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THE IMPACT OF TECHNOLOGY AUDIT ON TECHNOLOGY CAPABILITIES IN PAKISTANI TRAINING INSTITUTES

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Original Scientific Paper

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In recent times, there has been an increasing trend by organizations to focus on audits which help to find out their shortcomings and identify hidden opportunities. Technology audit is one significant example of audits being conducted in Pakistan. In this research, the benefits of the technology audit in the training institutes of Pakistan and its relationship with various technology capabilities are examined. The literature review developed a framework and revealed the positive and significant relationship of technology audit with specific technology capabilities. The top government sector organizations, such as WAPDA Engineering Academy, Faisalabad, and Regional Training Centre (Lahore & Faisalabad) were approached for responses to the questionnaire. For this study, a survey research methodology was adopted in the form of a questionnaire. 205 valid responses were used to analyse the data using Reliability analysis, Normality Tests, Correlation Matrix and Regression Analysis. The results revealed the potential benefits of technology audit, such as a better technology environment; improved knowledge about competitors; improved innovation; better quality and research; and improved technology creation, acquisition, exploitation, and protection. The tested and verified model filled to void in the literature of demonstrating the benefits of technology audit, and how this would allow the training institutes to identify the technical shortcomings in their organization leading to better technology capabilities. Moreover, as a practical contribution, macro and micro-level recommendations are made, supporting training institutes to improve overall organisation technology capabilities.

Keywords: Technology Audit; Quantitative Methods; Technology Capability.

INTRODUCTION

Presently, it is an era where the competition in organizations is at its peak (Rashid et al., 2020) Organizations try to perform better than their competitors to get a competitive advantage. So, organizations use various strategies to be able to present themselves as unique. One of the key areas for growth is to identify and eradicate shortcomings. In this regard, auditing is an important practice that is helpful (Huang, 2019).

Audits identify the current status of an organization in any particular area (Naik & Saunshi, 2017). For example, The use of financial audits, to identify financial lackings, is common in organizations. However, to judge the technological capacity of the organizations, a technology audit shall be used. Technology audit aids in identifying the strengths and weaknesses of an organization (Kovács & Stion, 2016). Moreover, it also helps to determine the position of an organization with respect to other organisations (mainly competitors). After conducting technology audits, proposals are developed that help to improve the technological capabilities of an organisation. These are mostly developed by consultants, from outside of the organisation, focusing on specific objectives. The most common goals are:

– To identify the position of the company's products and market to achieve growth with greater sustainability.
– To identify the areas in technology that need to be focused on.

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- To solve general problems that require innovative solutions.
- To find out the means of transferring technologies.

In Pakistan, although, different types of audits such as quality audits, and financial audits are conducted, however, anecdotal evidence suggests that it is not common to perform technology audits, especially, in training institutes. The possible reason for this is the unawareness of the organizations about the technology audit and its potential advantages. Furthermore, the literature lacks any information on the potential benefits of technology audits in training institutes, and why is it worth investing in adopting them. Therefore, a need to explore the impact of technology audit in a firm, with regard to technological advancements is needed to be identified. This leads to our overarching research problem:

> *"What is the role of technology audit performed in improving the technological capabilities of the organization"*

This research conducted a literature review to identify the previous studies, both theoretical and empirical, on the use of technology audit. This led to the development of a framework and associated hypotheses. Later, a quantitative analysis was conducted, leading to the discussion, and exploring the benefits of using a technology audit to improve an organization‟s technological capabilities.

LITERATURE REVIEW

In the past, technology has been defined in different ways and from different perspectives. For example, before 1930, technology was considered the study of industrial arts (Schatzberg, 2006). As technology advanced, it was defined as 'the way we do things' to help organizations achieve their objectives (Khalil, 2000). Arthur (2009) defined technology in a broader context as "a means to fulfill a human purpose" (Arthur, 2009). With regard to its impact on society, technology was viewed as an activity that impacts the overall organizational culture (Borgmann, 2006). Technology can significantly reduce the risk of failures (Bakator, Đorđević, Ćoćkalo, Nikolić, & Vorkapić, 2018). Similarly, White and Bruton (2010) defined technology as:

> "*It is the practical implementation of learning and knowledge by individuals and organizations to aid human endeavour*".

The Need for Technology Audit

Organizations have used different strategies, such as 5s tools, to improve the organizational business processes (Vorkapić, Ćoćkalo, Đorđević, & Bešić, 2017). Technology strategy includes the policies, plans, and procedures for acquiring knowledge and managing technology by exploiting them for maximum organizational profit. For developing the technology strategy of the organization, the role of technology audit cannot be undermined (Hannafin, 2008).

Several researchers agree that technology assessment methodologies need to be improved (James et al., 2000, Tushman, 1995; Zou, 2002). However, the measurement of technology integration along with technology adoption is regarded as a difficult business (Balbinot, 2007; Hannafin, 2008).

As a subset of technology strategy, a technology audit is used to identify the strengths and weaknesses of the technological assets of the organization (Khalil, 2000). The technological capacity, procedures, and needs of an SME are investigated using a technology audit (Kelessidis, 2000). This allows the organisations to recognize their technology needs, explore technology trends and establish a detailed course of action by depicting the current status of the organization and its potential role in technology solutions to achieve its business goals (Report on relevant methods and examples of Technology Audit, 2013). The iterative process keeps the organization coherent with the latest technology trends (Khalil, 2000). It is important to mention that there is no universal standard to carry out a technology audit, however, there are some general guidelines that are usually followed. For example, Ford (1988) stated that the technology audit helps to identify

- The technologies on which the business depends.
- The position of the company compared to its competitors.
- The Life cycle position on which the company depends.
- The strength of the company (Either product or process).

- The company's policy on protecting its technology.
- The emerging and developing technologies.
- The value of the company's technology to its customers.
- The company's systematic procedures for the optimal exploitation of technologies.
- The chances of sharing the technological assets of the organisations be shared with other organisations.
- The various factors that can positively or negatively affect the technological progress of the organisation.
- The new emerging technologies inside and outside the organisation.

Role of Technology Audit in Technology improvement

The technology audit models are not generally applicable to all organisations but are designed to assess specific organisations that are in the interest of the authors (Štrukelj & Dolinšek, 2011).
Technology audit has been a topic of interest in the Higher education institutions of the United Kingdom for the last few decades. Questions, such as what is a technology audit? Are there any standard procedures for these techniques? What are the outcomes of the audit? etc. have been majorly addressed. The major opportunities identified by the technology audit were patents, software product development, research opportunities, media exposure, consultancy services, etc. Technology audits, especially, information technology audits have been found to reduce risks (Stoel & Havelka, 2021).

To find the outcomes of the technology audit in the education sector, Dr Margret Sheen conducted a survey at the University of Strathclyde with the aim to identify the linkages of the faculty of science and engineering with the outside industry (Sheen, 1998). The key areas of technology interests of the university, such as the importance of the need for digital communication between the departments of the University and the Industry, were identified. Similarly, Kirkland (1994) displayed that the technology assessment in a university can enhance university research. For example, in 1992, the department of state decided to carry out audits in about 40 of the top higher education institutions which provided a snapshot of the current standings of these institutions. The results of the audit stated technology was not considered as the core area of interest by many institutes due to the possible distraction from teaching and research. Therefore, technology audit was considered a useful tool in terms of the exploitation of technology, however, should be practiced in conjunction with research and innovation.

In the health sector, Gerrard identified the positive impact of technology audit in identifying the current standings of veterinary practices in UK health (Gerrard & Little, 1994). For example, thermometers and stethoscopes were used as the basic diagnostic instruments, along with some more technologically advanced instruments, such as ophthalmoscopes and microscopes. Moreover, other than diagnostics, the technology also contributed to the areas of accounting, stock control, telecommunications, etc. As the veterinary is becoming increasingly specialized, the chances of more accurate diagnosis are increasing. Therefore, it was concluded that there is a potential relationship between the exploitation of new technologies and the organization's probability of reaching its maximum efficiency.

These researches indicated that the use of a technology audit helps to improve the organization 'technologically. Furthermore, previous research has focused more on the need for auditing in terms of finances, rather than technology, in the training institutes (Mugo, 2013). This warrants a need to explore further benefits of the technology audit, especially on the training institutes, which has not been researched enough.

MODEL SPECIFICATION

Although numerous work has been done to improve innovation still a large number of organizations fail to maintain and continue innovation (Cormican & O'Sullivan, 2004; Ahmed, 1998). Jakubavicius explained the relationship between the technology audit and innovation management (Jakubavičius & Vilys, 2008). Some of the innovation performance indicators were identified, as shown in Table 1, using which a questionnaire was developed and a survey was conducted to find a relationship between technology audit and innovation. The correlation analysis is shown in Table 1.

Table 1: Correlations of technology audit and innovation performance of the SME (Jakubavičius & Vilys, 2008)

Variable	Means	SD	Rate of product innovation	Rate of process innovation	Technology indicators	Overall benefit
Technology audit used	4.22	1.17	0.47	0.444	0.473	0.419

Strong positive relationships were found between technology audit and innovation. So, it was established that the technology audit plays a vital role in improving the innovation capabilities of the organization.

Similarly, in the development of the conceptual framework for this research, various other models and previous literature were used. A significant model, in this study, was the Garcia-Arreola TAM (Technology Audit Model), shown in Figure 1. Dolinšek et al. (2007) in their research paper on the development of the 'technology audit', focused on the companies who were striving for the improvement in efficiencies and the effectiveness of their technical capabilities. The major focus of the research was the implementation of TAM (Technology Audit Model) which could be beneficial for organizations to improve their technology capabilities. Technology capabilities are known to be the major driver of the firm's performance (Wilden & Gudergan, 2015). This TAM was used as a principal model in developing our conceptual framework.

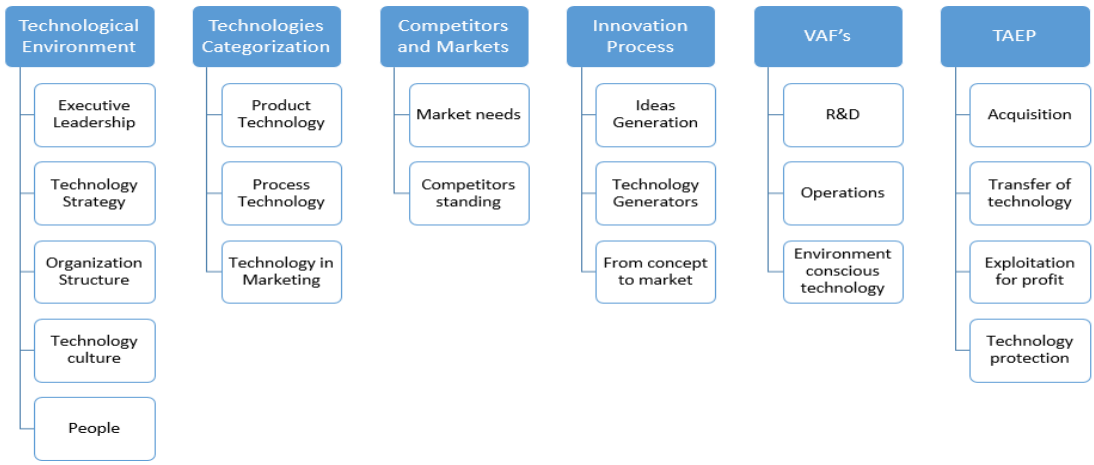

Figure 1: Technology Audit Model (TAM) Structure (Khalil, 2000)

This model identifies the major domains that Technology audit targets. These include Technological Environment, Technology Categorization, Competitors and Market, Innovation Process, Value-added functions (VAFs), Technology Acquisition, and Exploitation.

Similarly, a study on the technology audit with the case example in the School of Biological and Molecular Sciences BMS Oxford Polytechnic (Bell et al., 1992) was found relevant in the development of our conceptual framework. The technology audit was carried out to find opportunities in the institution. Mainly the opportunities were found in the areas of Research and Development, Technology Innovation, Collaboration with other institutes, Awareness about the changing trends and patents, and protecting technologies.

Furthermore, Dr Geoff Potter conducted a Technology audit at the Department of Chemistry at the University of Warwick (Bell et al., 1992). The potential benefits of technology audit found in his research consisted of Patents, Human Resource practices, and Organizational culture supporting technology.

Hannafin (2008) researched in the US regarding the technology audit in schools. The results of the audits found some of the findings of the technology audit. They found some improvements in the field regarding the implementation of new technology strategies, awareness about changing trends, technology innovation, acquisition, and exploitation.

The literature review in various educational/ training institutes showed some diversity in outcomes leading to the idea of a survey to see what might be of importance in a Pakistani training institute context. Further, the exact benefits of the technology audits need to be consolidated. From the TAM model and the work of authors, Figure 2 shows the significant areas that the technology audit can potentially impact, which are:

Technological Environment:
- Human Resource Practices,
- Implementing new technology strategies,
- Organizational culture supporting technology,
- Learning Organization.

Knowledge about Competitors:
- Competitors Assessment,
- Awareness about changing trends,
- Benchmarking.

Innovation:
- Technology Innovation,
- Ideas generation.

Quality & Research:
- Quality and standards,
- Research & Development,
- Analysing Progress.

Technology Acquisition and Exploitation:
- Creating acquiring and transferring technologies,
- Collaboration with other institutes,
- Exploiting current technologies,
- Patents and protecting technology.

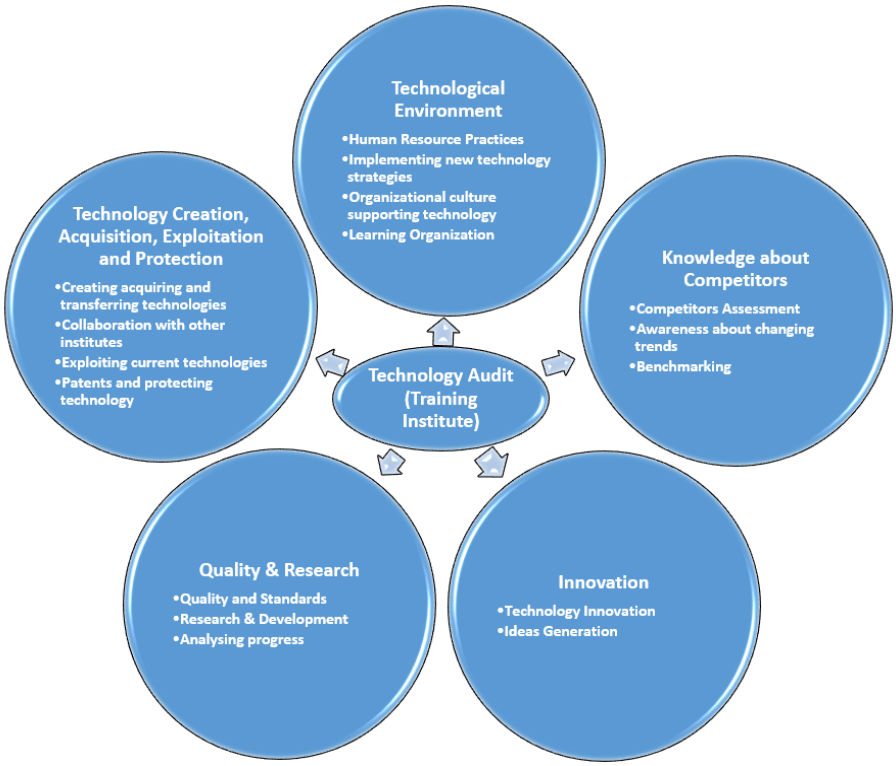

*Figure **Error! No text of specified style in document.**: Relationship of Technology Audit with Variables*

The Hypotheses developed from the model are:

H1: Technology Audit has a positive and significant impact on the Technological Environment.

H2: Technology audit has a positive and significant impact on knowledge about competitors.

H3: Technology audit has a positive and significant impact on Innovation.

H4: Technology audit has a positive and significant impact on Quality and Research.

H5: Technology audit has a positive and significant impact on Technology Creation, Acquisition, Exploitation, and Protection.

METHODOLOGY AND DATA COLLECTION

The research methodology was adopted from the book 'The advanced research methods' by Saunders et al. (2009). The positivism research philosophy was chosen for this research which means there is considered to have a single and

objective reality. In pursuance of this reality, a quantitative survey was used. Deductive research, which is used when already much of the work is done on the topic and further research is done to test the hypotheses, was chosen for this research.

Similarly, the purpose of research can be of three types; exploratory, explanatory, or descriptive (Saunders et al., 2009). Exploratory studies are conducted to find something new. Robson stated, "these studies are of great use to find out what is happening; to seek new insights; to ask questions and to assess phenomena in a new light" (Robson, 2002). Qualitative analysis and Inductive approach are examples of exploratory studies. Descriptive studies are referred to as "the studies which portray an accurate profile of a person, event or a phenomenon" (Robson, 2002). This is usually an extension of both explanatory and exploratory types of studies. In an explanatory study, we usually create a relationship between different types of variables. These studies usually create a relationship between different types of dependent and independent variables. For this research, an explanatory type of research was followed.

Questionnaire

According to Saunders et al. (2006), there are three types of sources that can be used for the collection of data; primary, secondary, and tertiary. The primary data in this research was gathered from the questionnaires and secondary data from organizational reports etc.

The main use of questionnaire-based research is to test the hypotheses. The questionnaire, adapted from Garcia-Arreola TAM (Technology audit model), consisted of questions relating to technology audit and technology capabilities. Firstly, a pilot questionnaire was circulated to understand the 'respondent fatigue and awareness'. 30 results were obtained. For this pilot study, Cronbach's Alpha was 0.82 which is acceptable (Hair, 2018). A total of 17 five-point Likert scale questions, based on five categories, were used for this research survey and the options ranged from strongly agree to strongly disagree.

Questions were formulated in such a way as to gather adequate information. Full efforts were made to remove the participant and the observer errors and minimise the bias error.

Sampling Technique

Purposive sampling was used for the data collection. In this technique, the respondents are selected based on certain qualities they possess (Etikan et al., 2016). In this case, the required quality of the respondent was adequate knowledge and understanding of the recently adopted technologies by their organization. A total of 281 questionnaires were distributed in three institutions. Some questionnaires were filled on the spot and most of them were handed over to the administration. A total of 208 questionnaires were gathered from the institutions. Their details have been mentioned in Table 2. Out of these, 3 were unfilled and incomplete, leaving 205 valid responses. So the overall response rate was 72.9%.

Table 2: Information of respondents

Age				
	Frequency	Percent	Valid Percent	Cumulative Percent
18-25	22	10.7	10.7	10.7
26-35	83	40.5	40.5	51.2
36-60	100	48.8	48.8	100.0
Total	205	100.0	100.0	
Qualification				
	Frequency	Percent	Valid Percent	Cumulative Percent
Under Graduate	50	24.4	24.4	24.4
Graduate	117	57.1	57.1	81.5
Postgraduate	35	17.1	17.1	98.5
PhD	3	1.5	1.5	100.0
Total	205	100.0	100.0	

DATA ANALYSIS AND RESULTS

Reliability, Validity, and Normality

Firstly, it is important to conduct the reliability test of the questionnaire, after which further analysis can be done. A reliability of 0.7 and above is considered very good (Hair, 2018). The reliability that has been calculated for each variable separately has been above 0.6 which is an acceptable range. So based on these results, the questionnaire has been proven to be fit to carry out further analysis, as shown in Table 3.

The questionnaire has been adapted from a validated model published in a book by Khalil (2000). Further, it has been validated by industrial experts and academic professors. They have done the content validity and face validity of the

questionnaire and declared the questionnaire valid for this research.

Table 3: Reliability Tests

Technology Audit	
Cronbach's Alpha	N of Items
.760	3
Technological Environment	
Cronbach's Alpha	N of Items
.770	4
Knowledge about competitors	
Cronbach's Alpha	N of Items
.744	3
Innovation	
Cronbach's Alpha	N of Items
.660	2
Quality and Research	
Cronbach's Alpha	N of Items
.635	3
Technology Creation, Acquisition, Exploitation and Protection	
Cronbach's Alpha	N of Items
.759	4

For the best results of the statistical analysis, one must be sure about the distribution of data. If the data distribution is close to normal, the results will be accurate. Once the normality of the data is tested, one can now select the statistical tools for this type of data. Therefore checking the normality of the data is considered a vital part of the research to obtain accurate results. The skewness and kurtosis method is usually used to check the normality of the data. The accepted range of skewness is taken from -1 to +1 and kurtosis is taken from -2 to +2 (George & Mallery, 2010). The normality test of our data for individual variables was carried out and all the data was found within the prescribed limits of normality.

The correlation analysis of the variables, as shown in Table 4, was conducted, as shown in Table 3. It is observed that the technology audit has the strongest correlation with 'Technology creation, acquisition, and exploitation' while the weakest relationship is with 'knowledge about competitors'. This will be further discussed in regression analysis for testing individual hypotheses.

A regression test for each of the hypotheses was conducted and the results were displayed.

Table 4: Correlations Analysis

	TA	TE	KAC	I	QR	TCAEP
Technology Audit (TA)	--					
Technological Environment (TE)	0.513**	--				
Knowledge about Competitors (KAC)	0.381**	.970**	--			
Innovation (I)	0.501**	.855**	.799**	--		
Quality and Research (QR)	0.446**	.958**	.923**	.849**	--	
Technology Creation Acquisition, Exploitation and protection (TCAEP)	0.586**	.991**	.959**	.858**	.952**	--

H1: Technology Audit has a positive and significant impact on Technological Environment

For testing the hypothesis, a regression is measured between the dependent and independent variables. Technology audit is the independent variable while the Technological Environment is the dependent variable.

In regression analysis (Table 5), the value of R (0.513) shows a strong relationship between technology audit and the technological environment. R square value (0.263) shows that 26.3% variance in the dependent variable is due to the technology audit.

As shown in Table 6, for every unit increase in technology audit, there is a 0.482 increase in the Technological environment. The sig value is less than 0.05 which shows that the independent variable rightly predicts the dependent variable.

Hence, Technology audit has a positive and significant impact on the technological environment.

H2: Technology audit has a positive and significant impact on knowledge about competitors

For testing the hypothesis, a regression is measured between the dependent and independent variables. Technology audit is regarded as the independent variable while Knowledge about competitors is regarded as the dependent variable.

In the case of regression analysis (Table 7), the value of R (0.381) shows a strong relationship between technology audit and 'knowledge about competitors'. R square value (0.145) shows that a 14.5% variance in the dependent variable is due to the technology audit.

As shown in Table 8, for every unit increase in technology audit, there is a 0.392 increase in 'Knowledge about competitors'. The sig value is less than 0.05 which shows that the independent variable rightly predicts the dependent variable.

Hence, Technology audit has a positive and significant impact on 'Knowledge about competitors'.

Table 5: Regression model summary - Technological Environment

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.513a	.263	.259	.60055
a. Predictors: (Constant), Technology Audit				

Table 6: Coefficients Summary- Technology Audit Vs Technological Environment

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.366	.145		9.454	.000
	Technology Audit	.482	.057	.513	8.514	.000
a. Dependent Variable: Technological environment						

Table 7: Regression model summary- Knowledge about competitors

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.381a	.145	.141	.70984
a. Predictors: (Constant), Technology Audit				

Table 8: Coefficients Summary- Technology Audit Vs Knowledge about competitors

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.636	.171		9.579	.000
	Technology Audit	.392	.067	.381	5.865	.000
a. Dependent Variable: Knowledge about competitors						

H3: Technology audit has a positive and significant impact on innovation

For testing the hypothesis, a regression is measured between the dependent and independent variables. Technology audit is regarded as the independent variable while Innovation is regarded as the dependent variable.

In the case of regression analysis (Table 9), the value of R (0.501) shows a strong relationship between technology audit and 'Innovation'. R square value (0.251) shows that 25.1% variance in the dependent variable is due to the technology audit.

As shown in Table 10, for every unit increase in technology audit, there is a 0.464 increase in Innovation. The sig value is less than 0.05 which

shows that the independent variable rightly predicts the dependent variable.

Hence, Technology audit has a positive and significant impact on innovation

H4: Technology audit has a positive and significant impact on Quality and Research

For testing the hypothesis, a regression is measured between the dependent and independent variables. Technology audit is regarded as the independent variable while 'Quality and Research' is regarded as the dependent variable.

In the case of regression analysis (Table 11), the value of R (0.446) shows a strong relationship between technology audit and 'knowledge about competitors'. R square value (0.199) shows that 19.9% variance in the dependent variable is due to the technology audit.

As shown in Table 12, for every unit increase in technology audit, there is a 0.405 increase in 'Quality and Research'. The sig value is less than 0.05 which shows that the independent variable rightly predicts the dependent variable.

Hence, Technology audit has a positive and significant impact on 'Quality and Research'.

Table 9: Regression model summary- Innovation

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.501a	.251	.248	.59622
a. Predictors: (Constant), Technology Audit				

Table 10: Coefficients Summary- Technology Audit Vs Innovation

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.342	.143		9.355	.000
	Technology Audit	.464	.056	.501	8.254	.000
a. Dependent Variable: Innovation						

Table 11: Regression model summary: Quality and Research

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.446a	.199	.195	.60545
a. Predictors: (Constant), Technology Audit				

Table 12: Coefficients Summary- Technology Audit and Quality and Research

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.539	.146		10.564	.000
	Technology Audit	.405	.057	.446	7.094	.000
a. Dependent Variable: Quality and research						

H5: Technology audit has a positive and significant impact on Technology Creation, Acquisition, Exploitation, and Protection

For testing the hypothesis, a regression is measured between the dependent and independent variables. Technology audit is regarded as the independent variable while 'Creation, Acquisition, Exploitation and Protection' is regarded as the dependent variable.

In the case of regression analysis (Table 13), the value of R (0.586) shows a strong relationship between technology audit and 'knowledge about competitors'. R square value (0.344) shows that

34.4% variance in the dependent variable is due to the technology audit.

As shown in Table 14 every unit increase in technology audit, there is a 0.554 increase in Technology creation, acquisition, exploitation, and protection. The sig value is less than 0.05 which shows that the independent variable rightly predicts the dependent variable.

Hence, the Technology audit has a positive and significant impact on 'Technology Creation, Acquisition, Exploitation, and Protection'.

The final framework, showing the relationship of variables, is shown in Figure 3.

Table 13: Regression model summary- Technology Creation, Acquisition, Exploitation, and Protection

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.586a	.344	.341	.56982
a. Predictors: (Constant), Technology Audit				

Table 14: Coefficients Summary-Technology Audit and Technology Creation, Acquisition, Exploitation, and Protection

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.211	.137		8.831	.000
	Technology Audit	.554	.054	.586	10.315	.000
a. Dependent Variable: Technology Creation, Acquisition, Exploitation, and Protection						

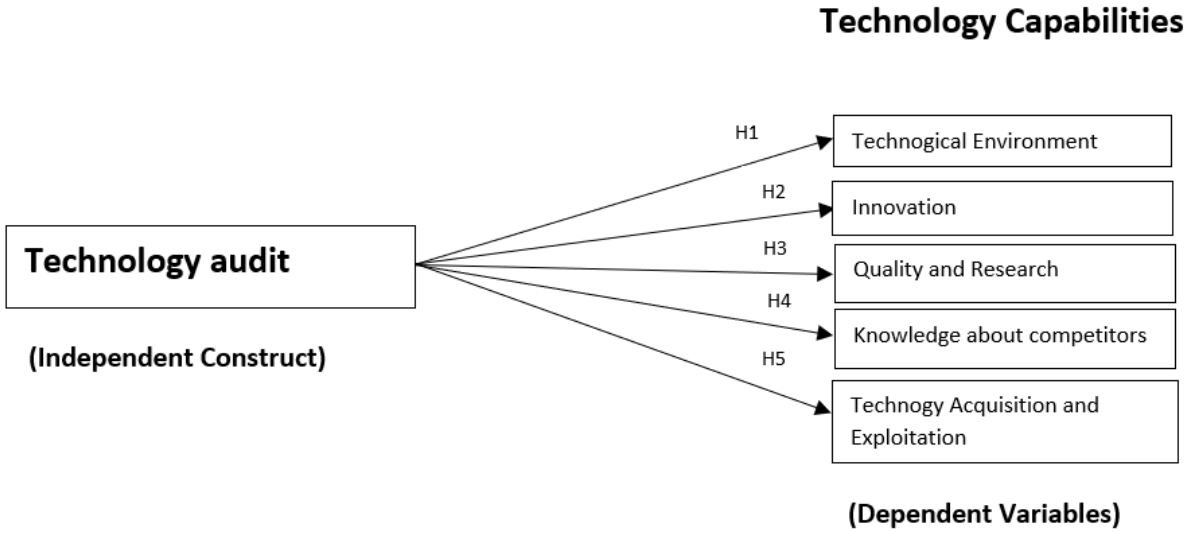

Figure 3: Relationship between technology audit and technology capabilities

DISCUSSION AND FINDINGS

The results revealed a strong association between the technology environment and the parameters of the technology capabilities of an organization. For example, the first hypothesis revealed that technology audit has a close association with the technology environment. In support of this, (Bross, 1999) asserted that the technology audit helps in developing new technology strategies, which in return helps to create the overall technology environment in the organization. Further, the second hypothesis was partially supported showing a low variance caused in the dependent variable of 'knowledge about competitors'. Bross (1999) stated that technology audit has the potential to improve the competitiveness of an organization in the industry, without any empirical reference.

Similarly, the third hypothesis demonstrated that the introduction to technology audit can enhance innovation practices in the organization. This was supported by, Gordon and Tarafdar (2010), who claimed that an audit, specifically an Information technology audit, can boost innovation in different industries and on different levels. This would result in an overall improvement in organizational performance, as implied by Adegbesan and Ricart (2007). Similarly, the fourth hypothesis was supported by different audits in other sectors, such as clinical audits in the medical sector that can improve the overall quality of clinical care in the hospitals (Siddiqi et al., 2008). The testing of the final hypothesis revealed that the technology audit can lead to better creation, acquisition, and exploitation of technology. Akbar and Suraida (2017) stated that technology audits will not work if the workers rely on their competence. Therefore, employees need to follow and acquire new technologies rather than just relying on their skills. This can lead to better technology exploitation. However, some literature states that technology adoption does not necessarily lead to technology creation (Liu et al., 2017). This warrants a need to be explored further.

Overall, it can be seen that the technology audit has the strongest association with technology acquisition, creation, and exploitation, while the weakest (although significant) association is the knowledge about competitors. This shows that technology audit leads to new ideas and innovation, which further leads to the better acquisition and creation of technology, while, it does not necessarily enhance the knowledge about the competitors, as it is also dependent on gathering audit results of competitors.

RECOMMENDATIONS AND CONTRIBUTION

The training institutes in Pakistan are making an effort to improve their standards and be transformed into better institutions in terms of technology, however, still, a lot of factors are acting as constraints. For example, lack of knowledge about the latest techniques, poor organizational culture, and lack of commitment are some of the general factors which hamper the growth of these institutions. Based on our research, there are a few recommendations at both the macro as well as micro-level, to improve the technological capabilities of the organizations.

Recommendations at National Level (Macro Level)

A few recommendations at the Macro level are:

- A national-level technology policy should be made to make Pakistan in line with the top technology-oriented countries. The policy-making panel should include highly expert professionals from various fields to formulate efficient and effective policies for technology growth. Further, the new areas in technology, such as digital technologies, should also be addressed and explored.
- The funding for the technology sector must increase substantially by some top technology-rich countries.
- Efficient steps regarding secrecy and protection of technology must be taken by the government to encourage the development of technology.
- Extra incentives must be awarded to the people involved in the government institutions which work for the development of technology.

Recommendations at Institutional Level (Micro Level)

- The institutions must be educated about the advantages of efficient technology audit and their role in technology growth. If the institutions are already practising technology audit, then it must be assessed as per standard technology audit models.
- The institutions must create a technology environment that would transform the overall organizational culture into a technology culture.
- The institutions must benchmark themselves with other top training institutes of the country as well as of other developed countries. This will help the training institutes to adopt good policies to cover up the shortcomings.
- The institutions must be aware of the changing trends in technology locally as well as globally. This will make these institutions assess where they are currently standing and what target they should achieve.
- Innovation in terms of technology must be promoted and the employees must be encouraged to float the ideas regardless of their position in the organization. This will encourage the growth of technology in these organizations.

- Research and Development play a vital role in the progress of any organization. Proper attention and funds must be allocated to these areas and special incentives must be given to the employees which are associated with this sector.
- The current technologies which are present in the organizations must be fully exploited and utilized. The creation of technology must be encouraged and in case of failure, proper technology acquisition measures must be taken.
- Protection of technology through patents must be done in the training institutes. Such practices will reward innovation and the creation of technology and will be a symbol of motivation.

Although the practice of technology audit is relatively common in the developed world, however, in Pakistan, it is not given much importance. This research would create awareness among organizations about the use of technology audit and their use as effective tools for enhancing the technological capabilities of the organizations (both in terms of teaching to trainees as well as using technology tools). Although this research was conducted in training institutes, the impact should not be restricted to this context and should be followed for any type of technology organization. The researchers who are researching in the field of technology could also from this research. They would understand that technology audits can play a significant role in the identification of hurdles in technology advancement. Moreover, the tested model may be applied to different types of organizations.

CONCLUSIONS

In the current global environment, organizations are adopting technology and becoming digitized at an exponential rate. In this era of technological growth, the standard of an organization can be judged by the type of technology it incorporates. Similarly, all the standard training institutions of Pakistan are striving hard to match up with the pace of rapidly changing technology and take a lead in comparison to others. In an attempt to answer the overarching research question, this research highlighted the importance of using technology audits in the organization. The positive relationship of technology audit with the technology environment, knowledge about competitors, innovations, quality, and research, and technology creation, acquisition, exploitation, and protection was conceptualized, tested, and verified. This research established that the technology audit has immense benefits starting from the acquisition of technology to become more innovative and developing better strategies. As for recommendations to the training institutes, indulging in the practice of regular technology audits can ultimately lead to better performance outcomes for the organizations.

This research is limited and restricted to the context of one country, i.e Pakistan. Further, only the training institutes are considered for this research. As a future recommendation, similar research can be conducted in other countries and use this research according to their environment. Moreover, the comparison of the public sector and private sector institutes in various technological environments, using specific technologies, such as digital technologies are proposed for future researchers. Finally, the research canvass can be expanded to other sectors, such as construction and information technology.

REFERENCES

Adegbesan, J. A., & Ricart, J. E. (2007). *What do we really know about when technological innovation improves performance (and when it does not)?* Working paper no. 668. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=982335

Akbar, M. S., & Suraida, I. (2017). Competence and Professional Care of External Auditor on Information Technology Audit. *Trikonomika, 16*(1), 21-27. https://doi.org/10.23969/trikonomika.v16i1.418

Arthur, W. B. (2009). The Nature of Technology. Newyork: Free press.

Bakator, M., Đorđević, D., Ćoćkalo, D., Nikolić, M., & Vorkapić, M. (2018). Lean startups with industry 4.0 technologies: Overcoming the challenges of youth entrepreneurship in Serbia. Journal of Engineering Management and Competitiveness, 8(2), 89-101.

Balbinot, Z., Luiz, Paulo, Bignetti. (2007). *Technological Capabilities of High Technology Firms in Cross Border Alliances.* San Diego: Elsevier Ltd.

Borgmann, A. (2006). Technology as a Cultural Force. *The Canadian Journal of Sociology, 31*(3), 351-360. https://doi.org/10.2307/20058714

Bross, U. (1999). Technology audit as a policy instrument to improve innovations and industrial competitiveness in countries in transition. *The European Journal of Social Science Research, 12*(3), 397-412. https://doi.org/10.1080/13511610.1999.9968611

Cormican, K., & O'Sullivan, D. (2004). Auditing best practice for effective product innovation management. *Technovation, 24*(1), 819-829. https://doi.org/10.1016/S0166-4972(03)00013-0

Dolinšek, S., Janeš, A., Čosić, P., & Ekinović, S. (2007). Development of The Technology Audit Model. Paper presented at the Managing Global Transitions: Globalisation, Localisation, Regionalisation, Proceedings of the *8th International Conference of the Faculty of Management Koper*, Portorož, Slovenia.

Etikan, I., Musa, S. A., & Alkassim, R. S. (2016). Comparison of convenience sampling and purposive sampling. *American Journal of Theoretical Applied Statistics, 5*(1), 1-4.

Ford, D. (1988). Develop Your Technology Strategy. *Long Range Planning, 21*, 85-95. https://doi.org/10.1016/0024-6301(88)90109-4

George, D., & Mallery, M. (2010). *Using SPSS for Windows step by step: a simple guide and reference*. Retrieved from Boston:

Gerrard, B., & Little, C. (1994). Technology audit of veterinary practice in the UK. *In Practice, 16*(4), 226-231.

Gordon, S. R., & Tarafdar, M. (2010). The IT audit that boosts innovation. *MIT Sloan Management Review, 51*(4), 39.Hair, J. F. (2018). *Multivariate data analysis*. Harlow: Pearson Education Limited.

Hannafin, R. D. (2008). K-12 Technology Audit: Lessons for School Leaders. *International Electronic Journal for Leadership in Learning, 6*.

Huang, X. (2019). Corporate Strategic Difference, High Audit Quality and Earnings Quality.

Zou, J. (2002). Methodologies and Tools for Technology Needs Assessment: an Overview. *Technology Management, 2*(2), 12-23. https://doi.org/10.1007/s00170-015-6893-9

Jakubavičius, A., & Vilys, M. (2008). Technology audit: Initial Tool for Supporting Innovations in Sme's. Paper presented at the *5th International scientific conference business and management*, Vilnius, Lithuania.

James, D., Eric, P., & Chiang, D. (2000). *Summary Report on Federal Laboratory Technology Transfer*. National Bureau of Economic Research.

Kelessidis, D. V. (2000). Technology Audit.

Khalil, T. M. (2000). *Management of Technology*. Singapore: The McGraw-Hill companies.

Kirkland, J. (1994). Technology audit: from ivory tower to brass tacks. *IEEE Review, 40*(5), 199-202. https://doi.org/10.1049/ir:19940506

Kovács, G., & Stion, Z. (2016). Innovation audit as a tool for boosting innovation power of universities. *Zarządzanie Publiczne, 35*(3), 221-235.

Liu, X., Vahtera, P., Wang, C., Wang, J., & Wei, Y. (2017). The delicate balance: Managing technology adoption and creation in multinational affiliates in an emerging economy. *International Business Review, 26*(3), 515-526. https://doi.org/10.1016/j.ibusrev.2016.11.002

Mugo, J. M. (2013). *Effects of internal controls on financial performance of technical training institutions in Kenya* (Doctoral dissertation, University of Nairobi).

Tushman, M. L. (1995). Special Boundary Roles in the Innovation Process. *Administrative Science Quarterly, 22*, 587-605. https://doi.org/10.2307/2392402

Naik, S. L., & Saunshi, B. (2017). Structural audit of RCC building.

Ahmed, P.K. (1998). Benchmarking innovation best practice. *Benchmarking for Quality Management & Technology, 5*(1), 45-58. https://doi.org/10.1108/14635779810206803

Rashid, M., Hafeez, M., Maeenuddin, A. K. S., & Wahid, N. (2020). The Role of Training and Development in Enhancing Employees Performance: Evidence from Sales Force of Pharmaceutical Companies at Shaheed Benazirabad Pakistan.

Report on relevant methods and examples of Technology Audit. (2013).

Robson, C. (2002). Real World Research: A Resource for Social Scientists and Practitioner-Researchers: Wiley.

Saunders, M. N. K., Thornhill, A., & Lewis, P. (2009). Research Methods for Business Students: Pearson Custom.

Schatzberg, E. (2006). Technik Comes to America: Changing Meanings of Technology before 1930. *Technology and culture, 47*(3), 486-512. https://www.jstor.org/stable/40061169

Siddiqi, K., Volz, A., Armas, L., Otero, L., Ugaz, R., Ochoa, E., . . . Walley, J. (2008). Could clinical audit improve the diagnosis of pulmonary tuberculosis in Cuba, Peru and Bolivia? *Tropical Medicine, 13*(4), 566-578. https://doi.org/10.1111/j.1365-3156.2008.02035.x

Sheen, M. (1998). Capitalizing Knowledge: New Intersections of Industry Academia.

White, M. A., & Bruton, G. D. (2010). *The Management of Technology and Innovation: A Strategic Approach*. Cengage Learning.

Wilden, R., & Gudergan, S. P. (2015). The impact of dynamic capabilities on operational marketing and technological capabilities: investigating the role of environmental turbulence. Journal of the Academy of Marketing Science, 43(2), 181-199.

UTICAJ TEHNOLOŠKE REVIZIJE NA TEHNOLOŠKE SPOSOBNOSTI U PAKISTANSKIM INSTITUTIMA ZA OBUKU

U poslednje vreme, sve je veći trend organizacija da se fokusiraju na revizije koje pomažu da se otkriju njihovi nedostaci i identifikuju skrivene šanse. Tehnološka revizija predstavlja značajan primer revizija koje se sprovode u Pakistanu. U ovom istraživanju se ispituju prednosti tehnološke revizije u institutima za obuku u Pakistanu i odnosi sa različitim tehnološkim mogućnostima. Kroz pregled literature razvio se okvir i otkrio se pozitivan i značajan odnos revizije tehnologije sa specifičnim tehnološkim mogućnostima. Za popunjavanje upitnika obraćeno najvećim organizacijama iz vladinog sektora, kao što su WAPDA Inženjerska akademija, Faisalabad i Regionalni centar za obuku (Lahore & Faisalabad). Za ovu studiju usvojena je metodologija anketnog istraživanja. Ukupno 205 validnih odgovora je korišćeno za analizu podataka korišćenjem analize pouzdanosti, testova normalnosti, korelacione matrice i regresione analize. Rezultati su otkrili potencijalne prednosti tehnološke revizije, kao što je bolje tehnološko okruženje; poboljšano znanje o konkurentima; poboljšane inovacije; bolji kvalitet i istraživanje; i poboljšano stvaranje, nabavka, eksploatacija i zaštita tehnologije. Testirani i verifikovani model doprinosi literaturi koja pokazuje prednosti tehnološke revizije i kako bi to omogućilo institutima za obuku da identifikuju tehničke nedostatke u svojoj organizaciji koji vode ka boljim tehnološkim mogućnostima. Štaviše, kao praktičan doprinos, date su preporuke na makro i mikro nivou, koje podržavaju institute za obuku da poboljšaju sveukupne tehnološke sposobnosti organizacije.

Ključne reči: Tehnološka revizija; Kvantitativne metode; Tehnološka sposobnost.