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The Possibility of Industrial Management using Technology Audit Model in the Public Sector Engineering Units of Pakistan

Sarina Zainab Shirazi *
Department of Management Sciences
SZABIST, Islamabad, Pakistan.

ABSTRACT

Technology audit is imperative for gauging the technological health and well being of any industrial unit. According to the current trend, technologically sound companies of first world nations conduct audits of technologies utilized in various industrial units. This study is a step towards ascertaining the presence of technology assessment technique in the service and manufacturing public sector engineering units of Pakistan. The study is also an effort to check whether Technology Audit Model can be utilized by Public Sector Engineering Units of Pakistan as was tested in a similar research conducted at Slovenia in the year 2007 by Dr Slavko Dolensik. The applicability of this technology assessment model can prove to be a vital aid in achieving efficient and systematic technological management of the target industrial units. This research is thus targeted towards identifying a method that systematically manages, identifies existing technological gaps and optimally utilizes technological expertise of Pakistan's target industry.

INSPEC Classification : C6130, C6160, 5220, D2050

Keywords : Management of Technology, Public Sector Engineering Units (PSEU), Strategic Business Unit, Technology Audit Model

1. INTRODUCTION

Management has a very broad scope. Recently the importance of management has been emphasized by all disciplines, whether they pertain to natural sciences, social sciences, technology, education sector or any other field. With booming industrialization, focus of management techniques has broadened to include management of technology (MOT) as a major area of research. Technology acts as the key factor for self sustainability, profitability and successful future of almost all industries. Therefore, conducting technology audits and ascertaining a systematic and methodical way of conducting such audits in public and private sector engineering industrial units are the first steps towards effective future planning. Introduction of a specific model that identifies the main areas of concentration may be instrumental in assessing technological standing of Pakistan's Public Sector Engineering Units.

*Sarina Zainab Shirazi :sarinaresearch@gmail.com

The objective of this study is thus, to propose a systematic framework for conducting audit of PSEU of Pakistan and to give the management a tool that may be instrumental in finding the technological health of a certain production and service unit and just as the financial health can be checked by conducting a financial audit. In a nut shell, objective is to equip target industries with an audit checklist applicable to them.

1.1 Technology Audit

Firms spend a lot of resources on evaluating the financial health of the strategic business units (SBU). To ensure proper disposal of funds, usually firms conduct financial audits. However, there exists a gap when it comes to assigning numerical values to Research and Development (R&D) processes. Assigning value to technical knowledge is extremely difficult. It is usually considered to be zero on any company's balance sheet (Joseph P. Martino, 1994).

Joseph P. Martino (Joseph P. Martino, 1994) explicitly identified the need for technology audit and mentioned that it is a key to success. He explains the technology audit as follows:

"Technology audit is intended to evaluate the state of the organizations technology resources" (Joseph P. Martino, 1994).

Joseph further classifies the technology audit or technological evaluation on the basis of base, key and pacing technologies (Joseph P. Martino, 1994). In fact his work provides the basic guidelines that are essential for the methodology for conducting a technology audit.

Joseph also identifies critical issues that must be addressed while conducting technology audit. In order to address difficulty of evaluation of the technological state, Martino uses four different taxonomies for various technologies namely technical discipline, function performed product category and underlying science (Joseph P. Martino, 1994).

1.2 Development of the Technology Audit Model

According to Tarek Khalil, Technology Audit and Planning come under the purview of a Technology Audit Model (TAM). TAM was proposed by Garcia- Arreola (Tarek Khalil, 2000). TAM is more clearly defined in the book named as," Management of Technology" (Garcia-Arreola, 1996). This model is very helpful for technology mapping support and portfolio of technology developing projects. TAM is also helpful for the review of existing as well as evolving company competencies.

The TAM model can be integrated into a management system with ease and a promising worthiness for further modifications (Garcia-Arreola, 1996).

1.3 Implementation of Technology Audit, on Education Sector

In the end of 2004 a report "Technology Audit Survivor's Guide" (Dr Larry S Anderson, 2004) was published. This report simplifies the audit of science and technology in academic scenarios (Dr Larry S Anderson, 2004). The author terms technology audit as a very positive beginning to effective planning of technology.

"It doesn't take us observers very long to realize that technology auditing, as a growing national activity, needs to have some of the "shaping" preformed in a fashion similar to the way technologies planning was shaped during the late 1990's and into the 21st Century". (Dr Larry S Anderson, 2004)

The report proposes that auditors should give their own "twist" to the audit process (Garcia-Arreola, 1996). The publication by the National Center of Technology Planning USA is

an example of how technology audit is being made a part of the education system (Dr Larry S Anderson, 2004). It is a comprehensive method that is devised to suggest a growth model for achieving a win-win situation for the educational sector. The framework concentrates on striving for excellence rather than finding fault with the existing procedures/practices. Thus, shaping technology management and audit in a fashion similar to the one used for Technology Planning in the late 1990's (Dr Larry S Anderson, 2004).

The evolving importance of these Technology Audits is being recognized at International levels. "Technology & Knowledge: Synthesis report of the National Research and Technology Audit" generated by Foundation for research development Pretoria, South Africa in 1998, also bears testimony to the applicability of the TAM process and its reflection of the actual picture in various fields observed (Foundation for research development Pretoria, South Africa, 1998).

1.4 Tech Audits and Attracting Inventions

In 2003 a cross functional study was conducted for the University of Oxford in order to evaluate the returns and benefits of research to society. The study was based on the research services of the educational institutes funded by government agencies, charities, industries etc and their transfer of expertise (under license) to industry that converts these projects into commercial ventures that benefit society and generates profits (Isis innovation Ltd, 2003). The study focused on the 1998- 2003 Oxford spin-outs. It was a technology audit of how funds utilized in universities (i.e technology and idea incubation centers) are transferred to business incubators and later evolve to form full fledged business enterprises (Isis innovation Ltd, 2003).

1.5 Management of Technology

Management of Technology (MOT) till the year 1990 had no formal theory. Interest in MOT made the revolutionary concept became popular amongst people from three very different stratum of society namely; organizational management, scientists /researchers and academicians (Aaron Shenhar, 1990). The research looks at a three dimensional model for organizational management that is the kind of approach also used by TAM (Garcia-Arreola, 1996), changing the qualitative approach and adopting the similar lines to formulate a tested questionnaire that has been proved to work in different countries like Slovenia (Slavko Dolinsek, 2007).

A further review of evaluation of Advanced Manufacturing Technologies (AMT) was also carried out (Tugrul Daim, 2007) in order to focus on the aspects of AMT that were of real consequence to the organizational success. Foundations of the AMT evaluation is attributed to technology, economy, society and political situation and each characteristic is further broken down on the basis of strategic and tactical aspects of technological accomplishment, organizational functions and market conditions (Tugrul Daim, 2007).

AMT attributes evaluation may be as close to the actual scenario and technology audit (Garcia-Arreola, 1996) that this study focuses on.

Another very interesting socio-economic critical appreciation of the science and technology sector of China was carried out on the turn of the century (Lin Miao, Su Jun, 2000). It is a SWOT of the technology evaluation for future planning and growth of Chinese technological capabilities in the evolving global village and the study highlights the dire need for existence of a streamlined action plan as well as appraisal procedure (Lin Miao, Su Jun, 2000).

Another research that tries to bridge the gap between the educational aspect of MOT and its application to the technology sector in addition to timely planning and forecasting of future industry requirements is that of Japan (Akio Kameoka, Steven W. Collins, Meng Li, Masahiro Hashimoto, 2003). Core focus of this research paper is on systematic training

of "innovators and techno- producers" that are essential for "high growth and high-tech industries" (Akio Kameoka, Steven W. Collins, Meng Li, Masahiro Hashimoto, 2003). This requirement was highlighted at a time when the Japanese were following the American quite closely in the race for technological advancements and patent statistics (Akio Kameoka, Steven W. Collins, Meng Li, Masahiro Hashimoto, 2003).

By 1992 researchers had already started contemplating the need for formal introduction of MOT as a part of curriculum so that technology innovation and future planning processes could be inculcated in next generation scientists and engineers (CWI Pistorius, A P Botha, 1993). And with this concept came awareness for essential requirement of qualitative and quantitative assessment and planning rather than case study and theoretical trends in the academic studies (Karl-Heinz Leitner, 2005).

The requirement and method for managing and measuring the intangible assets of the organizations with special emphasis on research and development (R&D) experiences of Austria were also investigated by using a specified model (Karl-Heinz Leitner, 2005) that proposed an "intellectual capital management program" that forms the basis of evaluation, management and eventually the planning of the Austrian R&D organizations (Karl-Heinz Leitner, 2005).

A study based on the strategic planning assessment and then re-evaluation of a specific production "Department of Defence" was carried out to formalize a focused competitive roadmap for the technological planning to ensure the competitive advantage of the particular department (Alexander Nauda, David L Hall, 2004). This study seems quite similar to Austrian (Karl-Heinz Leitner, 2005) assessment of technology planning and audit criteria.

On the same lines a patent paper (Hans-Helmuth Jung, Philip Bucher) takes a detailed view of strategic technology control as a present day requirement to streamline processes so that they can be most efficiently employed and the consistency in planning and control as a result ensures qualitative improvements in the over all business and technology plan (Hans-Helmuth Jung, Philip Bucher). Similarly a recent study in 2006 based on 89 companies that have a standing amongst the 500 biggest companies of Turkey focused on the various facets of MOT and its related disciplines that include diverse dimensions of technology assessment (Dilek Cetindamar, Ozge Can, Okan Pala, 2006).

Thus, the whole focus of MOT is shifting towards technological awareness its incorporation into the academic circles, exposure of related industry and formulation of an all encompassing model for the evaluation or as termed by other researchers (Garcia-Arreola, 1996), (Slavko Dolinsek, 2007) as technology audit, planning and forecasting procedures and models (Dilek Cetindamar, Ozge Can, Okan Pala, 2006).

2. PROBLEM STATEMENT

A lot of Technology Audit exercises have been conducted over the last few years. These exercises are conducted to evaluate the "Information Technology" and "Education" systems (Isis innovation Ltd, 2003). There is need to apply these exercises to the service and manufacturing companies in order to ensure that they operate at (ideally speaking) 100% efficiency levels to keep pace with and stay competitive with the evolving needs of the global economy (Garcia-Arreola, 1996), (Slavko Dolinsek, 2007). It has been observed that a Technology Assessment (TA) Framework is essential to ensure a systematic process of conducting such an exercise. Such a carefully devised and tested method exists in the form of TAM that has been tested by various nations and was tested in Slovenian service and manufacturing industries in the year 2007,(Garcia-Arreola, 1996).

The aim of this study would be to analyze the core components of the model and test them against the following hypothesis to ascertain their applicability to Pakistan's PSMU.

H0: There exists no significant relation between corporate environment, technologies categorization, markets & competitors, innovation process, value added functions and technology acquisition & exploitation.

H1: There exists significant relation between corporate environment, technologies categorization, markets & competitors, innovation process, value added functions and technology acquisition & exploitation.

3. RELATED WORK

Management of Technology; Case of Slovenian Industry:

For the last two decades Management of Technology (MOT), is really practiced in high technology organizations like Motorola (Tarek Khalil, 2000).. Many researchers are trying to evaluate the practices of such successful entities. In an effort to check the presence of MOT as a part and parcel of the Slovenian technology system Dr. Slavko Dolinsek in one of his research studies focuses on various facets of the "Development of the Technology Audit Model (TAM)" originally introduced by Khalil (Tarek Khalil, 2000), (Slavko Dolinsek, 2007).

MOT has a wide applicability and TAM is one aspect that evaluated most of the important concepts that are addressed in MOT in general. In the mentioned study TAM model focuses on Slovenian service companies and manufacturing companies. The TAM model was tested on 50 Slovenian companies (Garcia-Arreola, 1996). The results of this study show that evaluation of service companies and manufacturing companies are better for manufacturing companies which can be attributed to the fact that technology plays a more important role in manufacturing. This study overall focuses on identification of the technological assets, their evaluation and company capabilities (Slavko Dolinsek, 2007).

4. AUTHORS CONTRIBUTION

The author surveyed thirty public sector engineering industrial units of district Rawalpindi, Pakistan. For this study the Technology Audit Model (TAM) utilized by Dolensik (2007) is adopted in context of public sector engineering industrial units of Pakistan. TAM Model is checked for its validity and effectiveness in Pakistan's scenario in order to suggest a systematic audit framework for PSEU for future use by any organization or unit that may wish to conduct its own assessment for purpose of evaluation as well as future improvement.

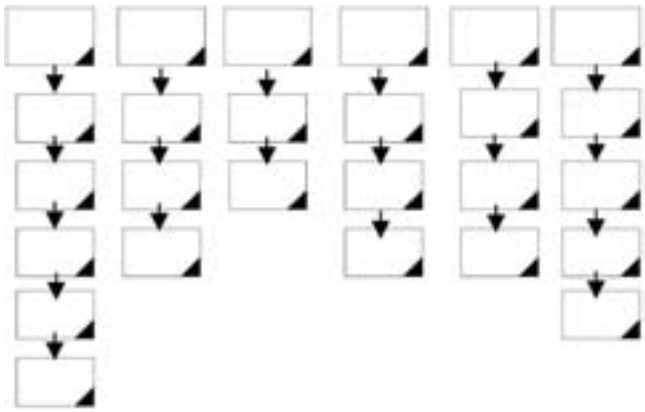
4.1 TAM Model

Garcia-Arreola (1996) developed a Technology Audit Model that included important areas that need to be considered in technology audit (Garcia-Arreola, 1996). The objectives of TAM are:

1. Determination of current technological status
2. To stress on areas of opportunity
3. Take advantage of firm's capabilities (Garcia-Arreola, 1996), (Slavko Dolinsek, 2007)

TAM is a three level model, with each level going deeper in to more specific functions. The upper level is composed of six categories, in the second level there exist twenty assessment areas and finally these assessment areas are further subdivided into forty three assessment elements as follows (Slavko Dolinsek, 2007):

Table 1
Technology Audit Framework



4.2 Questionnaire Design

The questionnaire adopted for this study is the one that is exactly used by Dolinsek study conducted in Slovenia in 2007. The questionnaire comprises six broad categories that include corporate environment, technologies categorization, markets and competitors, innovation process, value added function and technology acquisition and exploitation of profits. As these six areas indicate, a technology audit that can become a very demanding and complex process (Slavko Dolinsek, 2007). The checklist based questionnaire guides an auditor through the TAM process. A TAM checklist as explained above is based on a questionnaire.

The questionnaire was measured on a four point scale from 1-5 where 1 = poor, 2 = fair, 3 = good, 4 = very good, and 5 = outstanding. This scale was pre-tested and found to be valid and reliable with Cronbach Alpha equal to 0.97. As most market researchers prefer that the optimal level of scale entries should be content specific and respondents should make a specific response instead of a socially acceptable neutral mid point rating scale.

4.3 Correlation Matrix & Results

The correlation matrix of all six categories that are being tested for significance in this study give the results in the form of the correlation matrix. As seen from the results it is clear that all the six areas that is corporate environment, technologies categorization, innovation process, markets and competitors, value added functions and technology acquisition and exploitation are positively correlated. In addition to the positive correlation the six areas are also found to be highly significant and the level of significance is 0.01 and Pearson's correlation two tail test values range from 0.80 to 0.92 thus making the assessment areas highly reliable for conducting Audit in the target industrial units of Pakistan.

5. CONCLUSION

Thus on the basis of the above results of correlation, that are reflected by the following table, it may be said that the six areas of evaluation in the Technology Audit Model Checklist (Garcia-Arreola, 1996) can in fact be used by Pakistan's government sector engineering industrial units. The introduction of such a model in any PSEU can be a systematic approach for evaluation/assessment of the manufacturing and service engineering units. Thus, the applicability of TAM (Garcia-Arreola, 1996) can be utilized in Pakistan's

industries that were targeted during the course of this study.

Table 2
Correlation Matrix Results for six Areas of TAM

		Area 1	Area 2	Area 3	Area 4	Area 5	Area 6
Area 1	Corr	1	.920 (**)	.807 (**)	.910 (**)	.822 (**)	.891 (**)
	Sig		.000	.000	.000	.000	.000
	N		30	30	30	30	30
Area 2	Corr		1	.847 (**)	.905 (**)	.819 (**)	.878 (**)
	Sig			.000	.000	.000	.000
	N			30	30	30	30
Area 3	Corr			1	.837 (**)	.820 (**)	.805 (**)
	Sig				.000	.000	.000
	N				30	30	30
Area 4	Corr				1	.890 (**)	.843 (**)
	Sig					.000	.000
	N					30	30
Area 5	Corr					1	.889 (**)
	Sig						.000
	N						30
Area 6	Corr						1
	Sig						
	N						

6. FUTURE WORK

From the conclusion it is clear that the technologyaudit can be conducted using the TAM framework (Garcia-Arreola, 1996). Additionally future work can be conducted on the following lines:

1. This exercise will be conducted for private sector industries of Pakistan in order to build a similar framework for their evaluation.

2. A comparison between the public and private sector efficiencies based on their audit results canalso be evaluated.
3. A similar study can also be conducted to compare the performance of the service versus manufactured goods providing units of Pakistan

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