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Adoption of Computer-Aided Technology (CAx) in Textile and Apparel Industries

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ABSTRACT
The extended nature of industrial operations demanded the integration of information and communication technologies (ICT) and computer aided technology (CAx) in industrial processes. Although there are 130 textile and apparel industries in Ethiopia, the adoption of such technology is limited. Hence, this research studied factors affecting CAx adoption through the extension of the technology acceptance model of Davis (1989) by adding perceived competitive advantage, cost effectiveness, and perceived security. The finding revealed that perceived ease of use, perceived service, perceived competitive advantage, cost effectiveness, perceived security and perceived usefulness are significant predictors of intention to use CAx in textile and apparel industries.

General Terms
Information Systems, ICT Adoption, Technology Acceptance, Computer-Aided Technology.

Keywords
Technology Adoption, Technology Acceptance, ICT Adoption, ICT in industries, CAx

1. INTRODUCTION
Information and Communication Technologies (ICT) are changing the way organizations do businesses, and transforming public service delivery [1]. Industries use these technologies to facilitate product manufacturing, process management, and administrative operations. Researches show that ICT is an enabler for any industry in creating an efficient information handling, processing, disseminating, storing mechanisms, and getting feedbacks from customers [2]. The textile and apparel industry is one of the most globalized industries in the world. The global apparel market is valued at 3 trillion UDS, and accounts for 2% of the global gross domestic product (GDP) [3]. This industry encompasses 6% of the global production and 14% of the world employment in manufacturing industries [4].

The use of ICT is no longer an optional tool for developing country manufacturers demanding to boost their involvement in this competitive global textile and apparel market where speed-to-market and price are major determinants. According to McNamara (2008), “The shift to ‘just in time’ operations is possible with the appropriate uses of ICT across the length of the value chain. At the same time, as margins are driven lower by global competition, ICT can help secure necessary cost savings in the sourcing and manufacturing process” [5].

ICT has different forms in textile and apparel industries but collectively it is known as Computer -aided technology (CAx). It is a general term that refers to the use of computer technology to assist in design, analysis, and manufacture of products [6]. It is shortly expressed as CAx where CA stands for “Computer-Aided” and “x” stands for any activity that the computer technology assists to. CAx commonly comprises computer-aided design (CAD) that is used for development of designs, creating and grading patterns and lay planning; computer-aided manufacturing (CAM) which is used for store design, lay planning and cutting, sewing and pressing; computer-aided engineering (CAE) used for simulation, validation, and optimization of products, processes, and manufacturing tools; computer-aided process planning (CAPP) which assists the process planning in manufacturing a part or a process by mediating CAD and CAM; computer-aided styling (CAS) that involves sketching, 3D modeling, and converting the model into CAD files; and product data management (PDM) that is used in handling and managing electronic information related to a products. Recent developments in digital printing are enabling rapid prototyping of textile designs and are cost-effective solutions for more expensive processes.

In industries, computer-aided or assisted technologies are referred to as CAx that support varieties of services. In textile and apparel manufacturers, CAx aids them in planning, design, manufacturing, and accessing information about products, processes, and prices.

CAx is enhancing the fashion industry in assisting design, development and sampling of textiles more efficiently. Industries which have implemented CAx confirmed that it is improves efficiency, highly cheaper, enhances clarity, and reduces duplication. The industry uses CAx in fashion design, design package storage, pattern making, pattern laying and cutting, making a finished sample, grading and sizing of products, planning, product design and development, material and color development, sourcing, and quality and compliance assurance [7]. Moreover, CAx enabled firms to exchange the right product information to the right receiver at the right time [8]. Consequently, firms have been adopting such technologies so as to improve their efficiency.

Although 130 Textile and garment firms found in Ethiopia, the textile manufacturing sector showed insignificant economic contribution to the country [9]. The Ethiopian textile and apparel firms are being challenged from low productivity, limited quality awareness, ineffective and inefficient management structures, limited capability of own design and development, inefficient system, and limitations of skills training [10]. Moreover, the sector has also challenges such as shortfall in infrastructure, potential competitors, sustainability, excessive costs incurring in logistics, administrative red-tape and rigidity [11].

In this competitive global market, establishment of good information and communication mechanisms is becoming mandatory for textile and apparel industries. Besides, CAx are facilitating industry activities drastically. However, the adoption of such technologies is limited in Ethiopian Textile and Apparel Industries (ETAI). Thus, this research work has the objective of identifying factors affecting CAx adoption in ETAI in order to develop technology adoption strategies that will create improved productivity, and accessible product data and control mechanism. Moreover, the research outcome will be a helpful tool for different scholars working on CAx technologies and fashion industries as reference material.

This field survey research followed positivist epistemological assumptions to gather and analyze data from selected ETAI using structured questionnaire, document analysis, and field-observation as main data gathering instruments. The data was analyzed using statistical software and then interpreted in line with the objective of the research.

Finally, based on the research outcome, conclusions were drawn; and recommendations were forwarded.

2. PROBLEM STATEMENT

Although manufacturing industries have been manually processing information concerning products, processes, and managerial issues beginning from the industrial age, gradually they applied modern technological products such as ICT in order to reduce the time and effort of employees. The introduction of ICT brought significant impact in controlling routine operations and exchanging industrial information [12]. Industries use ICT to control inputs, processes, output, feedbacks, and distribution of information. The expansion of ICT is changing how business organizations and individuals are operating. ICT has been used in inter-business or inter-organizational transactions such as e-commerce, consumer-to-consumer (C2C); business-to-government (B2G); business-to-business (B2B); business-to-consumer (B2C); and mobile commerce (m-commerce) [13]. Moreover, in relation to the expanding nature of industrial activities and the competitive market, it is becoming mandatory to be assisted by CAx. Globalization enabled industries to be interconnected in order to exchange product, process/manufacturing and administrative information.

Although the global textile and apparel sector is growing and significantly contributing to countries' GDP, in Ethiopia, the contribution of the sector was 1.6% in 2010; and in 2014 the manufacturing share in general was 4.1% of GDP [14].

Researches show that industries which have understood the benefits of CAx have adopted them earlier and improved their performances. Gholami et al (2004), confirmed that ICT investment showed positive effect on the technical efficiency and production processes [15]. However, acceptance of such CAx in ETAI is challenging and it is limited to some latest industries alone. This is due to lack of information on the impact of CAx on their productivity. Hence, this research investigated factors affecting adoption of CAx in ETAI in order to improve the performance of industries.

The objective of this research was to identify factors affecting CAx adoption in ETAI in order to improve their performance.

Consequently, this leads to the following research questions: (1) What are the factors that impact textile industries' acceptance of CAx in ETAI? (2) To what extent do these factors affect CAx adoption in ETAI? (3) What is the status of CAx adoption in ETAI?

3. THEORETICAL FRAMEWORK

A core set of theoretical framework emanates from a body of research on CAx acceptance. Having the objective of identifying factors affecting CAx acceptance in ETAI, this research work has reviewed relevant and related literature on technology acceptance.

To study technological acceptance by individuals and organizations, several technology acceptance theories have been utilized by various researchers. For instance, Theory of Reasoned Action (TRA) was developed in 1975 by Fishbein and Ajzen. According to this theory "individual behavior is driven by behavioral intentions where behavioral intentions are a function of an individual's attitude toward the behavior and subjective norms surrounding the performance of the behavior" [16].

Diffusion of Innovation (DOI) was first formulated by Rogers (1983). This theory states that "Individuals are seen as possessing different degrees of willingness to adopt innovations and thus it is generally observed that the portion of the population adopting an innovation is approximately normally distributed over time. Breaking this normal distribution into segments leads to the segregation of individuals into the following five categories of individual innovativeness (from earliest to latest adopters): innovators, early adopters, early majority, late majority, and laggards" [17].

Technology Acceptance Model (TAM) was first developed by Davis et al in 1989. According to this theory, "perceived usefulness and perceived ease of use determine an individual's intention to use a system with intention to use serving as a mediator of actual system use" [18].

Then, Task Technology Fit Theory (TTF) was developed by Goodhue and Thompson in 1995. This theory states that "information technology is more likely to have a positive impact on individual performance and be used if the capabilities of the IT match the tasks that the user must perform" [19].

Unified Technology Acceptance Theory (UTAUT) was developed by Venkatesh et al in 2003. This theory states that "user intentions to use an information systems and subsequent usage behavior. Four key constructs (performance expectancy, effort expectancy, social influence, and facilitating conditions) are direct determinants of usage intention and behavior. Gender, age, experience, and voluntariness of use are posited to moderate the impact of the four key constructs on usage intention and behavior" [20].

Hence, the researcher hypothesized that acceptance of CAx is affected by other factors too such as perceived competitive advantage, perceived security, cost effectiveness and perceived service.

Perceived ease of use: the degree to which customers believe that using a particular new technology would be free of effort [18] [21] [22] [23]. Perceived usefulness: the degree to which customers believe that using a particular new technology would enhance their job performance [18] [21] [22] [23] [24]. Perceived competitive advantage: the degree to which customers believe that using a particular new technology would enhance their competitive advantage in the market [25]. Cost effectiveness: the degree to which customers believe that the cost of a new technology desired to be adopted is affordable and it deserves for the intended service [25] [26]. Perceived security: the degree to which customers believe that using a certain technology is secured; it would be safe, free from risk and maintain their privacy [27] [28]. Behavioral intention to use: The degree to which customers believe and plane to use a particular new technology [18] [21] [22] [23] [24].

Based on the theoretical propositions of the TAM and related relevant literature, this study proposed then hypotheses with regard to the adoption of CAx in textile and apparel industries.

H1a: Perceived ease of use is positively related to perceived usefulness of computer-aided technology in textile and apparel industries.

H1b: Perceived service is positively related to perceived usefulness of computer-aided technology in textile and apparel industries.

H1c: Perceived competitive advantage is positively related to perceived usefulness of computer-aided technology in textile and apparel industries.

H2a: Perceived ease of use is positively related to behavioral intention to use computer-aided technology in textile and apparel industries.

H2b: Perceived usefulness is positively related to intention to use of computer-aided technology in textile and apparel industries.

H2c: Perceived security is positively related to intention to use of computer-aided technology in textile and apparel industries.

H2d: Cost effectiveness is positively related to intention to use of computer-aided technology in textile and apparel industries.

H2e: Perceived competitive advantage is positively related to intention to use of computer-aided technology in textile and apparel industries.

H3: Intention to use computer-aided technology is positively related to its actual use in textile and apparel industries.

H4a: Cost effectiveness is positively related to perceived competitive advantage of computer-aided technology.

H4b: Cost effectiveness is positively related to perceived service computer-aided technology. Fig. 1 shows the research model and the proposed hypotheses.

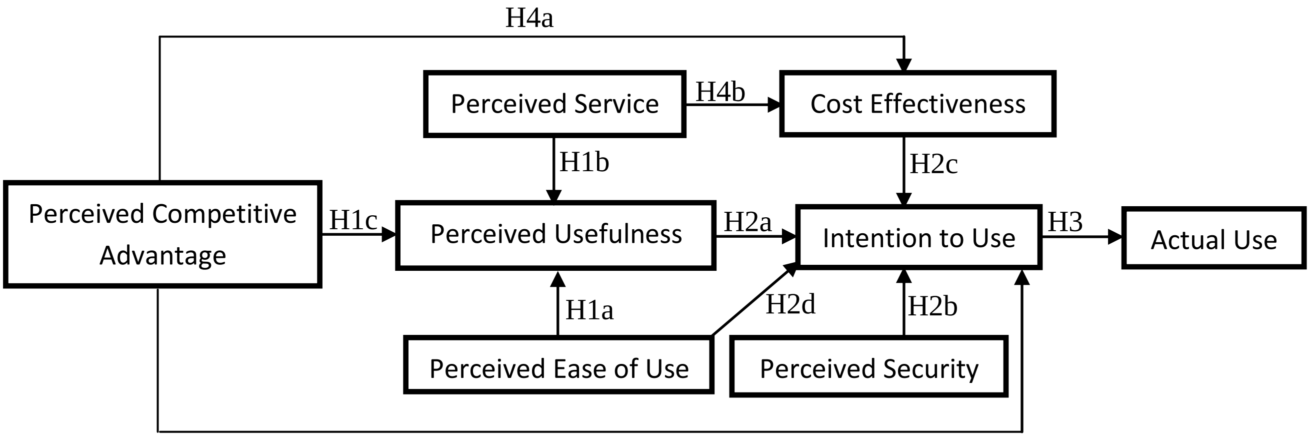

Fig. 1: Proposed Research Model

4. METHODOLOGY

Research philosophy shows the perspective of the researcher in determining the research design and methodology [29]. Philosophical stand of the researcher shows the position of the researcher in fact finding. Epistemology is a branch of philosophy that constitutes what is known to be true in a particular field of study. Two philosophical assumptions exist in research: positivism and post-positivism/ interpretivism/ constructivism/ phenomenology. Positivist epistemology assumes that knowledge is objective, measurable and it is objectively described [30]. On the other hand, interpretivist epistemology assumes that knowledge is subjective and it depends on human mind, values, perceptions and contextual issues [31]. In order to address the raised research questions and objective of this research, positivist philosophical assumptions are found to be appropriate.

This study used quantitative research design in order to examine the adoption of computer-aided technologies in ETAI. Research design denotes the strategy by which the study data was collected, measured and analyzed in an appropriate way so as to address the purpose of the study [32]. One of the aspects of research design is research approach. There are three types of research approaches; quantitative, qualitative and mixed approach [33]. The research approach is selected based on the type of research questions that the study raised the research philosophical stand of the researcher. That means if positivists follow quantitative approach while interpretivists apply qualitative approach. Quantitative measures were used in order to answer research questions. In Ethiopia, there are 130 textile and apparel industries. This figure constitutes the population of this research work. Two hundred fifty-seven samples were selected using stratified sampling strategy. Stratification criteria of the population includes type of product the industry is producing, their foreign relations and marketing strategy.

This survey study gathered data from samples using questionnaire, interview, document analysis, and field observation. The primary instrument was standardized questionnaire which constitutes questions under each construct. The last version of the instrument consisted of thirty-nine 5-Likert scale questions on adoption of computer-aided technologies in textile and apparel industries. The data that was collected through this instrument enabled the researcher to measure CAx adoption quantitatively. Since this research work deployed quantitative research type, deductive data analysis method was carried out. The theory-based quantitative data was analyzed using SPSS statistical software.

The sample population in this research were 257 employees of ETAI. Two hundred fifty-seven responses were collected from 56 different ETAI. From the 257 responses received, 15 were incomplete responses and excluded from the study. All of the respondents participated in the study with full willingness. All of the 242 respondents have ICT background. Most of the respondents were males (Table 1) whom account for 81%. Most of them were between the age of 31 and 40; their highest education completed is first degree. Most of were managers, marketing and sales officers.

Validity of the study is measured by its Cronbach Alpha value. According to [34], the acceptable Cronbach Alpha (α) value has to exceed 0.7. The result of this study shows that all of the constructs had α> 0.8 which is acceptable and strong. (Table 2) Although the optimal value for composite reliability was 0.7, results reported that all constructs exceeded 0.8 which showed strong reliability of the survey. Another measure of reliability to assess convergent validity was average variance extracted (AVE). AVE results should be greater than 0.5 which means fifty or more of the variance of the indicators should be accounted for [35].

Table 1: Demographic characteristics of participants

	Characteristics	Frequency	Valid Percent
Gender	Male	195	81
	Female	47	19
Age	Less than 21	15	6
	22 - 30	51	21
	31 - 40	93	38
	41 - 50	57	24
	Above 50	26	11
Education Level	High school	16	7
	College	76	31
	First degree	134	55
	Graduate	16	7
Occupation	Designer	41	17
	Marketing officer	62	26
	Manager	68	28
	Sales	56	23
	Others	15	6
Year of Service	Less than 1	25	10
	1 - 5	43	18
	6 -10	92	38
	10 - 15	52	22
	Above 15	30	12

Table 2: Psychometric properties of the survey scale

Variable	Item	Composite Reliability	AVE	α	Mean	Std. Dev
AU	2	0.871	0.772	0.711	3.281	1.470
IU	2	0.856	0.601	0.782	5.595	1.314
PU	7	0.917	0.614	0.907	3.318	1.279
EF	7	0.930	0.658	0.908	3.405	1.394
PEU	6	0.919	0.657	0.890	3.054	1.391
CE	4	0.852	0.592	0.758	3.409	1.444
PCA	6	0.898	0.689	0.835	3.174	1.358
PS	5	0.921	0.702	0.892	3.227	1.467

AU- actual use; IU- intention to use; PU- perceived usefulness; EF- effective functionality; PEU- perceived ease of use; CE- cost effectiveness; PCA- perceived competitive advantage; and PS- perceived security.

5. RESULTS

The Pearson product-moment correlation coefficient was used to test the relationship between variables that were hypothesized in this study. According to Kothari (2004) "amongst the measures of relationship, Karl Pearson's coefficient of correlation is the frequently used measure in case of statistics of variables" [36]. Based on Pearson's coefficient analysis, if a coefficient value r is above 0.5 it shows significant correlation between two variables. In this study, ten hypotheses were analyzed. All hypotheses showed positive association between the factors at a significance value of 0.01. The first hypothesis (H1a) stated that perceived ease of use (PEU) is positively related to perceived usefulness (PU) of CAx. The correlation coefficient between these two variables is r=0.797 at p<0.05, which depicts positive correlation. Hence, hypothesis 1a (H1a) is supported. The second hypothesis (H1b) stated that perceived service (PeS) is positively related to perceived usefulness (PU) of CAx. The correlation coefficient between these two factors is r=0.751 at p<0.05, which portrays positive correlation. Therefore, hypothesis 1b (H1b) is supported. The third hypothesis (H1c) stated that perceived competitive advantage (PCA) is positively related to perceived usefulness (PU) of CAx. The correlation coefficient between these two factors is r=0.806 at p<0.05, which represents strong positive correlation. Therefore, hypothesis 1c (H1c) is supported. The fourth hypothesis (H2a) stated that perceived usefulness (PU) is positively related to intention to use (IU) of CAx. The correlation coefficient between these two factors is r = 0.810 at p < 0.05, which portrays strong positive correlation. Therefore, hypothesis 2a (H2a) is supported. The fifth hypothesis (H2b) stated that perceived security (PS) is positively related to intention to use (IU) of CAx. The correlation coefficient between these two factors is r=0.711 at p<0.05, which shows positive correlation. Therefore, hypothesis 2b (H2b) is supported. The sixth hypothesis (H2c) stated that Cost effectiveness (CE) is positively related to intention to use (IU) of CAx. The correlation coefficient between these two factors is r=0.862 at p<0.05, which shows positive correlation. Therefore, hypothesis 2b (H2b) is supported. The seventh hypothesis (H3) stated that intention to use (IU) is positively related to actual use (AU) of CAx. The correlation coefficient between these two factors is r=0.738 at p<0.05, which shows positive correlation. Therefore, hypothesis 3 (H3) is supported. The eight hypothesis (H4a) stated that Cost effectiveness (CE) is positively related to perceived competitive advantage (PCA) of CAx but it is the least relation in the model. The correlation coefficient between these two factors is r=0.564 at p<0.05, which shows positive correlation. Therefore, hypothesis 4a (H4a) is supported. The ninth hypothesis (H4b) stated that Cost effectiveness (CE) is positively related to perceived service (PeS) of CAx. The correlation coefficient between these two factors is r=0.715 at p<0.05, which shows positive correlation. Therefore, hypothesis 4b (H4b) is supported. All correlation tests were found significantly supporting all hypotheses stated in this study.

In order to identify the predictors of perceived usefulness (PU), intention to use (IU) and actual use (AU) of computer-aided technologies, multiple regression analysis was carried out between independent variables and dependent variables. As shown in Table 3, two regression analysis tests were performed in this study. The first regression analysis was performed between the independent variables, including perceived ease of use (PSU), perceived competitive advantage (PCA), and perceived service (PeS), and the dependent variable perceived usefulness (PU).

Table 3: Results of multiple regression analyses

Hypotheses	Path	R^2	F	Std. Error	β	t
H1a	PU→PEU			.030	.40	12.46
H1b	PU→EF	.853	467.7	.030	.27	8.75
H1c	PU→PCA			.032	.39	11.84
H2a	IU→PU			.034	.51	15.91
H2b	IU→PS	.872	542.1	.027	.21	7.03
H2c	IU→EC			.029	.34	10.47

The coefficient of determination R^2 measures the proportion of the variance in the dependent variable that is predictable from the independent variables [37]. Higher coefficient of determination indicates greater explanatory power of the regression model. The value of R^2 for perceived usefulness (PU) is 0.853, meaning that 85.3% of the variance in perceived usefulness is explained by this regression model. This high value of R^2 depicts that the regression model is very good. The model is statistically significant at F=467.7, confidence interval=95%, and p<0.001. Regression coefficients of perceived service, perceived competitive advantage, and perceived ease of use are statistically significant.

The second regression analysis was performed between the independent variables, including perceived security (PS), Cost effectiveness (PeS), and perceived usefulness (PU), and the dependent variable intention to use (IU). The value of R2 for intention to use (IU) is 0.939, meaning that 93.9% of the variance in intention to use computer-aided technologies is explained by this regression model. This high value of R2 depicts that the regression model is very good. The model is statistically significant at F=542.1, confidence interval=95%, and p<0.001. As shown in the Fig. 2, regression coefficients of perceived usefulness, Perceived Cost, and perceived security are statistically significant.

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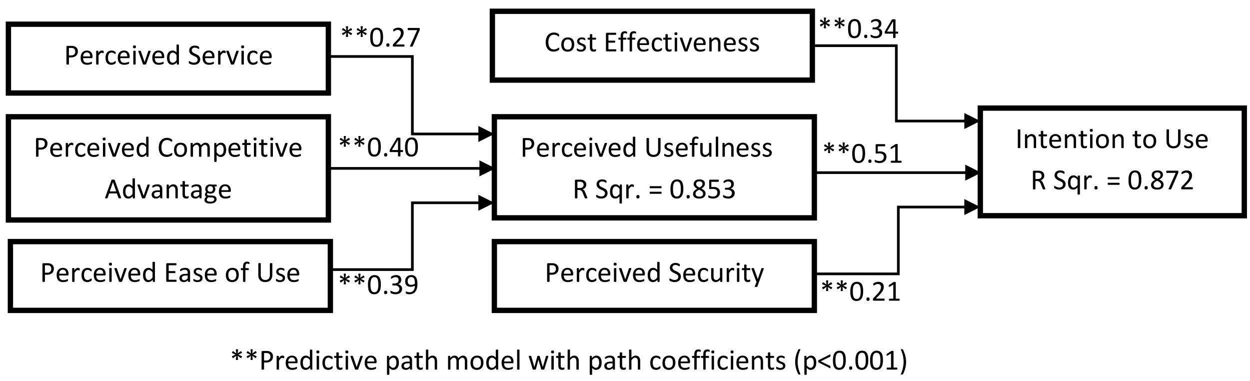

Figure 2: Regression coefficients of the model

Hence, the study proved that perceived ease of use (PEU), perceived competitive advantage (PCA) and perceived service (PeS) had significant role for perceived usefulness of computer-aided technologies in textile and apparel industries in Ethiopia. Moreover, perceived usefulness (PU), Cost effectiveness (CE) and perceived security (PS) had significant impact on intention to use computer-aided technologies within the context of the study.

6. CONCLUSION

This research was investigated to identify factors affecting adoption of CAx in ETAI. The research model used in this research was the extension of Technology Acceptance Model (TAM) studied by Davis in 1989. First the problem statement of the research work was presented. Then, relevant related literature was reviewed in order to support the identified constructs with theory and prepare the data gathering instrument. The validity and reliability of the instrument was pilot tested. The last version of the instrument consisted of thirty-nine 5-Likert scale questions on adoption of computer-aided technologies in textile and apparel industries. There were two hundred and forty-two complete questionnaires that are used in the data analysis phase. In order to test the hypothesized statements, correlation and regression statistical analyses were carried out using SPSS software. According to the Pearson product-moment correlation and regression analysis, all of the nine hypotheses were analyzed. All hypotheses showed positive association between the factors at a significance value of 0.01.

The first research question was concerned with factors that impact textile industries' acceptance on CAx in Ethiopian context. In order to answer this research question, hypotheses were developed based on the proposed model. Pearson product-moment correlation coefficients were used to confirm the relationship between variables but such analysis lacks pairwise or partial correlation effect. Hence, regression analysis was applied to determine the predictors of intention to use (IU) and perceived usefulness (PU) of computer-aided technologies and test the hypotheses in a multivariate setting.

Correlation analysis supported all hypotheses formulated based on the model. All correlation tests were found significant supporting all hypotheses stated in this study. Accordingly, perceived ease of use (PEU) shown positive relation with to perceived usefulness (PU) of CAx (r=0.797); perceived service (PeS) demonstrated positive relation with perceived usefulness (PU) of CAx (r=0.751); perceived competitive advantage (PCA) depicted positive relation with perceived usefulness (PU) of CAx (r=0.806); perceived usefulness (PU) demonstrated positive relation with intention to use (IU) of CAx (r=0.810); perceived security (PS) demonstrated positive relation with intention to use (IU) of CAx (r=0.711); Cost effectiveness (CE) demonstrated positive relation with intention to use (IU) of CAx (r=0.862); intention to use (IU) demonstrated positive relation with actual use (AU) of CAx (r=0.738); Cost effectiveness (CE) demonstrated positive relation with perceived competitive advantage (PCA) of CAx (r=0.564); Cost effectiveness (CE) demonstrated positive relation with perceived service (PeS) of CAx (r=0.715), and perceived competitive advantage (PCA) demonstrated positive relation with intention to use (IU) CAx (r=0.716).

Regression analysis depicted that perceived ease of use, perceived service and perceived competitive advantage were significant predictors of perceived usefulness of computer-aided technologies in textile and apparel industries. The second regression analysis demonstrated that Perceived Cost, perceived usefulness and perceived security were predictors of intention to use computer-aided technologies.

7. LIMITATIONS

This research work possesses the following limitations: this research focused only on textile and apparel industries found in Ethiopia but it would be better for generalization if included data from other countries. The research was a cross-sectional one which means the data was collected at once but it would be better if longitudinal data gathering method was applied.

8. FUTURE RESEARCH

This research mainly investigated CAx adoption in ETAI. Firstly, while doing this, the researcher observed that it is important to measure how much these CAx are contributing to the income of the industries and to the GDP of the country.

Secondly, in order to increase the generalizability of the studied CAx adoption model, it is better to study the CAx adoption of industries in other countries outside of Ethiopia. Third, longitudinal study is required to see the long-term effect of CAx adoption in textile and apparel industries. Moreover, technology adoption strategies of textile industries have to be investigated in order to inform them improvements.

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