging from software requirement management to software integration. Whitgift has identified methods and tools for SCM [15]. Software testing tools provide variety of options from code review or analysis to bugs reporting and tracking, from test case management to functional and load testing etc.

D. *Product Performance*

Product performance is an extent or measurement that describes how a product performs when in use. Product performance, even among similar type of products, can vary due to design and quality issues. Lilien et al. identified customer's inputs and solutions are vital in designing of high performance based new products [16]. Im and Workman carried out study on market orientation, creativity and new product performance in high-tech firms [17]. The majority of product performance is based on consumer feedback. Akman and Yilmaz carried out a study to examine the role of innovation strategy and customer orientation on innovation capability of software industry [18].

1) Customer Satisfaction: customer satisfaction is a key issue for the organizations for their performance [19]. Customer satisfaction can lead to customer loyalty only if product performance fulfills customer needs and specifications. Fred Selnes has examined the effect of product performance on customer satisfaction, loyalty and brand reputation [20]. Earlier Swan and Combs has identified that product performance is important to customers and is significantly related to satisfaction [21]. For software products, Kekre et al. identified and suggested capability and usability as important product performance drivers of customer satisfaction [22].

2) Product Safety: Product safety is an important element of product performance and quality. This characteristic becomes very significant when detection of safety malfunctions is complex and non observable. Alan Ching Biu Tse [23] has discussed various factors that can affect consumer's perception on product safety. Dowlatshahi [24] highlighted and studied three safety techniques useful in product design; that include Preliminary Hazard Analysis (PHA), Fault Tree Analysis (FTA), and Failure Mode and Effect Analysis (FMEA).

There are many standards which are related to the development, production and testing of safety or mission-critical software systems. Fenton and Neil explained and evaluated one of the standards for safety critical system and showed how the system can be improved [6].

3) Product Development Time: Organizations and managers are too concerned about faster product development cycles. It is an imperative strategy to launch and introduce new products in market in less time. In literature various researches have been carried out that affect and can foster product development time. Zirger and Hartley [25] explored effect of twelve acceleration techniques on product development time. Swink and Swan [26] investigated the effect and relationship of marketing-manufacturing integration (MMI) on new product development time and competitive advantage. Kusar et al. have pointed concurrent product development process can reduce development time [27]. Harter et al. pointed that software development firms, to survive, must develop high quality software products on time and at low cost [28].

III. RESEARCH METHODOLOGY

A. *Research Framework*

The framework for the study is constructed as shown in Fig. 2. There are three independent variables in 'software quality practices' construct; those are software quality standard, software configuration management and software tools. While there are other three dependant variables in 'performance' construct; and those are customer satisfaction, product safety and product development time. The framework shows relationship and effect of software quality practices on product performance.

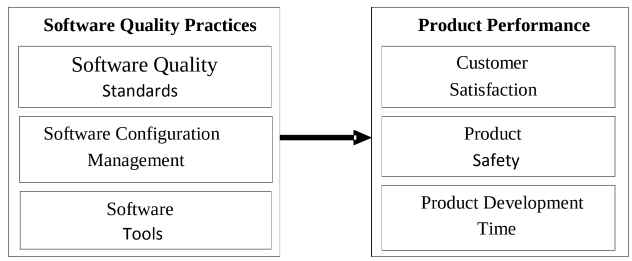

Fig. 2. Proposed research framework

B. *Research Hypotheses*

Following hypotheses have been taken into account for study in the research;

H1 = Implementing software quality practices improves customer satisfaction

H2 = Implementing software quality practices enhances product safety

H3 = Software development time is reduced in adopting software quality practices

C. *Research Methodology*

The elements of research methodology are charted down in Fig. 3.

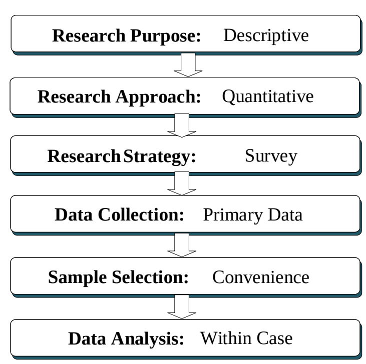

Fig. 3. Research methodology chart

The study is cross sectional and longitudinal in nature. In the study four engineering firms have been taken into consideration. These firms are involved in the design, development and production of advanced engineering products; complex systems comprised of hardwares, softwares and firmwares. The firms are certified to ISO 9001 standard since more than five years. All the three firms are large scale organizations, but are located in three different cities of Pakistan.

The research is survey based and carried out through questionnaire design and distribution. The questionnaires were gathered twice from the target sample at an interval of eight months. During the interval software quality practices including quality standards, software configuration management and software tools were introduced and implemented to certain extent and level in the ongoing projects. In initial term (pre-SQP phase) 54 respondents completed the questionnaire while in second term (post-SQP phase) 75 responses received (Table I). The respondents belong to different departments of the same firms and are the next level users and customers of the softwares for applications in designing and production of engineering products at their end.

TABLE I. RESPONSE RATE

Industry	***Pre-SQP***		***Post-SQP***	
Firms	***No.***	***%***	***No.***	***%***
Firm A	19	35.2	26	34.7
Firm B	16	29.6	19	25.3
Firm C	8	14.8	15	20.0
Firm D	11	20.4	15	20.0
Total	***54***	***100***	***75***	***100***

The questionnaires were sent by mail to the head of departments in the firms and were asked to get completed by related designers, engineers and users. The number of responses increased in the second term due to increased awareness during the implementation period. Table I and Fig. 4 show the responses received in pre-SQP phase and post-SQP phase.

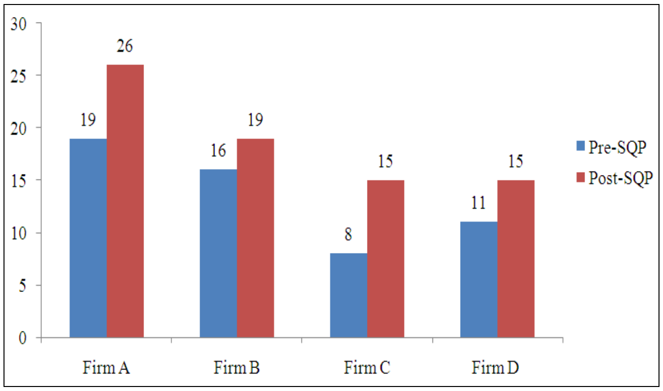

Fig. 4. Graphical presentation of responses received from the firms during pre-SQP and post-SQP phase

The respondents belonged to different job positions, age groups and educational status. The corresponding percentage distributions of respondents of post-SQP phase have been shown in Fig. 5., Fig. 6 and Fig. 7 respectively.

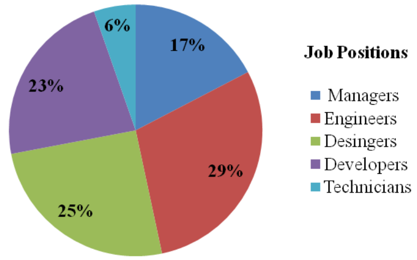

Fig. 5. Respondents Job positions in percenatges

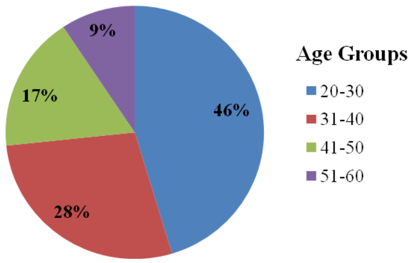

Fig. 6. Respondents Age Group in percentages

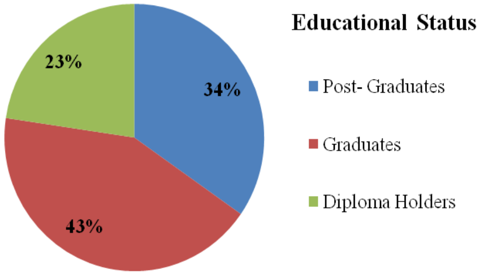

Fig. 7. Respondents Educational staus in percenatges

IV. Results and Analysis

A. *Reliability and validity*

Reliability can be described as the ability of an instrument to provide consistent results in repeated uses [29]. Reliability of a questionnaire across various items is generally measured with a statistic named Chronbach's alpha [30]. The alpha values range from 0 to 1 where higher values depict higher level of internal consistency [31]. Commonly 0.7 value is a benchmark and used to imply that the items measure the same factor [32]. In the study the alpha values achieved greater than 0.7 (Table II) against each factor depicting a good internal consistency of the selected items.

TABLE II. STATISTICS OF FACTORS

Factors	Statistics	
	No. of Items	*Cronbach's alpha*
Software Quality Practices (SQP)		
Software Quality Satndard	4	0.83
Software Configuration Management	5	0.79
Software Tools	3	0.73
Performance		
Cutomer Satisfaction	4	0.77
Product Safety	3	0.82
Product Development Time	4	0.86

There were total 24 items used in the study. Among these 4 items were related to 'software quality standard', 5 items were related to 'software configuration management', 4 were items related to 'software tools', 4 were items related to 'customer satisfaction', 3 were items related to 'product safety' and 4 items were related to 'product development time'. One item was deleted from 'software tools' that resulted in increased alpha value; from 0.69 to 0.73. Table II shows the corresponding alpha values.

Content validity is checked and ensured qualitatively by reviewing and approval of the questionnaire from the experts and professionals of the field with general agreement among the items of the factors under study [33]. Construct validity was assured through factor analysis conducted separately on each variable or factor.

B. Factor Analysis

The factor analysis was conducted separately on each variable in order to find that a variable can only be valid if all the items of that variable form a single variable with Eigen value greater than 1 [33]. The corresponding 'Eigen values' and '% of variation' are measured and presented in Table III. All Kaiser Meyer Oklin (KMO) values observed greater than 0.7 for each factor which describes that sample adequacy is good. It has been recommended that KMO value greater than 0.5 is acceptable [34].

TABLE III. ITEM ANALYSIS RESULTS

Factors	Statistics		
	KMO	*Eigen value*	*% of Variation*
Software Quality Practices (SQP)			
Software Quality Satndard	0.81	3.56	58.13
Software Configuration Management	0.76	4.12	63.43
Software Tools	0.78	3.94	67.23
Performance			
Cutomer Satisfaction	0.83	3.76	63.24
Product Safety	0.77	3.82	73.37
Product Development Time	0.84	3.53	65.11

C. Pre and Post-SQP Analyis

The effect of introduction and implementation of software quality practices was assessed through responses received on the performance factors. Initially received responses (N=54) depicted mean value of customer satisfaction as 2.82, mean value of product safety as 3.10 and mean value of product development time as 2.93. The initial phase named as pre-SQP. After the introduction and implementation of software quality practices 75 responses received (N=75). The phase then named as post-SQP. The results showed some increase in mean values of the three factors. The mean values achieved are; 3.05 for customer satisfaction, 3.31 for product safety and 2.98 for product development time. The results are shown in Table IV and in Fig. 8.

TABLE IV. PRE-SQP AND POST-SQP RESULTS

Product Performance Factors	Statistics		
	Respondents	*Mean*	*Std. Dev.*
Pre-SQP			
Cutomer Satisfaction	54	2.82	0.44
Product Safety	54	3.10	0.65
Product Development Time	54	2.93	0.30
Post-SQP			
Cutomer Satisfaction	75	3.05	0.56
Product Safety	75	3.31	0.49
Product Development Time	75	2.98	0.44

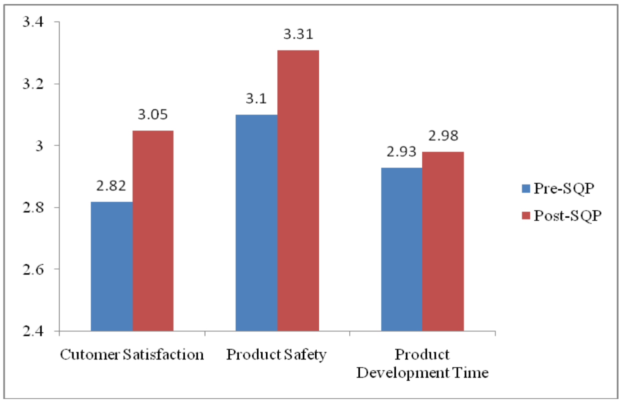

Fig. 8. Pre and post-SQP Results of Product Performance

D. Two-sample t-test

Results showed that there is some increase in the performance factors after the implementation of software quality practices. However to conclude statistically the difference a two-sample t-test was performed. The significance observed through p-value (significant if $p<0.05$). Table V shows the increase in mean of each factor; which is positive in the case. The T-value and p-value are calculated and shown. Table V shows that there is significant improvement in customer satisfaction and product safety ($p<0.05$; N=75,54), however the improvement in product development time is insignificant.

TABLE V. TWO-SAMPLE T-TEST RESULTS

Product Performance Factors	Statistics		
	Increase in mean	***T-value***	***p-value***
Cutomer Satisfaction	0.23	- 2.61	0.010
Product Safety	0.21	- 2.07	0.042
Product Development Time	0.05	- 0.77	0.444

First two hypotheses regarding effect of software quality practices on customer satisfaction and product safety are positively determined in the case; however the third hypothesis of the study did not show significant effect of software quality practices on product development time. The reason could be that the post-SQP analysis is taken only after a shorter period of eight months. The gain may be achieved once the practices are firmly ingrained. The same result was discussed with some senior employees of the firms and it was admitted that due to introduction of software standards there was increase in requirements to fulfill; therefore efforts were also directed to complete the set requirements along the project work.

V. CONCLUSION

Software quality and configuration control standards and tools have become a necessary part of engineering practices in the development and production of sophisticated and complex products. The area of software quality can never be ignored as to tackle inefficiency or malfunctioning of products based on software design and applications. Software development life cycle should be assisted with such techniques.

The results of the study show positive effect of software quality practices upon customer satisfaction and product safety. The results found significant in, however its effect on product development time is found insignificant in the case. The insignificance of product development time due to induction of quality practices, standards or other techniques has also been found in the studies of Swink and Swan [26] and Harter et al. [28]. The reasons in this case are; number of requirements increased due to introduction of software standards and configuration management in the projects and insufficient time given to conclude the results.

The limitations are attributed to time span and selection of limited firms for the study. As the study was empirical and targeted towards the assessment of pre and post phase comparison; therefore convenient sample of four firms were selected to implement. The future dimension of the study can be targeted to investigate the factors or drivers that can enhance product development time while considering a much larger sample.

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REFERENCES

[1] R. M. Balzer, "Imprecise Program Specification.," DTIC Document, 1975.
[2] R. E. Kraut and L. A. Streeter, "Coordination in Software Development," *Commun ACM*, vol. 38, no. 3, pp. 69–81, Mar. 1995.
[3] R. C. Martin, *Agile software development: principles, patterns, and practices*. Prentice Hall PTR, 2003.
[4] J. Highsmith and A. Cockburn, "Agile software development: The business of innovation," *Computer*, vol. 34, no. 9, pp. 120–127, 2001.
[5] S. H. Kan, *Metrics and models in software quality engineering*. Addison-Wesley Longman Publishing Co., Inc., 2002.
[6] N. E. Fenton and M. Neil, "A strategy for improving safety related software engineering standards," *IEEE Trans. Softw. Eng.*, vol. 24, no. 11, pp. 1002–1013, Nov. 1998.
[7] S. Wheeler and S. Duggins, "Improving software quality," in *Proceedings of the 36th annual Southeast regional conference*, 1998, pp. 300–309.
[8] M. Ortega, M. Pérez, and T. Rojas, "Construction of a systemic quality model for evaluating a software product," *Softw. Qual. J.*, vol. 11, no. 3, pp. 219–242, 2003.
[9] W. F. Tichy, "Software Configuration Management," in *Encyclopedia of Computer Science*, Chichester, UK: John Wiley and Sons Ltd., pp. 1601–1604.
[10] P. Navrat and M. Bielikova, "Knowledge controlled version selection in software configuration management," 1996.
[11] B. Westfechtel and R. Conradi, "Software architecture and software configuration management," in *Software Configuration Management*, Springer, 2003, pp. 24–39.
[12] J. Estublier, D. Leblang, A. van der Hoek, R. Conradi, G. Clemm, W. Tichy, and D. Wiborg-Weber, "Impact of software engineering research on the practice of software configuration management," *ACM Trans. Softw. Eng. Methodol. TOSEM*, vol. 14, no. 4, pp. 383–430, 2005.
[13] L. Jaccheri, J.-O. Larsen, and R. Conradi, "Software Process modeling and Evolution in EPOS," in *Software Engineering and Knowledge Engineering, 1992. Proceedings., Fourth International Conference on*, 1992, pp. 574–581.
[14] N. H. Madhavji, "Environment evolution: The Prism model of changes," *Softw. Eng. IEEE Trans. On*, vol. 18, no. 5, pp. 380–392, 1992.
[15] D. Whitgift, *Methods and tools for software configuration management*. J. Wiley, 1991.
[16] G. L. Lilien, P. D. Morrison, K. Searls, M. Sonnack, and E. von Hippel, "Performance assessment of the lead user idea-generation process for new product development," *Manag. Sci.*, vol. 48, no. 8, pp. 1042–1059, 2002.
[17] S. Im and J. P. Workman Jr, "Market orientation, creativity, and new product performance in high-technology firms," *J. Mark.*, vol. 68, no. 2, pp. 114–132, 2004.
[18] G. Akman and C. Yilmaz, "Innovative capability, innovation strategy and market orientation: an empirical analysis in turkish software industry," *Int. J. Innov. Manag.*, vol. 12, no. 01, pp. 69–111, Mar. 2008.
[19] L. Gronholdt, A. Martensen, and K. Kristensen, "The relationship between customer satisfaction and loyalty: Cross-industry differences," *Total Qual. Manag.*, vol. 11, no. 4–6, pp. 509–514, Jul. 2000.
[20] Fred Selnes, "An Examination of the Effect of Product Performance on Brand Reputation, Satisfaction and Loyalty," *Eur. J. Mark.*, vol. 27, no. 9, pp. 19–35, Oct. 1993.
[21] J. E. Swan and L. J. Combs, "Product Performance and Consumer Satisfaction: A New Concept," *J. Mark.*, vol. 40, no. 2, p. 25, Apr. 1976.
[22] S. Kekre, M. S. Krishnan, and K. Srinivasan, "Drivers of Customer Satisfaction for Software Products: Implications for Design and Service Support," *Manag. Sci.*, vol. 41, no. 9, pp. 1456–1470, Sep. 1995.
[23] Alan Ching Biu Tse, "Factors affecting consumer perceptions on product safety," *Eur. J. Mark.*, vol. 33, no. 9/10, pp. 911–925, Oct. 1999.
[24] S. Dowlatshahi, "The role of product safety and liability in concurrent engineering," *Comput. Ind. Eng.*, vol. 41, no. 2, pp. 187–209, Nov. 2001.

[25] B. J. Zirger and J. L. Hartley, “The effect of acceleration techniques on product development time,” *IEEE Trans. Eng. Manag.*, vol. 43, no. 2, pp. 143–152, May 1996.

[26] M. Swink and M. Song, “Effects of marketing-manufacturing integration on new product development time and competitive advantage,” *J. Oper. Manag.*, vol. 25, no. 1, pp. 203–217, Jan. 2007.

[27] J. Kušar, J. Duhovnik, J. Grum, and M. Starbek, “How to reduce new product development time,” *Robot. Comput.-Integr. Manuf.*, vol. 20, no. 1, pp. 1–15, Feb. 2004.

[28] D. E. Harter, M. S. Krishnan, and S. A. Slaughter, “Effects of Process Maturity on Quality, Cycle Time, and Effort in Software Product Development,” *Manag. Sci.*, vol. 46, no. 4, pp. 451–466, Apr. 2000.

[29] S. Rahman, “A comparative study of TQM practice and organisational performance of SMEs with and without ISO 9000 certification,” *Int. J. Qual. Reliab. Manag.*, vol. 18, no. 1, pp. 35–49, 2001.

[30] J. M. Cortina, “What is coefficient alpha? An examination of theory and applications.,” *J. Appl. Psychol.*, vol. 78, no. 1, p. 98, 1993.

[31] L. J. Cronbach, “Coefficient alpha and the internal structure of tests,” *psychometrika*, vol. 16, no. 3, pp. 297–334, 1951.

[32] S. W. O’Leary-Kelly and R. J Vokurka, “The empirical assessment of construct validity,” *J. Oper. Manag.*, vol. 16, no. 4, pp. 387–405, 1998.

[33] T. Kuo, T.-J. Chang, K. Hung, and M. Lin, “Employees’ perspective on the effectiveness of ISO 9000 certification: a total quality management framework,” *Total Qual. Manag.*, vol. 20, no. 12, pp. 1321–1335, 2009.

[34] P. Trivellas and I. Santouridis, “TQM and innovation performance in manufacturing SMEs: The mediating effect of job satisfaction,” in *Industrial Engineering and Engineering Management, 2009. IEEM 2009. IEEE International Conference on*, 2009, pp. 458–462.

BIOGRAPHY

Muhammad Tasleem is a Mechanical Engineer graduated from University of Engineering & Technology, Lahore, Pakistan. He completed his MS with distinguish grade in TQM from Institute of Quality & Technology Management, University of the Punjab, Lahore, Pakistan and presently doing PhD in Engineering Management from National University of Sciences & Technology (NUST), Islamabad, Pakistan. He is profound professional in the field of Quality Management and is an Assessor for Prime Minister Quality Award (PMQA), certified Six Sigma Black Belt and ISO 9001 Lead Auditor. He has 13 years enriched professional experience in production engineering and quality management and is a consultant, trainer and auditor in quality.

Dr. Engr. Syed Athar Masood is presently working as Professor at International Islamic University, Islamabad. He has done his bachelor’s in Mechanical engineering from NED University of engineering and Technology, Karachi in 1992, Master’s in Mechanical Engineering from UET Taxila in 2001 and PhD in Mechanical and Manufacturing Engineering from Loughborough University, UK in 2007. He has more than 20 years of industrial experience in engineering management and quality assurance and more than 7 years of teaching experience at Master’s and PhD level in different universities.

Dr. Nawar Khan is a professional Mechanical Engineer. He graduated from the UET Peshawar in 1981 and later did his MSc Mechanical Engineering (Specialized in Production Engineering) from the University of Engineering and Technology Lahore in 1995. He completed his PhD under a split PhD program of MoST from the University of Engineering and Technology Lahore and De Montfort University, Leicestershire UK in August 1999. He has authored more than 90 national/ international research publications.

Dr. Syed Tasweer Hussain is PhD in Management Sciences from NUML, Islamabad, Pakistan. He has also done MBA (Marketing) from AIOU, Islamabad, Pakistan. He has more than 10 years production and teaching experience at NDU and NUST, Islamabad, Pakistan.