Identification of Barriers in Implementation of Industrial IoT in Pakistan: A Case of Apiculture Industry

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Declaration

I certify that this research work titled "*Identification of Barriers in Implementation of Industrial IoT in Pakistan: A Case of Apiculture Industry"* is my own work. The work has not been presented elsewhere for assessment. The material that has been used from other sources it has been properly acknowledged / referred.

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Language Correctness Certificate

This thesis has been read by an English expert and is free of typing, syntax, semantic, grammatical and spelling mistakes. Thesis is also according to the format given by the university.

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Dedicated to my exceptional parents and adored siblings whose tremendous support and cooperation led me to this wonderful accomplishment

Abstract

Beekeeping or Apiculture is an important production branch of the agriculture. Honeybees are very valuable economical insects and they are the main pollinators in the world [1]. Usage of technology in apiculture can increase the beekeepers' knowledge about behavior of individual bee colonies and improve the efficiency of beekeeping by bringing it to the next technological level [2]. Nowadays Cloud Computing and The Internet of Things (IoT) are the two hot points in the Internet field [3]. The application of the two new and trending technologies is in hot discussion and research, but still quite less on the field of agriculture and especially in the apiculture, however IoT has great potential in Apiculture. This study is conducted to analyze factors affecting acceptance of smart beekeeping in Pakistan. Smart beekeeping technology is rapidly being introduced to agriculture in accordance with the progress of the 4th Industrial Revolution around the world, but still there is no research on this in Pakistan. Therefore, in this study, based on the unified theory of acceptance and use of technology (UTAUT), a research model reflecting the characteristics of smart beekeeping based on IIoT technology is constructed. To test this, empirical analysis is performed. A survey was conducted for beekeepers in North region of Pakistan. Valid 204 sample were used for analysis. The hypothesis test was based on multiple regression analysis using SPSS 24 statistical package. For the mediating effect and moderating effect, Process Macro 3.4 based on the regression equation was used. The results of testing the hypothesis are as follows. First, in the causal hypothesis test, it was shown that performance expectancy, social influence, effort expectancy and facilitating conditions have a significant positive effect on the intention to use IIoT technology. As a result of analyzing the mediating effect of behavioral intention, it was found that behavioral intetntion plays a mediating role between performance expectancy, effort expectancy, social influence, facilitating conditions and use behavior to use IIoT technology. Behavioral intention was found to be a full mediating between the effort expectancy and the intention to use the IIoT technology. The age of beekeepers has been shown to play a moderating role between performance expectancy, effort expectancy and intention to use IIoT technology.

In particular, the age is found to strengthen the relationship between performance expectancy, effort expectancy and intention to use IIoT technology. Based on the results of these studies, academic and practical implications are also suggested.
Key Words: *Apiculture, Smart Beekeeping, Industrial Internet of things (IIoT), Unified theory of acceptance and use of technology (UTAUT),User acceptance*

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CHAPTER 1: INTRODUCTION

The introduction chapter will provide details about the research problem, research background. The research question, outline of the thesis and limitation of the research will be presented here.

1.1 Background of the Study

Throughout history people have witnessed dramatic economic and social changes, which were in one way or another triggered by the technological progress and innovations. The Industrial Internet of Things (IIoT) is an innovation with future potential that has led to increase of rapid developments in various industries. The IoT is being described as a network of physical devices, digitalized machines, and digital objects that co-operate with software, sensors and other services of connectivity for enhancing the efficiency of information interoperability [1]. In recent years, IoT is considered to have a huge market potential and must be placed into companies' objectives. There are provided IoT solutions in various sectors, such as: agriculture, automotive, healthcare, and so on. Nowadays Cloud Computing and The Internet of Things (IoT) are the two hot points in the Internet field [3]. The application of the two new and trending technologies is in hot discussion and research, but still quite less on the field of agriculture and especially in the beekeeping, however IoT has great potential in Apiculture.

Nowadays, the alarming situation that apiculture and bees suffer worldwide is mainly correlated to the fact that for extended periods, the evolution of plants and flowers was always conditioned by resistance and adaptation [1]. The human being in a few years has drastically modified the life cycles, as well as the environments on which they depend. In addition to this and other factors, bees can't adapt to this accelerated pace that has been imposed on them and consequently they are collapsing around the world [1]. Factors such as the transformation and radical alteration of forestry and agrarian landscapes, deforestation and intensive agriculture, the systematic multiplication of couriers, antennas and wireless networks present today in almost all natural environments, the strong tendency to monoculture and use of transgenic seeds in the fields around the world, the generalization and use of pesticides, insecticides and all kinds of agrochemicals to control pests or accelerating the growth of crops have affected the sense of orientation, memory, and metabolism of bees and other insects. One of the greatest of all time Albert Einstein says that “If the bee disappeared off the face of the Earth, man would only have four years left to live” [1]. Bees are one of the greatest vigorous elements of our earth. But among all the group of bees, honeybee is the most important creature because they not only produce honey and bees wax but also act as primary pollinating agents of many agricultural and horticultural crops. Nowadays a beekeeping is currently based largely on manual work that requires regular visits to bee apiaries and to monitor bee hives. However, physical inspection interferes bees’ life and causes stress that negatively affects the productivity of all product lines. To improve the productivity and quality of honey for commercialization, farming methods around the world are using modern technologies like IIoT. Using IoT enabled devices for monitoring beehives makes the work of collecting data more efficient. Since the observed beehives might be on distant places, its preferred to use technology to record and to transfer data.

By monitoring the temperature, humidity, smoke and the weight of Bee hive, the bee-keeper acquires the information about the queen lay, the activities of colonies, presence of pests and the level of honey produced. It enables bee-keepers to get real-time information from hives. Sensor fitted to the beehives detect temperature, humidity, smoke gas and the weight and send the real-time result to the beekeepers via cloud so that they can check and analyze the bee activity through Internet. With an eye toward lessen the loss of colony and honey production impact, a development of Internet of Things (IoT) monitoring stingless bees and stingless bee health is being carried out around the world to monitor the habitat environmental need for productive and healthy colonies [5]

Despite the clear importance of IIoT integration into beekeeping, the state of Pakistani beekeeping farms is uncertain largely because of technological readiness. The IoT user-friendly capabilities have remarkably altered the potential usages of the Internet in beekeeping around the world. The first stage in using the IoT is the technology adoption. Once the users adopt the technology then it could develop and optimize the decision-making processes [5], as well as the controlling measures, which lead to more productivity and sustainability [6,7]. Technology acceptance research is a constantly developing field, as new technologies keep evolving all the time. Two major disciplines have contributed to the development of models and theories addressing technology acceptance, adoption and usage. Psychology and Sociology focus on technology acceptance behavior, whereas Information Systems focuses on systems' characteristics in relation to technology acceptance [6]. This research is concerned with the technological readiness of bee farms in Pakistan for smart bee farming.

In recent years, several studies have underlined the potential of integrating intelligent digital technologies to monitor honey-bees. The Industrial Internet of Things (IIoT) is driving strong demand for more data acquisition, communication, real-time analytics and data-driven decisions across a wide range of industrial verticals A significant amount of work has been done regarding IoT technology in agricultural area to develop smart farming solutions [7].

Whereas the apicultural sector is far behind other sectors in technological acceptance rate for both automation and control of bee farming systems in Pakistan. Floral sources are abundant for beekeeping in most of the areas in Pakistan. Northern Punjab and KPK province of Pakistan are very suitable for beekeeping on account of different ecological zones containing rich bee flora and ideal climatic conditions. But beekeepers in these areas are facing severe stress to carry on beekeeping activities these days due to continuous pest attacks, low temperature, delayed flowering and reduced foraging activities of bees [8]. Therefore, decrease in beekeeping activities is more likely to affect the production in agriculture commodities particularly fruits, vegetables and oilseed crops. Just like The world after realizing the potential of apiculture subsector and the problem associated to traditional beehive, have tried to introduce different beekeeping technologies to beekeepers Pakistan should also attempt to know the reasons affecting the implementation of IIoT.

Technology Adoption is not a simple and overnight activity, but it is a mental process which an individual farmer (decision maker or group of decision maker's family members) goes through for decision-making. To ensure adoption of new innovation the fulfillment of specific economic, technical and institutional condition is required. From the farmers' perspective, the new technology should be economically more profitable than the existing alternatives. Moreover, the new technology should also be technically easily manageable by small holders and adaptable to the surrounding socio-cultural situations and availability of the new technology and all other necessary inputs to small holders at the right time and place and in the right quantity and quality are necessary conditions.

Consumers' intention to accept a new technology depends on many different important features; like attitude towards the product, subjective norms, perceived usefulness, intention and many more. "Self-reported purchase intentions for the new product or concept are measured and used as a proxy variable. Intentions are also often used to predict sales over time for existing products among different market segments, models relating demographic, psychographic, or other characteristics of consumers to purchase intentions are often developed" [2].

There are ways to measures intention which forecast the acceptance behavior in the society. From that perspective, intention is one of the most precise indicators of human behavioral science. Research conducted on social psychology suggested that, to learn about the behavior one should focused on the intention, because intention control the actual behavior of the person [3].

1.2 Overview of Apiculture industry of Pakistan

Beekeeping or apiculture is the preservation of honey bee colonies to get pure honey and helps in pollination. Beekeeping is a useful mean of strengthening livelihoods because it creates a variety of assets in Pakistan. The topography of Pakistan has diverse climates, most of the areas receive adequate rainfall in Kharif and Rabi seasons which boost the vegetative growth and enhance the flowering of numerous plant species which are rich sources of nectar and pollen for bees. Pakistan currently has around 16000 beekeepers with 0.5 million honeybee colonies. Beekeeping does not compete with other enterprises for resources as the bees use nectar and pollen grains of plants. Therefore, this enterprise can be taken up both at the household and commercial levels to generate substantially more profits. Floral sources are abundant for beekeeping in most of the areas in Pakistan. Northern Punjab and KPK province of Pakistan are very suitable for beekeeping on account of different ecological zones containing rich bee flora and ideal climatic conditions. [7] Most beekeeping practices are focused in KPK and central and north regions of Punjab but are growing rapidly. that despite the fact Pakistan has great potential to get itself listed in the major honey producers in the world, the country still falls at number 20th in terms of production. There are about 35,000 beekeeping farms in Pakistan but only 10,000 of them are registered with the Pakistan Beekeepers Association. He said that the beekeepers find themselves in trouble whenever their bees are attacked by termites, and in such a situation, they cannot find anti-termite medicines at reasonable prices. [8]

Pakistan has 10 to 12 main varieties of honey, but its per capita honey production is not as impressive. Statistics of the United Nations Food and Agriculture Organization (FAO) shows that 11.7kg of honey was produced in 2019 by each Pakistani beekeeper on average, whereas the world average was 20.6kg. Demand of honey in international market particularly in Gulf is manifold higher than the present supply. Lack of modern technology is a major disadvantage of Pakistani beekeeping industry. For increase in the production, modern ways should be adopted.

Like China, Pakistan should provide technology in production and processing, including intelligent apiculture management platform. A fully automated honey production will improve the processing amount of honey, reduce personnel contact, avoid pollution by bacteria, microorganisms, etc. [10]

Intelligent Apiculture Management Platform refers to the Internet of Things and monitoring system in the bee farm, performing 24-hour monitoring of negative oxygen ions, rainfall, light, etc. It can also detect whether the honey is normal or not. If the bees contract any disease, keepers need to open the hive frequently every day, to the distaste of the bees. With the far-infrared monitoring or camera, this system can judge the health condition of the bees by the various sounds they make, avoid frequent disturbance, and reduce labor intensity. It can also add functions such as automatic weighing.

1.3 Problem Description

Consumers are frequently confronted with new technological innovation where they need to adopt with new behaviors based on their needs and demands that may lead to change their previous behavior. [11]

Consumers are frequently confronted with new technological innovation where they need to adopt with new behaviors based on their needs and demands that may lead to change their previous behavior. [11]

Figure 1.1. Traditional Beekeeping

The adoption of new technological innovation is not only a matter like that whether consumers will prefer to use or not use the new technology or subscribe to the new service but also a combination of some particular reasons which led to the consumers for adoption with new technology and subscription of this particular service [13] The increasing trend in using the IoT is going to connect approximately 50 billion things to the Internet up to the end of the current year [4]. The IoT user-friendly capabilities have remarkably altered the potential usages of the Internet. The first stage in using the IoT is the technology adoption. Once the users adopt the technology then it could develop and optimize the decision-making processes [5], as well as the controlling measures, which lead to more productivity and sustainability [6,7].

Beekeeping is evidently one of the widespread agricultural activity around the world. Several studies have shown adoption of modern technologies plays crucial role in high quality production of bee products and successfully beekeeping. Pakistan comprises potential areas for effective beekeeping. Despite the large number of bee colonies available in the district, there is insignificant production of bee products and the economic gains are limited to beekeepers. most of the bee keepers in the area are traditional farmers with less knowledge on modern beekeeping technologies (top-bar hives). Consequently, low productivity and poor quality of bee products are the major economic impediments for beekeepers. To avoid the high rate of failure of new technological innovation, it requires more research before it is introduced. Moreover, there is little/no evidence of peer study that has been done to investigate barriers of beekeepers on adoption of Industrial Internet of Things in beekeeping and its potential in honey production. Thus, this research is conducted to determine factors acting as barriers in adoption IIoT technology in beekeeping Industry of Pakistan using technology acceptance model.

1.4 Purpose and Research Question

The main purpose of our thesis is to explore the factors which are acting as barriers to beekeeper's intentions to adopt a new technology IIoT in Pakistan Apiculture sector by using the 'Unified Theory of Acceptance and Use of Technology (UTAUT)' theory. As IIoT is expected to drastically increase the productivity, prior understanding of the benefits as well as the barriers, it is necessary for any firm deciding to invest in this new technology. Consequently, research questions formulated are:

I. **How does UTAUT factors affect Behavioral Intention of Beekeepers?**

II. **How does Behavioral Intention affect use of Industrial Internet of Things?**

III. **Does Behavioral Intention mediate the relationship between UTAUT factors and Use of Industrial Internet of Things?**

IV. **Is the relationship between UTAUT factors and Behavioral Intention affected by moderators (Age & Experience)?**

The objective of this research is to identify factors that act as barriers in the use of IIoT applications by beekeepers for data and information management. With this information, politicians, scientists, and software-companies can help farmers to cope with environmental problems, comply with regulations, and increase operational efficiency to improve the sustainability of modern apiculture in Pakistan.

1.5 Delimitation

Despite its contributions to aspects that are important for beekeeper to adopt IIoT technology to provide apicultural-related information about hives, some limitations merit discussion. First, the factors important to technology adoption might differ from location to location, so assessing the validity of this model with beekeepers across different cultures both in developed and developing countries would be theoretically and practically useful. By the same token, our findings are specific to a certain part of Pakistan, and the context can be very different in other areas (e.g., areas with lower literacy and less smartphone adoption). Therefore, care must be taken before generalizing to other geographies with other ICT infrastructures. Moreover, the study does not claim to statistically represent beekeepers in Pakistan (neither in terms of gender, nor geographically). It would be interesting to test the model with more female beekeepers and in other parts of Pakistan. Second, since most of the beekeepers in this study had not used the IoT application, we did not examine the effect of behavioral intention on the use behavior. Therefore, it is recommended that future research include the examination of the effect of behavioral intention on beekeeper' actual use behavior. Additional research would also allow an assessment of whether the importance of the constructs would change over time or contexts. For example, the effect of trust on beekeepers' behavioral intention to use the IoT technology might become important when the information is being shared with particular organizations, including companies, along with the perceived risk associated with use [38]. Data-sharing perceptions then possibly become a crucial issue that warrants further study.

Out of a time perspective, the study will be limited to studying a problem during a certain timeframe. Therefore, it is not longitudinal.

1.6 Outline of the Thesis

We divided our thesis into six chapters for getting the better understanding of our research. Each chapter contains a separate issue to others chapter. In the following, we have to show a framework of our thesis.

Chapter 1: Introduces our topics of the research and describe the background under chosen topics. We have also set the research question, objective of the research and limitations of our research.

Chapter 2: In this chapter we provide the theories and concepts which been used for the purpose of this study.

Chapter 3: Presents a total overview of the methodological aspect which approach used to conduct the research and deliberations have taken to finish our thesis.

Chapter 4: This chapter is introducing to the empirical findings based on the collective data from the survey.

Chapter 5: The findings have been analyzed in this part.

Chapter 6: Finally, in this chapter we have discussed our findings and drawn a conclusion.

CHAPTER 2: LITERATURE REVIEW

This chapter presents the literature and theories reviewed. Since the study examines many variables a funnel format is used, where the discussion of the topic starts out in general terms, and then gradually narrow to become closer and closer to the purpose of the study. The review of literature generates a theoretical framework that guides the data collection and analysis.

2.1 Industrial Internet of Things (IIoT)

Internet of Things (IoT) is a computing concept describing ubiquitous connection to the Internet, turning common objects into connected devices. The key idea behind the IoT concept is to deploy billions or even trillions of smart objects capable to sense the surrounding environment, transmit and process acquired data, and then feedback to the environment. It is expected that by the year 2021 there will be around 28 billion connected devices [1]. As a subset of IoT (see Fig. 3), Industrial IoT (IIoT) covers the domains of machine-to-machine (M2M) and industrial communication technologies with automation applications. IIoT paves the way to better understanding of the manufacturing process, thereby enabling efficient and sustainable production. IIoT applications typically require relatively small throughput per node and the capacity is not a main concern. Instead, the need of connecting a very large number of devices to the Internet at low cost, with limited hardware capabilities and energy resources (e.g. small batteries) make latency, energy efficiency, cost, reliability, and security/privacy more desired features [5]. IIoT (the basic pillar of digital manufacturing), is about connecting all the industrial assets, including machines and control systems, with the information systems and the business processes. As a consequence, the large amount of data collected can feed analytics solutions and lead to optimal industrial operations. On the other hand, smart manufacturing obviously focuses on the manufacturing stage of (smart) products life-cycle, with the goal of quickly and dynamically respond to demand changes. Therefore, the IIoT affects all the industrial value chain and is a requirement for smart manufacturing.

As underlined in the following, communication in IIoT is machine oriented, and can range across a large variety of different market sectors and activities. The IIoT scenarios include legacy monitoring applications (e.g., process monitoring in production plants) and innovative approaches for self-organizing systems (e.g., autonomic industrial plant that requires little, if

any, human intervention) [9]. In IIoT, communications are in the form of machine to-machine links that have to satisfy stringent requirements in terms of timeliness and reliability. Comparing the data volume, the generated data from IoT is heavily application dependent, while IIoT currently targets at analytics, e.g. for predictive maintenance and improved logistics. This implies that very large amount of data is exchanged in IIoT.

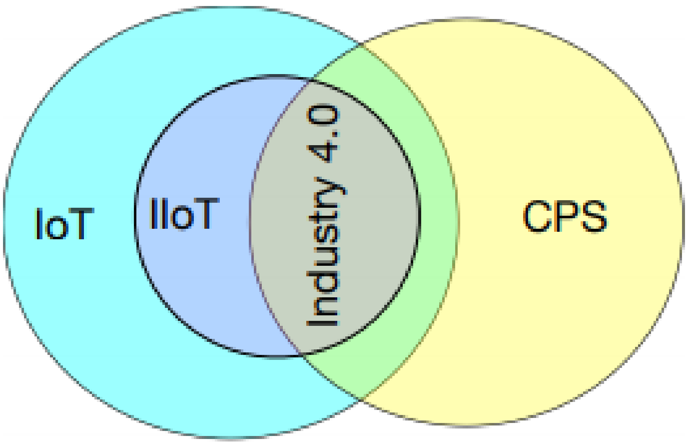

Figure 2.1 Industrial Internet of Things

2.2 Industrial Internet of Things (IIoT) in Apiculture

There are many existing relevant articles in the subject of IoT in beekeeping. There are many projects focusing on collecting data and some of them also aimed towards end-users (beekeepers that are not scientists or IT professionals). In this field of research there are different approaches, the data captured varies, the method used varies and the presentation of data are done in different ways.

Researchers have used temperature measure in the hive in one or several points to try to detect the increasing of food consumption, the start of brood rearing, the pre-swarming states or the death of the colony. [20] The hive weight monitoring is used to detect the start and the end of nectar flow during the foraging season and to measure daily nectar storage. Otherwise, the variation of the hive weight allows to measure the consumption of food during non-foraging periods, estimate the number of foragers and indirectly the fecundity of the queen. Weather factors such as precipitation, relative humidity, hours of sunshine and wind can affect weight data14. Finally, the occurrence of swarming events can be correlate with the decrease of the hive weight. The weight can be automatically measure by weighting systems such as, BeeWatch, CAPAZ or WiFi HiveScale. [9] Bees in a hive produce vibration frequencies comprised between <10 Hz to >1000Hz14. Vibration, Audio signals and processing techniques allow to predict event such as swarming period. The sound of flying bees near the beehive entrance can also be used to evaluate the productivity of the hive. The most popular bee counter is the BeeScan is sophisticated precision scanner which use 32 channels of detection to measure the entering or exiting bees. [26]

The literature abounds in terms of bee monitoring systems. Among the most remarkable contributions are those of Edwards-Murphy et al. who proposed a monitoring system based on heterogeneous WSN which measures with two nodes carbon dioxide (CO2), dioxygen (O2), Nitrogen Dioxide (NO2), Ethanol (CH3CH2OH), Ammonia (NH3), Carbon Monoxide (CO) and Methane (CH4), temperature, relative humidity and acceleration. The data transmission is ensured by a base station ZigBee/3G11. Although this approach is interesting, it remains dependent on the availability of 3G. In addition, the ZigBee protocol is a short-range protocol (about ten meters) which only supports a limited number of nodes. Jiang et al. in 2016 have worked on a system of counting of bee entrance and exiting based on infrared led detection. The proposed system uses the WSN technology and measure also temperature and relative humidity in and out of the hive10. The data that acquired at hive level are transmitted to a gateway which transfer them to a backend platform by GPRS. Kridi et al. used a WSN and temperature sensor measure of microclimate in the hive and compare it with thermal pattern in 2016. Gil-Lebrero et al. in 2017 have built a Remote Monitoring System based on Waspmote and measure in multiple point temperature in hives. The architecture in three level has been proposed with communication using IEEE 802.15.4 protocol for local communication and 3G/GRPS, WiFi or WiMax for communication between local database server and global database server. Furthermore, in recent years, precision apicultural techniques are fundamentally affected by the Forth Industrial Revolution. [21]

Eltopia, an agricultural communications innovator, and Gemalto, the global leader in digital security and Machine to Machine (M2M) technology, have developed a pesticide-free Internet of Things (IoT) solution to eliminate mites in hives. MiteNot is an another smart beehive frame that monitors and manages hive temperatures and prevents mites from reproducing. Easy to use, biodegradable, and non-toxic, Mite Not is essentially a flexible screen-printed circuit camouflaged as a honeycomb. Beekeepers simply swap out one frame within the beehive with a reusable, sensor-embedded MiteNot frame. For fighting honey-bee colony mortality through IoT IoBee aims to disrupt the bee-keeping market by providing effective, timely and user-friendly monitoring systems. The project focuses on the commercialization of a new application of the Internet of Things (IoT) sensor, able to automatically assess the health and threat status of colonies, becoming the technical framework for a European Interoperable and Open Surveillance Network for Bee Health.

Most of the reviewed studies articulate the role of modern technologies in beekeeping has influenced significant changes in terms productivity increase and rise of beekeeper’s household income. The studies also examined major determinants which influence adoption of modern beekeeping technologies including socio-demographic features such as level of education, age, household size, and gender. [18] Other factors deemed to influence adoption were adaptability and complexity of technology as well as technical competency [22]. Literally works also identified major constraints facing beekeepers to adopt modern technologies including inefficient capital, lack of beekeeping equipment, and extension support (Kiros and Tsegay, 2017). In Pakistan context, none of the recent reviewed study assessed adoption of modern technologies in beekeeping. Infact few/no literature has investigated perception of beekeepers on adoption of modern technologies. Moreover, adoption of theoretical model to study behavior and perception of beekeepers towards acceptance of technology. Therefore, present study intends to fill this gap through adoption of UTAUT which is one of the most useful model to study perception of users towards technology adoption particularly in Performance Expectancy, Effort Expectancy, Social Influence and Facilitating Conditions.

Figure 2.2 Traditional Vs Modern Beekeeping

2.3 Technology Acceptance

Acceptance of technology is a subject of continuous interest in the area of information systems (IS) research as adoption of technology amongst users remains a central concern for researchers and practitioners. For example, low technology usage has been found to be a significant factor that contributes to low productivity and low returns on investment in technology. In this context, technology acceptance research seeks to understand and create settings in which technology is accepted by users. Technology acceptance frameworks are based on underlying theories and have the purpose of not only predicting acceptability of a given technology, but also but also identifying changes that must be made to increase the acceptability amongst users [7]. More specifically, the purpose of technology acceptance research is to understand user behavior as a dependent variable The use of new technology is the subject of many studies. Various models have been developed to determine factors influencing the intention to adopt or use new technologies. Some relate to personal factors, others to organizational factors, or environmental factors influencing the adoption intention and use of innovation.A number of models and frameworks have been developed to explain user adoption of new technologies and these models introduce factors that can affect the user acceptance such as Technology Acceptance Model [4-6],Theory of Planned Behavior [7] and Diffusion of Innovation theory [8], Theory of Reasoned Action [9],Unified Theory of Acceptance and Use of Technology [12] and many studies have used these traditional frameworks to conduct their researches and the rest combined previous models or add new constructs to developed models to carry out their study. More than one theoretical approach is necessary for complete understanding of the issues involved, and for clarity, approaches are treated independently. However, various theoretical complete understandings of involved issues require approaches. Therefore, an overview on available general adoption model is necessary in this field.

During the past few decades' researchers have established a set of theories that are used in describing and explaining the adoption of technologies amongst users. Early studies in the fields of technology and various other research disciplines have identified behavior as a vital element in predicting technology acceptance (Ajzen, 1991) (Ajzen, 1985) (Taylor & P.A., 1995). Below follows a visualization of the fundamentals that form user acceptance of a certain technology**.**

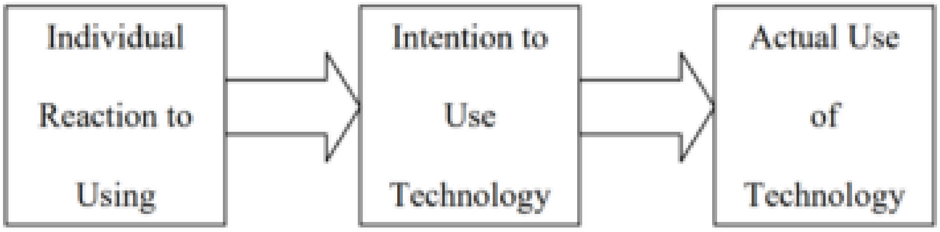

Figure 2.3 Visualization of User Acceptance

Theoretically, researchers explore the interaction between a user's reaction to using a technology, how reaction affects their intention in using said technology and ultimately - the actual behavior of the user.

In the next coming sections, underlying theories and associated models used to explain related to technology acceptance will be defined, described and reviewed.

2.4 Theory of Reasoned Action

TRA was founded in 1975 by researchers and is a model that is derived from sociology and psychology. The model was formed to predict and understand users' behavior and attitudes towards information technology. TRA views behavioral intentions as main predictors for behavior rather than attitudes. In the model, it is suggested that a user´s prior intention and beliefs determines his/her behavior. Furthermore, the theory indicates that behavioral intention is a main predictor for behavior, while intention affects the influence of the attitude on a certain behavior. [11]]. In time, the model was proved to be insufficient as it has several limitations.

For example, the TRA does not regard individuals that have little control over their behavior and attitudes.

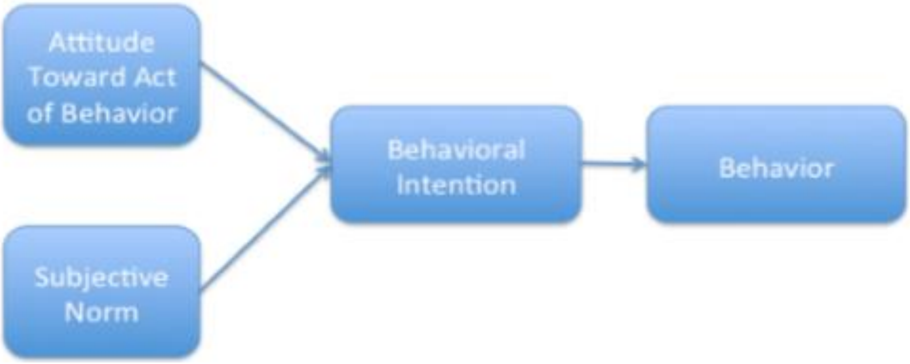

Figure 2.4 Theory of Reasoned Action

2.5 Theory of Planned Behavior

Theory of planned behavior is based on theory of reasoned action. The theory is developed by physiologist Ajzen (1985) and claims that behavioral achievement depends jointly on motivation (intention) and ability (behavioral control). Attitude towards the Act or Behavior is how the person believes the action will have a negative or positive impact on the action (Ajzen, 1991; Matiesen 1991), for example if the end-user thinks that the system will support her in her work. Subjective Norm is the belief of others, which are important to the person, for example if others belief it is important to use the system and the person care what the others think; it will have an impact on the behavior [12]. Perceived Behavioral Control can be situational, such as having access to the IS system and also personal, which could be being able to use the system.

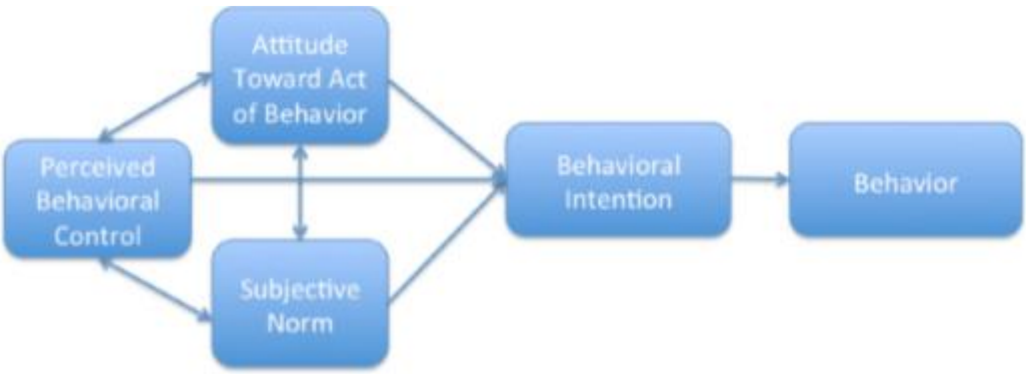

Figure 2.5 Theory of Planned Behavior

Thus, the purpose of TPB is to predict and understand influences on behavioral intention that are driven by motivational factor – which in turn predicts a certain behavior in a given setting. With the following predictions available, it is of interest to identify how and where to target strategies for changing that behavior through the TPB model (Ajzen, 1991). The constructs included in the TPB model are explained below:

Behaviour: In the TPB model and IS research, behaviour is a construct specifically designed to change the behaviours of individuals (Ajzen, 1991).

Behavioural Intention: A construct that can be used in approximately measuring a behaviour and also one of the most significant contributions to the TPB model in contrast to previous models depicting attitude-behaviour relationships. Its significance is mainly due to its ability in determining effectiveness of intervention, despite lack of measurements of actual behaviour (Ajzen, 1991).

Attitude: Attitude towards a certain behaviour is a user's overall evaluation towards a behaviour. In turn, attitude is formed mainly by two fundamental pillars; (1) influence from people important to the user and (2) positive/negative judgement about each belief regarding the user's decision in performing a behaviour (Ajzen, 1991).

Subjective norm: Subjective norm is social influence in engaging/not engaging in a behaviour out of the user's perspective. The construct is formed by the accumulation of available normative beliefs (influence from people important to the user).

Perceived behavioral control: Lastly, this construct is the extent to which a user feels able to enact a given behaviour. As with attitude, there are two constructs being perceived behavioral control; (1) the extent to which a user has control over a behaviour and (2) how confident the user feels regarding being able to perform/not perform the behaviour (Ajzen, 1991).

2.6 Innovation Diffusion Theory

The innovation diffusion theory (IDT), developed by E. M. Rogers in 1961, is also rooted in sociology. Based on the IDT and TRA, Moore and Benbasat developed seven core constructs to investigate the diffusion of information systems. The following constructs were evaluated: Relative advantage, ease of use, image, visibility, compatibility, result demonstrability, and voluntariness of use (Moore & Benbasat, 1996). DOI model examines a diversity of innovations by introducing four factors (which are the time, channels' communication, innovation or social system) which influence the spread of a new idea. DOI not only has been used at both organizational and individual levels but also, offers a theoretical foundation to discuss adoption at a global level. DOI model integrates three major components: adopter characteristics, characteristics of an innovation, and innovation decision process. In innovation decision step, five steps namely confirmation, knowledge, implementation, decision, and persuasion have took place through a series of

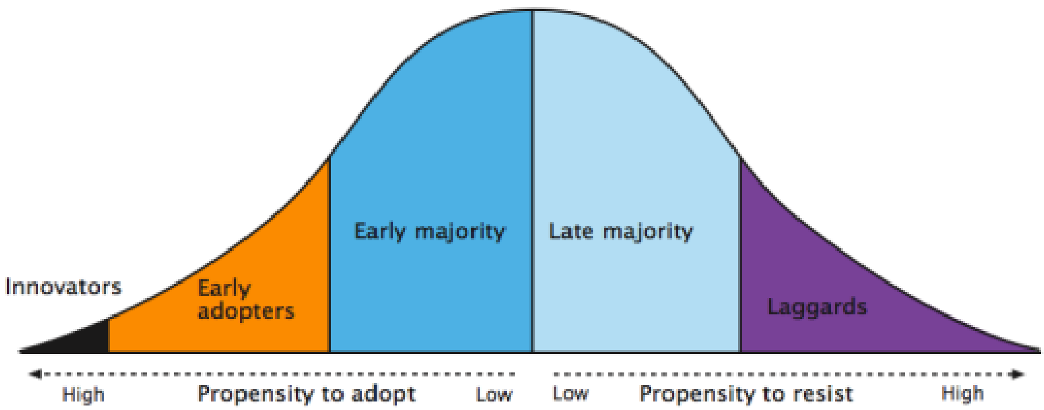

Figure 2.6 Innovation of Diffusion Theory

communication channels among the members of a similar social system over a period of time. In characteristics of an innovation step, five main constructs; relative advantage, compatibility, complexity, trialability, and observability have been proposed as effective factors on any innovation acceptance. In adopter characteristics step, five categories; early adopters, innovators, laggards, late majority, and early majority are defined [32]. In conclusion, DOI more focus on the system characteristics, organizational attributes and environmental aspects, it has less power in explanatory and less practical for prediction of outcomes compared to other adoption models.

To understand about the diffusion of innovation we need to know about the adopters who will adopt the innovation and also about the attribute which influence them to adopt the innovation. Everett M. Rogers (1962, 1983, 1995, 2003) developed a theory about the diffusion of innovation, which in know as the 'Rogers Innovation of Diffusion theory'. In the theory he mentioned about five (05) types of adopters who adopt an innovation time to time. They are: inventors, early adopters, early majority, late majority and the last one known as laggards.

2.7 Technology Acceptance Model

Fred Davis (1989; 1993) presented the technology acceptance model based on theory of reasoned action to better explore acceptance of information science (IS). Davis claims perceived usefulness is one of the reasons a user will accept or reject a system and the other is perceived ease of use, which is the easiness or free of effort the user interpret the system. Mathiesen (1991) compares the TAM with TPB and concludes that TAM better explains the attitude towards IS than TPB, and that it is easier to apply.

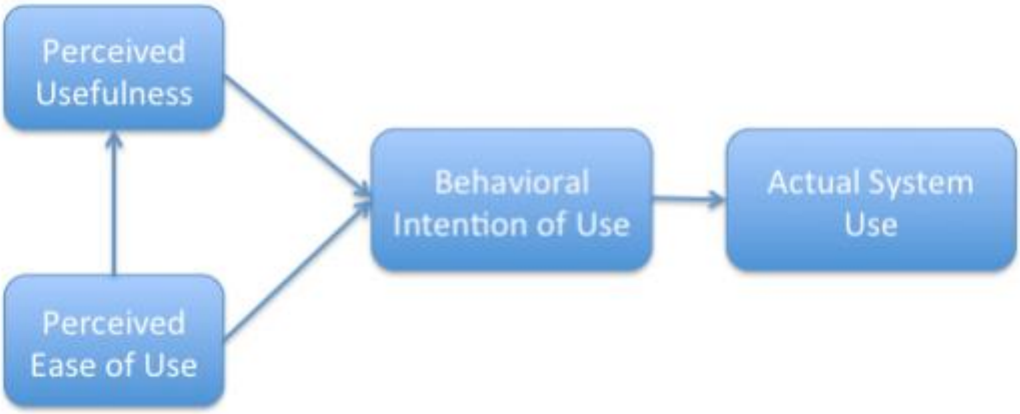

Figure 2.7 TAM

Perceived usefulness: Perceived usefulness is a user's belief in that a technology will increase their performance or provide a benefit. As a result, users make a decision to use/not use a certain technology to the extent that they believe it will lead to an enhancement in job performance (Davis et al., 1989).

Perceived ease of use: Perceived ease of use is the extent to which a user expects a technology to be free of effort. Even though a technology might be useful for job performance, it can be difficult to use or learn to use. Therefore, perceived usage can be outweighed by perceived ease of use (Davis, 1989).

TAM has been used to explain the behavior of IS systems that are voluntary and the same goes for TRA, which focus on volitional behavior such as losing weight or participate in an election (Ajzen, 1991). Brown et al. (2002) is trying to explain the user's behavior when the system is mandatory to perform one's job and found out that TAM does not generalize directly to mandatory use situations. They classify that a system is mandatory when the options are to use the system or leave the work place. Legris et al. (2003) pointed out that TAM studies in general are considering an application or system to be an independent issue rather than putting it into the context of organizational dynamics, and suggest that the model should be put into a broader perspective including organizational and social factors. Amoako-Gyampah and Salam (2004) analyzed an ERP implementation in a large organization and found out that the role of IT implementation factors such as training, project communication and shared beliefs influenced the TAM variables. In comparison to TPB, TAM does not include subjective norm as a determinant of behavior. Davis TAM hypothesizes that a user's attitude towards a system is a key determinant for his/her actual acceptance or rejection of a system. In turn, the users' attitude is believed to be influenced by perceived use and perceived usefulness, who in turn are considered to be directly influenced by undefined system´s design characteristics.

In order to further explain the usage of a system, the model was enhanced to also include subjective norms among others and TAM2 was developed (Venkatesh and Davis, 2000). An extended model of TAM – called TAM2 - was introduced as an attempt to facilitate variables that influence perceived usefulness (Venkatesh, 2000). The following variables were introduced in the extended model: subjective norm (the influence of others on a user´s decision to use/not use a technology), image (a user´s desire to uphold a positive standing among other users), job relevance (the degree to which the technology was applicable), output quality (the degree to which the technology performed a vital task sufficiently) and result demonstrability (the production of concrete outcomes). Moreover, in the extended model experience and voluntariness were as factors affecting subjective norm.

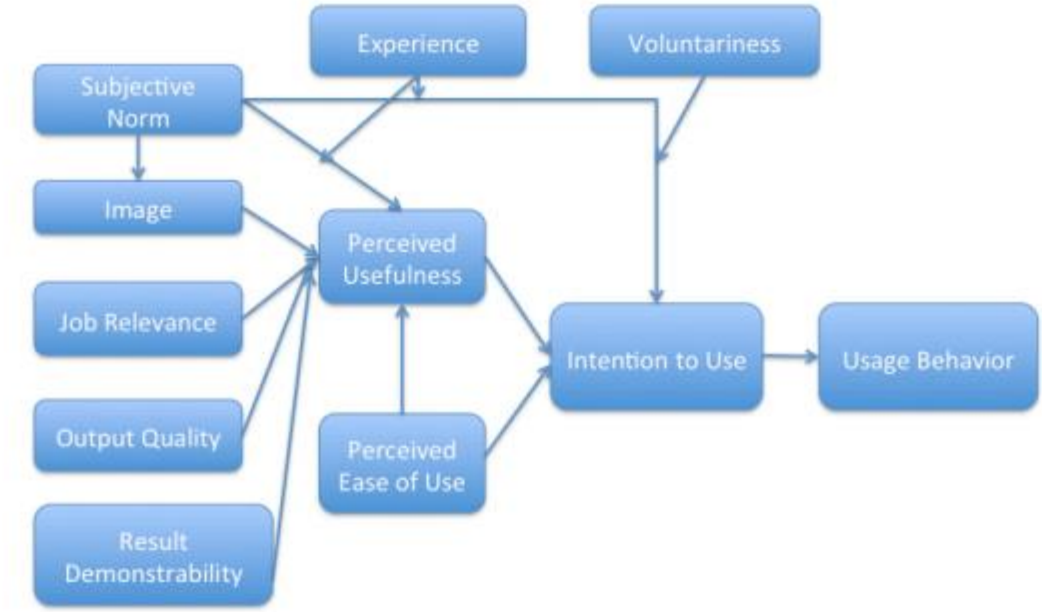

Figure 2.8 TAM 2

2.8 Unified Theory of Acceptance and Use of Technology (UTAUT)

As researchers continuously extended the TAM in different studies, and as new findings originated the UTAUT model was founded to create an integrated model of said findings and extensions (V, et al.,2003). The theory is developed out of TAM, but also based on TRA and TRB along with other theories such as:

• Model of PC utilization (MPCU)

• Social Cognitive Theory (SCT)

• Motivation Model (MM)

• Diffusion of Innovation Theory (IDT)

• Combined Theory of Planned Behavior/Technology Acceptance
(C-TAM-TPB)

The main constructs in the UTAUT model are performance expectancy, effort expectancy, social influence and facilitating conditions and serve as independent variable in research where UTAUT is applied. Gender, age, experience and voluntariness are also included in the model as moderating variables. The model suggests that the primary constructs all affect behaviour, while the moderating variables might also have an effect on a user’s behaviour (V, et al., 2003). All in all, the framework provides a possibility in not only examining relationships between the constructs in the model, but also in exploring their combined effect to a user's behaviour in a technology-heavy environment. Below follows a visualization of the model and an in-depth explanation of its construct.

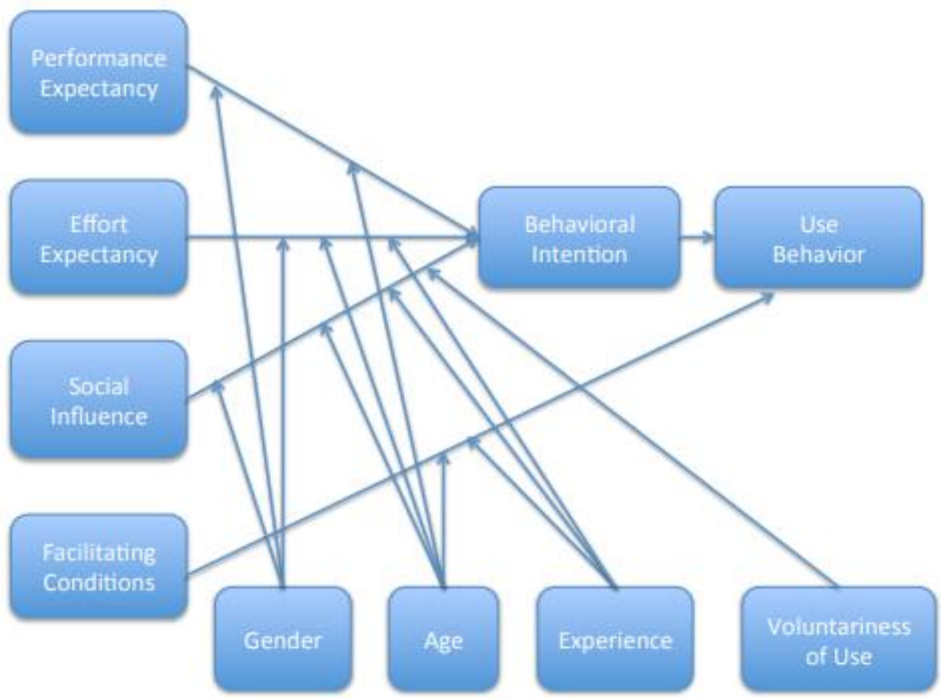

Figure 2.9 UTAUT

Behaviour: In the context of technology acceptance research, behaviour is measured in context of performance-oriented outcomes in technology-heavy environments (V, et al., 2003). In turn, performance-oriented outcomes of behaviour are described as consequences of a certain behaviour (Compeau & Higgins, 1995).

Behavioural Intention: The construct of behavioral intention is a person's readiness to perform a certain usage behaviour (Ajzen, 1991). For example, it can be a consumer´s intention to subscribe and use a certain service (Ajzen, 1991).

Performance Expectancy, which defines the user's belief on how useful the system is and how it will enhance the performance. The factors are related to:

• Perceived Usefulness (PU), as discussed earlier in TAM

• Extrinsic Motivation such as improved job performance, pay or promotion.

• Relative Advantage (RA) of using the system, i.e. using the new system is better than the previous system/way of working

• Job-fit (JF), i.e. how the system will enhance the job performance.

• Outcome Expectations (OE), which is related to the consequences of the behavior. It includes both job-related issues such as pay rise and personal/individual goals such as quality of work or perception from colleagues.

Performance expectancy can be defined as “the degree to which the user expects that using the system will help him or her to attain gains in job performance” (Venkatesh et al., 2003, p. 447). The variables of performance expectancy include perceived usefulness, job-fit and outcome expectation, which are used to characterize the extent to which an individual perceives the use of the system to help the work. Perceived usefulness refers to the perception that individuals believe that using the system can improve performance or increase efficiency (Davis, 1989; Davis et al., 1989). Extrinsic motivation can be understood as the perception that individuals perform an event, in order to help achieve additional value with the event, for example, premium or promotion (Davis et al., 1992). Job-fit refers to how the functionality of the system enhances individuals' performance and quality (Thompson et al., 1991). Relative Advantage is defined as the degree to which using an innovation is more advantageous than using its precursor (Moore and Benbasat, 1991). Outcome Expectations include the performance expectations (job-related) and personal expectations (individual goals). Outcome expectations relate to the individual behaviour. As an example, if using the system, an individual can improve the work efficiency and has the opportunity to be promoted (Compeau & Higgins, 1995; Compeau et al., 1999). In theory, gender and age affect the relationship between performance expectancy and intention. Although gender role has a strong psychological foundation, it can change over time. Moreover, age also plays the moderating role. There are also gender and age differences in the context of technology adoption. From the point of view, the attitude, young people pay more attention to extrinsic rewards (Venkatesh et al., 2003). Performance expectancy is the strongest predictor of intention of use in both voluntary and mandatory settings and all the underlying five constructs have many similarities (Venkatesh et al., 2003).

Effort Expectancy, correlates to the degree of ease to use the system: it is based on following factors:

• Perceived Ease of Use (PEU), which is from the TAM/TAM2 and defines which degree of effort the system will require.

• Complexity (CO) refers to how difficult/easy the system is perceived to be, for example that it is believed to take too long time to learn.

• Ease of Use (EU) measures the level to which using the application is perceived as being difficult to use.

It is interesting to notice that Venkatesh et al. (2003) could only verify that this variable was significant during the first phases of the implementation and over periods of extended and sustained usage it became non-significant. A study undertaken in China found no significance between perceived ease of use and behavioral intention to use (Srite, 2006). However, one has to take into consideration that the sample size in that study was rather limited and the respondents were students. Effort expectancy can be defined as “the degree of ease associated with the use of the system” (Venkatesh et al., 2003, p.450). The variables of effort expectancy include perceived ease of use, complexity, and ease of use. Perceived ease of use refers to the idea of using new technology without any effort. Complexity is understood as the difficulty of the user in perceiving the use of the system. Conversely, ease of use refers to that the user believes that the system is easy to operate and use (Venkatesh et al., 2003). Most researchers found that effort expectancy positively influences the behavioral intent of use and the actual use of the technology (Davis, 1989; Venkatesh et al., 2003; Gao & Deng, 2012). Effort expectancy had a positive impact on performance expectancy. Davis (1989) indicated that the system can improve performance if it is easy to use. Venkatesh et al. (2003) mentioned that “the influence of effort expectancy on behavioral intention will be moderated by gender, age, and experience”. For women, effort expectancy is more prominent than men. Particularly for young women at early stages of experience, the effect will be stronger.

Social Influence, looks upon how important it is what the people around believe; it is based on following factors:

• Subjective Norm (SN) is based on TRA, TPB and TAM/TAM2 and is defined as people, who are important to the person, such as the manager, think the individual should use the system.

• Social Factors (SF) originates in the model of PC utilization and takes into account if the coworkers use the system, if the management is helpful and supportive.

• Image refers to if the application enhances one's image or status in the organization.

As stated by the UTAUT, social influence is “the degree to which an individual perceives that it is important that others believe he or she should use the new system” and it is direct determinant of the behavioral intention to use a technique or technology (Venkatesh et al., 2003, p. 451). The variables of social influence include the compatibility of social factors, which are used to characterize the extent to which individual perceptions are influenced by surrounding groups. The three concepts contained in social influence are subjective norm, social factors and image. Venkatesh et al. (2003) suggested that the social environment has a major impact on people’s behaviours. Subjective norm means that personal behaviour is influenced by the people around you, especially those who are considered important (Ajzen, 1991; Davis et al., 1989; Fishbein & Azjen, 1975; Mathieson, 1991; Taylor & Todd, 1995a,1995b). Social factors can be seen as the subjective culture of the individual reference group. Personal behaviour is influenced by specific social situations or by interpersonal relationships, such as colleagues and leaders (Thompson et

16al., 1991). Image can be understood as the perception that using new technologies or technologies can enhance the image or status of a person’s social system and have the opportunity to increase reputation and visibility (Moore & Benbasat, 1991). Venkatesh et al. (2003) mentioned that the influence of social influence on behavioural intention will be moderated by gender, age, voluntariness, and experience. Especially for women, the impact will be more significant in the early stages of experience. Women are more sensitive to the opinions of others. So, when it comes to the intention of using new technologies, the social influences on them are more significant. Venkatesh and his colleagues (2003) point out that this construct was also more significant in the beginning of the system use and that the opinions of others are applicable in mandatory settings, for example the opinion of the supervisor at a work place. Hartwick and Barki (1994) highlight that subjective norm is more important in an early stage and in a recent study by Schepers and Wetzel (2007) showed that a competent system user is less open to social aspects.

Facilitating Conditions are the degree to which the person believes that there is organizational and technical support of the system.

• Perceived Behavioral Control (PBC), from TBP and refers to for example if the individual believes she has control over the system usage.

• Facilitating Conditions (FC), such as support and introduction to the application.

• Compatibility (C) refers to which degree the system is compliant with existing needs, values and experience.

Facilitating conditions can be explained as “the degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system” (Venkatesh et al., 2003, p. 453). The variables of facilitating conditions include perceived behavioural control, facilitating conditions and compatibility. Perceived behavioural control refers to the individual’s perception of ease or difficulty in performing the particular behaviour (Ajzen,1991; Taylor & Todd, 1995a, 1995b). Facilitating conditions can be understood as that objective factors in the environment increase the willingness of individuals to use technology, e.g. guidance can be obtained when selecting a system or timely assistance can be provided when the system is difficult (Thompson et al., 1991). Compatibility can be explained as that innovation is considered to be consistent with the value, needs and experience expected by potential adopters (Moore & Benbasat, 1991). Venkatesh et al. (2003) indicated that behavioural intentions will not be affected by facilitating conditions, but when moderated by experience and age, facilitating conditions will have a major impact on usage behaviour. According to the UTAUT (Venkatesh et al., 2003), the facilitating conditions do not influence the behavioral intention but the use behavior, where experience plays a role, as the need for support goes down when the experience of the system goes up.

In addition to the above-mentioned constructs, there are four variables that have moderate impact of the four key hypotheses according to Venkatesh et al. (2003):

• **Gender,** for example that women in general emphasize ease of use more important than men do.

• **Age,** in general older end-users find it harder to adapt to the use of a new system.

• **Experience**, the researchers reported that when the users gained experienced for example, ease of use is over shaded by other factors.

• **Voluntariness** is to which degree the system is used voluntarily.

Several studies (Bhattacherjee and Premkumar, 2004; Taylor and Todd, 1995) have identified that user's beliefs and attitudes change as they gain experience. A study conducted in Saudi Arabia (Al-Gahtani et al., 2007) demonstrated that gender and age had no interaction effect with performance expectancy. Computer usage is so common today (Schepers and Wetzel, 2007), which makes one question the importance of gender and age today. Kim and Malhotra (2005) draw our attention regarding users' evaluation of the system as they gain experience and Bhattacherjee's (2001) developed a post-acceptance model of IS continuance, where he stated that post–use perceived usefulness is determined by pre-use perceived usefulness. Bhattacherjee and Premkumar (2004) argue that it is important to invest in end-user training to gain a positive user experience that will later on increase satisfaction and acceptance.

The UTAUT model is widely used in the information and information technology industry. It helps management and decision makers make more effective decisions by explaining the factors that influence users' behaviour in terms of acceptance of technical and/or socio-technical innovation. Therefore, this thesis adopts the Unified Acceptance and Use Technology Theory (UTAUT) as the theoretical model for the exploration of factors influencing the beekeeper' intentions to Industrial Internet of Things. The idea of model construction in this study is based on the fact that the user's acceptance and use of the IIoT is a process in which the user accepts the new technology or service. Therefore, this research can be conducted using the UTAUT model. Further, many studies on similar topics are based on UTAUT. According to the research object, the modified model retains the four variables of the original model and three moderators are also introduced, namely "gender", "age" and "experience".

2.9 Factors Influencing the Use of New Technology in Apiculture

Many factors influencing the use of new technology by beekeeper/farmers are cited in the literature. Studies often investigated the adoption of computers by farmers or the use of Farm Management Information Systems (FMIS). [26] These studies use different names to describe a tool or system that collects and aggregates data to help beekeepers make decisions (Fountas et al., 2015). Common names are Farm Management System (FMS), Management Information System (MIS), Decision

Support System (DSS) (Rose & Bruce, 2018) or Decision Support Tool (DST) (Rose et al., 2016). These tools and systems combine the ability to aggregate data from multiple sources and merge them into a complex structure to support decision making. All of these Ag-Tech industry programs belong to the precision apiculture (PA) and smart farming (SF) subdivisions, as they are designed to optimize production and increase the efficiency of apicultural operations (Pivoto et al., 2018). All these tools belong to the field of information and communication technologies (ICT).

With the advent of mobile phones in 2007, the rapid spread of these devices and the applications installed on them, farmers and businesses have achieved entirely new possibilities for data collection, use, and presentation (Jayaraman, Yavari, Georgakopoulos, Morshed, & Zaslavsky, 2016; Köksal & Tekinerdogan, 2018). Currently, around 78 percent of all adults in Germany use a smartphone (Bitcom, 2017). Many farmers are included who use devices not only for private purposes but also for business communication and management (Schlee, 2014). In general, the smartphone fits in very well with everyday agricultural life, since most processes in agriculture are mobile and a device must, therefore, be available for data collection that supports this mobility (Schlee, 2014). Through qualitative and quantitative interviews with farmers in the United Kingdom, Rose et al. (2016) have identified fifteen different factors that convince farmers to use FMIS. These include usability, cost-effectiveness, performance, user relevance, compatibility with compliance demands, farming type and scale, peer recommendation, farmer-advisor knowledge transfer, privacy and data security, integration between different systems as well as internet connectivity. Other important user characteristics are age and habit, as well as trust in the company that offers the software (Rose & Bruce, 2018). Privacy and data security were highlighted as a critical factor for the adoption of new technologies in a study (Wolfert et al., 2017). Farmers fear that their data is misused, e.g., by competitors. Also, sociodemographic factors have a significant impact. Several studies have highlighted that the age of farmers has a negative influence on the willingness to use new technologies (Hasler, Olfs, Omta, & Bröring, 2017; Rose et al., 2016). The older the farmer and the more farming experience he has, the less willing he is to try new technologies. Younger farmers, on the other hand, are less experienced and can benefit from the support of new systems (Rose et al., 2016).

Their planning horizon for using the new technology is longer than the planning horizon of older farmers (Rose et al., 2016). According to the study by Rose et al. (2016), habits play a significant role. Farmers who are used to try new technologies and to deal with change will integrate new technologies more quickly into their daily work. Further studies show that education has a positive influence on farmers' use of new technologies (Carrer et al., 2015). Better educated farmers see more excellent benefits in data collection through new software and technologies. The personal assessment of a farmer´s apicultural skills also plays an important role. Overconfidence has a positive influence on the willingness to use, as the farmer has high expectations of himself and the use of the new technology (Carrer, Souza Filho, & Batalha, 2017). The behavior can be due to the previously described habits in daily work processes, as well as the additional costs for familiarization with and conversion to a new system.

2.10 UTAUT Research

The UTAUT model has risen as a reliable model in research as it has a good capability in investigating acceptance and usage of technology. By merging key findings from eight dominant models, it provides a unified framework for further research. In a first attempt to test UTAUT, it was found that it outperformed the eight individual models that it originates from with an adjusted R2 of 69% (V, et al.,2003). The model has been widely cited, and applied on technologies such as hospital Information Systems, Tax payment systems, mobile technology and amongst a variety of users such as students, professionals and general users. However previous research is limited as most studies are limited in sample size, lacking in longitudinal work, self-reported use, use of student samples and lack of consideration on moderating variables (Williams, et al., 2015). Examples of studies in student environments include attempts in identifying behavior associated with technology acceptance of ICT and digital tools (El-Gayar & Moran, 2006) (Rahman & Adnan Jamaludin, 2011) (Attuquayefio, 2014). Relevant to this study, technology acceptance research of behaviour in an optional based setting (where a user has a choice whether or not to use a technology in performing a behaviour) found that models such as TAM were not ideal for studying technology acceptance in such cases.

2.11 Research Hypothesis

a. **Performance Expectancy (PE)** refers to the extent to which an individual believes that the use of a technology facilitates performing a task or improves his or her job performance. Consequently, the theory postulates a positive effect of PE on an individuals' behavioral intention (BI) to use a technology (Venkatesh et al. 2003). In this research, it is the degree to which a beekeeper believes that providing bee colony information to others using IIoT will benefit beekeeper.

H1: PE positively affects BI to use IIoT

b. **Effort Expectancy (EE)** is the degree of ease associated with beekeeper' use of technology (Venkatesh et al., 2003). If beekeepers find data receiving in mobile easy to use, then it is expected that they are more willing to use IIoT. Therefore, it is hypothesized that:

H2: EE positively affects BI to use IIoT

c. **Social influence (SI)** is the extent to which beekeepers perceive that how important others believe they should use a particular technology (Venkatesh et al., 2003). The underlying assumption is that individuals tend to consult their social network, especially friends and family, about new technologies and can be influenced by perceived social pressure of important others. Therefore, it is hypothesized that:

H3: SI positively affects BI to use IIoT

d. **Facilitating conditions (FC)** refers to how beekeepers believe that technical infrastructure exists to help them to use the system whenever necessary (Venkatesh et al., 2003). Using IIoT requires some skills, such as being able to operate a mobile phone or internet. A beekeeper who has educated household members or has access to a favorable set of facilitating conditions, such as support from extension workers, will have a greater intention to use. Therefore, it is hypothesized that:

H4: FC positively affects BI to use IIoT

e. **Behavioral Intention (BI)** is defined as person's subjective possibility that he will perform the behaviors in question (Venkatesh et al., 2003). In the UTAUT model the BI has a strong influence on use behavior.

H5: BI positively affects UB of IIoT

Mediation

We hypothesized as:

H6: The influence of PE on UB is positively influenced by BI

H7: The influence of EE on UB is positively influenced by BI

H8: The influence of SI on UB is positively influenced by BI

H9: The influence of FC on UB is positively influenced by BI

Moderation

a. **Age**

We hypothesized age as:

H10: The influence of PE on BI is moderated by age.

H11: The influence of EE on BI is moderated by age.

H12: The influence of SI on BI is moderated by age.

H13: The influence of FC on BI is moderated by age.

a. **Experience**

H14: The influence of PE on BI is moderated by experience.

H15: The influence of EE on BI is moderated by experience.

H16: The influence of SI on BI is moderated by experience.

H17: The influence of FC on BI is moderated by experience.

CHAPTER 3: RESEARCH METHODOLOGY

This chapter contains the description and motivation of the chosen study design. Under this section, research approach, purpose and strategy, data collection method, data analysis method and ethical issues related to the research are thoroughly explained and discussed.

3.1 Conceptual Framework of Study

As proposed by the literature review above, there are several theoretical models in the field of technology acceptance. Conceptually, acceptance of technology starts with user reaction to using a certain technology, which then forms user intention to use the technology and ultimately the actual behaviour towards the technology. TPB theory originating from psychology forms the base pillars of technology acceptance as the constructs of behaviour, intention, attitude, subjective norm and perceived behavioral control form a model for social behaviour research (Ajzen, 1991). The TAM is based on TPB but is specifically modified for researching behaviour towards technology acceptance in the field of IS (Davis, 1989). It builds upon the construct of the TPB model but makes an addition of external variables influencing perceived usefulness and perceived ease of use of a technology. Research using the TAM was capable in predicting behaviour in the context of technology acceptance in 30-40% of cases (Venkatesh, 2000), which prompted researchers in further refining the model in improving its predictability. As a result, the UTAUT model was formed which builds upon the findings of eight strongly cited models (including TAM, TAM2, TPB & TRA) and with the addition of human/social elements. This increased the rate of prediction to 70%. The UTAUT elements of performance expectancy, effort expectancy, social influence, facilitating conditions and behavioral intention are used to predict actual usage behaviour (V, et al., 2003). Gender, age, experience and voluntariness act as moderating variables in the UTAUT model. However, in this study the technology is taken as a subject under study therefore, voluntariness could not be measured which was not the intention either. Moreover, many studies use gender as a moderating variable in the research framework but keeping in view the regional culture and environment where no female beekeepers actively participated hence it is not considered in the conceptual framework. Also, since the environment is mandated, the construct of attitude towards usage is added in this thesis since it is theorized to have an effect on usage behaviour even though it is not included (but still tested) in the original model (V, et al., 2003). It is also suggested in previous research that attitude towards usage is a suitable factor in this environments (Dalcher & Shine, 2003). Summary wise, The UTAUT model was found as the most suiting for this study. Not only does the model encompass other model's (TAM, TAM2, TPB, TRA) key findings, but it has also shown to account for high rates of predictability in previous studies and proven to be applicable in voluntary and in mandatory environments as explained in above sections. Due to the nature of this study, which is predicting behaviour of beekeepers in usage of IIoT the model was found most suitable. Moreover, no previous research has covered such technology acceptance studies in such environments.

This is another argument for the models' suitability in this study, as the environment of study will be a small portion with no or little knowledge about technology as assumed. Lastly there are few studies that investigate factors that affect acceptance of IIoT as a technology in other sectors of Pakistan, and even less out of an employee perspective and in the industry of retail. Therefore, this study will seek do so by applying the UTAUT model. Below follows a visualization of the model used in this thesis.

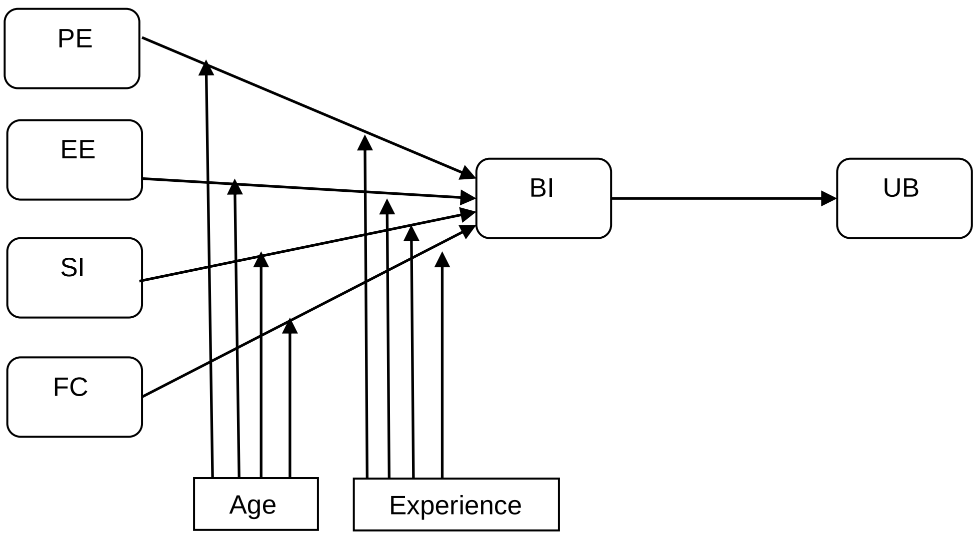

Figure 3.1 Conceptual Model

The model of this study is designed based on the UTAUT model. It integrates the previous research with the actual situations of the survey object to evaluate beekeeper's intention to use the IIoT technology to determine the challenges in the implementation. The conceptual UTAUT research model, is shown in Figure 3.1. The independent variables in this research model include the performance expectancy, effort expectancy, social influence and facilitating conditions whereas Moderators include two variables: age and experience. Behavioral intention is used as a dependent variable. This study will explore the effects of individual variables and moderators on the dependent variables and effect of behavioral intention on Use behaviour through an empirical research. Thereafter, the model and assumptions will be validated. Definitions of the variables in the initial research model are presented in Table 1, based on the definitions proposed by Venkatesh et al. (2003).

Variables	Definitions
PE: performance expectancy	The degree to which beekeepers perceive that IIoT technology can improve their performance.
EE: effort expectancy	The degree of ease associated with the use of IIoT technology.
SI: social influence	The degree to which beekeepers perceive that the acceptance of IIoT technology is affected by people surrounding.
FC: facilitating conditions	The degree to which beekeepers perceive that the knowledge and skills required to use IIoT technology can be obtained from the technical infrastructure (e.g. users' guide)
BI: behavioral intention	The degree to which beekeepers perceive their intentions to use the IIoT technology.
UB: use behavior	The degree to which beekeepers perceive frequent usage of IIoT technology.

Table 3.1 Model Constructs Definitions

The independent variables in the proposed research model are presented below:

1. **Performance Expectancy (PE)-** the degree to which individuals believe that using a system will help them improve their job performance. PE will be measured by the perceptions of using IIoT technology in terms of benefits, such as saving time, money and effort and facilitating communication with beehives at distant.

2. **Effort expectancy (EE)-** the degree of ease associated with the use of the IIoT system. EE will be measured by the perceptions of the ease of use of IoT technology, as well as the ease of learning how to use these services.

3. **Social influence (SI)-** the degree to which peers influence the use of the system, whether positive or negative. SI is a main factor in many aspects of the lives of young people and is likely to be powerful (Venkatesh et al., 2003). This variable will be measured by the perception of how peers affect beekeepers use of IIoT technology.

4. **Facilitating conditions (FC)-** the degree to which an individual believes that an organizational and technical infrastructure exists to support the system (Venkatesh et al., 2003). This variable will be measured by the perception of being able to access required resources, as well as to obtain knowledge and the necessary support to use IIoT technology.

The dependent variables in the proposed research model are presented as follows:

1. **Behavioral intention (BI)** - is defined as the person's subjective possibility that he or she will perform the behaviour in question (Venkatesh et al., 2003,). BI will be measured by the intention, prediction, and planned use of IIoT. In the UTAUT model, behavioral intention (BI) has a positive and strong influence on use behaviour (Venkatesh et al., 2003).

2. **Use Behaviour (UB)-** defined as the actual use behaviour (USE) of a specific system (Ong, Day, Chen, & Hsu, 2008). According to Ajzen and Fishbein (1980) the actual use behaviour (USE) is dominated by behavioral intention (BI). In the UTAUT model, the direct influence of behaviour intention on use behaviour (USE) has been tested and validated during the development of the UTAUT model (Venkatesh et al., 2003).

The proposed model for this study is presented in Figure 3.1. It is mostly derived from UTAUT with some modifiers, which are as follows. First, experience, in Venkatesh et al.'s (2003), model. IIoT technology are more likely to be used by experienced beekeepers. Thus, experience needed to be considered in order to explain users' effort and performance expectancies (Lu et al., 2003).

A second modifier to the UTAUT model is that voluntariness of use was deleted because use of IIoT technology is highly voluntary (AlAwadhi & Morris, 2008). Also, the number of bee farms are not connected to the Internet or the ICT world. Thus, it is suitable to consider the IIoT technology at this period of time as highly voluntary.

3.2 Research Design

Bryman & Bell (2007) argue that research design provides a framework for the collection and analysis of data stating that design reflects decisions about the priority being given to a range of dimensions of the research process. On the other hand, they consider research methods as the techniques for collecting data which can involve specific instruments such as self-completed questionnaires or structured interviews. De Vaus (2001) stated: “the function of a research design is to ensure that the evidence obtained enables us to answer the initial question as unambiguously as possible”. Sekaran (2003) argued that research design involves a series of rational decision-making choices regarding the purpose of the study (exploratory, descriptive, hypothesis testing), its location (i.e., the study setting), the type of investigation, the extent of researcher interference, time horizon, and the level to which the data will be

analyzed (unit of analysis). In addition, decisions have to be made regarding the sampling design, how data is to be collected (data collection methods), how variables will be measured and analyzed to test the hypotheses (data analysis). According to Sekaran (2003), the methods are part of the design; thus, she agrees with Bryman & Bell (2007) that methods are meat to describe data collection.

The term research design covers several topics, but in management studies there are three major research designs that are of importance; exploratory, descriptive and casual design. The choice of research design specifies the strategy of a study and the plan behind it (Cooper & Schindler, 2014).

Correspondingly, based on Sekaran’s definition of research design, this study is conducted for the purpose of testing the hypotheses derived from the conceptual framework presented. It is believed that studies employing hypotheses testing purpose usually tend to explain the nature of certain relationships, or establish the differences among groups or the independence of two factors or more in a situation.

Hypotheses testing offer an enhanced understanding of the relationships that exist among variables.

3.2.1 Exploratory

An exploratory research design is applied when there is a lack of clarity in what potential problems that might arise during the research process. The approach is usual in contexts where studied are new or vague, which gives the researcher a reason to explore the area to receive an understanding of problem. The approach is beneficial as it can save time and money, but the design type is also said to be lacking in objectivity, systematic approach and representativeness; which is related to a qualitative approach. However, qualitative and quantitative techniques can be applied in an exploratory research design even though the first-mentioned technique is more common and dependent. The main objective of an exploratory study is the development of hypothesis, and not the testing of one (Cooper & Schindler,2014).

3.2.2 Descriptive

In contrast to exploratory research, descriptive studies are more formal and structured through clearly stated hypotheses or research questions. Descriptive studies have three different objectives. Firstly, it can be used to describe associations to phenomena/characteristics within a certain setting (with emphasis on the “who”, “when”, “where”, “what” and “how” of a certain theme). Secondly, estimations of proportions of population sizes that might have the characteristics can be achieved through the design type. Lastly, discovery of correlations between various variables is an option. A descriptive study can either be complex or simple, which puts high requirements on the researcher in terms of design and execution. In this context, a descriptive and casual design are alike as they both can be equally demanding (Cooper & Schindler, 2014).

3.2.3 Explanatory

Studies applying an explanatory research design usually try to find out what effect a certain variable or set of variables has on another variable(s). Alternatively, they try to examine why a certain outcome was gained. For example, by using statistical correlations on collected data in a study causal relationship can be explained. Also, studies with an explanatory approach have a good structure, specific hypothesis or answer specific research questions – meaning that they are highly formal. (Cooper & Schindler, 2014)

3.2.4 Approach in this Research

A combined research approach of descriptive and explanatory research design is chosen for this thesis since theories (TRA, TPB) and frameworks (TAM, TAM2 etc.) based upon those theories are thoroughly researched. In turn, those theories and frameworks are the basis for the conceptual model UTAUT. Also, this approach is chosen since the author seeks to investigate interrelationships between the main constructs of UTAUT (PE, EE, SI, FC, BI and UB) and if they ultimately can predict usage behaviour. Moreover, beekeepers' perception of IIoT will be described thoroughly with the help of the data collected from each indicator that forms the six constructs. The research design includes type of approach, type of study, study setting, time horizon/study design and unit of analysis.

3.3 Research Approach

Research approach or research strategy describes the pattern of assumptions, ideas and techniques that characterize quantitative and qualitative research (Bryman and Bell, 2007). Quantitative and qualitative research has distinctive approaches, but they also have similarities and areas of overlap, and can be brought together in various ways. Depending upon the definition of the problem and the nature of the information sought, researchers choose one of these two approaches, or a combination of them (Punch, 2003). In this study, the quantitative was selected as the best approach to fulfil the research aims and to answer the research questions. The quantitative data was analyzed first; then, data was used to prove and investigate the quantitative results and finding. This study utilized the UTAUT model as the base theoretical model. This model was evaluated using a series of quantitative data and analysis steps to produce a final model that best explains the predominant phenomena of the collected data. This study aims also to test a set of hypotheses to understand and study the affect between the models' constructs. Therefore, a quantitative approach was chosen to be the research approach for this study to examine and study the proposed research model. It should be noted that there is a gap in the literature in identifying ‘what’ the factors are that influence and affect the acceptance and use of IIoT technology in the beekeeping sector of Pakistan; therefore, the current research attempts to understand and identify the factors that hinder or prompt beekeepers in Pakistan to use IIoT technology in beekeeping sector. The research is an engaging in-depth analysis of ‘what’ these factors are through structured questionnaires.

3.4 Nature of Study

In this study the impact of performance expectancy, effort expectancy, social influence and facilitating conditions on use behaviour of IIoT technology with mediating role of behavioral intentions and moderating role of age and experience is measured on the responses provided by respondents about these variables so this study is co relational in nature. The study is also causal in nature.

3.5 Study Setting

It is a field study as the respondents have filled the survey questionnaire in the work setting where they are contacted by researcher. Thus, no false environment has been created for carrying out this survey. The questionnaires were got filled by the beekeepers located in twin cities of Rawalpindi and Islamabad during working hours in their natural work environment and settings.

3.5 Time Horizon

The research study can be cross sectional or longitudinal as per time horizon. In cross sectional study, data collection is at one point of time while in longitudinal study researchers collect the data in different phases for carrying out tests and attainment of results. The data has been collected within two months (Sept, 2020 to Dec 2020). Cross sectional study is conducted because of the nature of research questions and short period of time as there is no frequent changes in creative self-efficacy within short period of time.

3.6 Unit of Analysis

In empirical research an important part is entity which is being analyzed called unit of analysis. Each member in an organization is called unit and one element of the population is called unit of analysis. The selection of unit of analysis relies upon the span, purpose and nature of research. The unit of analysis can be an individual, groups, organizations or cultures. In Micro level research, the unit of analysis is individual and at broader level it focuses on groups. The Macro level research is based on social structure, social procedures and their interconnections and the focus is on organization. The Meso level research lies between individuals and structure. It is difficult to get data from organizations, so individual beekeepers who were working in two cities of Pakistan were the unit of analysis in this study.

3.7 Population of the Study

Gray (2009) defines a population as the entire number of possible groups or elements that the researcher wishes to include in the study. The population of this study consists of individuals from the sector of Apiculture Industry of Pakistan. With regard to the targeted population of this study, this research is targeting twin cities of Pakistan.

The survey questionnaires were distributed among beekeepers in three big cities. The aim is to obtain their views and comments about the acceptance and use process of IIoT technology in the apiculture sector of Pakistan, starting with the acceptance and use process from a low level with the implantation of the services, up to the publishing phase. Their opinions are useful and valuable as they may narrow the possible factors that affect the acceptance and use of IIoT technology in the beekeeping sector. It would be neither practical, economical, or time- efficient to conduct face-to-face or telephone interviews with a large number of citizens. To gain as much as possible opinions from beekeepers about the research topic, the researcher distributed the study questionnaire among a relatively large sample; a maximum of 250, taking into consideration the study’s complexity and the importance of the views gleaned from this sample.

3.8 Sampling

A sample refers to a small sub-group that is chosen for a study (Bryman and Bell, 2011). With other words, a sample is a subset of a population that represents the population in research. The sampling units are the individual members of the sample that contribute to the research. For this study, the sampling units are individual beekeepers from Twin Cities of Pakistan. Denscombe (2010) believes, there are two ways to get a sample – exploratory and representative. Each tends to be associated with different kinds of social research. Exploratory samples are often used in small-scale research and concentrate mostly on qualitative data. However, quantitative data can also be collected using the exploratory sample. It is used to explore or discover new ideas and theories. Such samples explore the know-how, experiences and expertise of the respondents. It includes unusual examples of the things to be studied. Conversely, representative samples deal with large-scale surveys. It tends to lend more to the quantitative data from a cross-section of a population. Representative samples should also match all the relevant factors, variables or events of a population. It allows the researcher to generalize the findings for the studied population and draw valid conclusions (Denscombe,2010). This study involved relatively small-scale survey to gather quantitative data from twin cities beekeepers. Hence, any generalization and conclusion based on the exploratory sample (non-representative sample) in this study is relevant only to the beekeepers of Twin cities of Pakistan.

Two types strategies to the selection of samples are available – probability and non-probability (Saunders, et al., 2011; Denscombe, 2010). Probability approach involves random selection of samples for a representative sampling. It is suited for large-scale surveys that deal with quantitative data. However, non-probability approach to sampling does not involve random selection of the individual units in a sample of a population. When the researcher does not have enough time and resources or adequate information about the population or reaching the sample is extremely difficult (e.g. sample of homeless people), the non-probability approach is used. In addition, the non-probability approach is usually associated with exploratory research. Hence, as this study involved exploratory sample involving relatively small-scale survey to collect quantitative data from beekeepers in twin cities of Pakistan, the non-probability sampling approach was chosen.

For the non-probability sampling strategy, Denscombe (2010) recommends quota, convenience, purposive, theoretical and snowball sampling techniques. In quota sampling, a sub-group of a population is surveyed based on the known characteristics and traits to compare the relationship with other sub-groups. Theoretical techniques are usually preferred to develop new or existing theories involving multi-stages. Snowball sampling technique is preferred when the target population is very rare and hard to locate. In the snowball technique, the target sample refers similar individuals with the similar conditions and characteristics under the study. In convenience sampling, individuals are selected based on the convenience of a researcher. Limited time and resources are some of the reasons behind the inclusion of some elements of 21 conveniences in most of the research. This technique is quick, cheap and easy (Denscombe, 2010). For purposive sampling, the respondents should have relevant information and knowledge about the subject being studied. Besides, in the purposive sampling method, the researcher already knows something about particular people to be involved in the sample, and deliberately choose the respondents to produce valuable data. This technique is recommended when a broad cross-section of individuals is intended to be included in the sample, but not randomly selected. Therefore, this technique sometimes emulates representative (probability) sample (Denscombe, 2010). Considering the proposed non-probability sampling techniques, the researcher of this study chose– convenience sampling to gather the required data for this study. For convenience sampling, the researcher distributed the questionnaire to every beekeeper located in twin cities (both English and Urdu), where all the beekeepers had equal opportunity to be included in the sample.

Furthermore, according to Denscombe (2010), for a population of 5000 items/individuals and over, a representative (probability) sample size of 384 respondents from the population is adequate to represent the population. However, for non-probability sampling techniques and exploratory sample, Denscombe (2010) recommends a sample size between 30 to 250 respondents. To ensure generalization of study results, emphasis was placed on the sampling technique having known the population size, a sample size of 250, according to (O'Leary, 2010), would accurately reflect the population mentioned in the target frame with an estimated margin of error deemed acceptable for this study and this along with a selected confidence interval of +/- 5% and 95 % confidence level. In fact, to be able to conduct a reliable and valid SPSS statistical test, the researcher expected to collect around 200 responses. The researcher was able to collect 214 responses for this study, out of which all were valid to conduct statistical tests. This study followed the Process, by Andrew. F Hayes to evaluate the mediation and moderation relationship between the study variables and was done by using SPSS v.21.All of these steps were taken to ensure that the sample would be representative of the population so that the generalization of results becomes more acceptable and applicable to the apiculture industry in the context of this study.

250 questionnaires were distributed among beekeepers in total. 214 questionnaires were returned from them. 206 out of these questionnaires were found complete in all respect. Thus, the overall response rate remains 82.4 percent.

3.9 Sample Characteristics

These are the respondent's demographics included in Questionnaire.

The table 3.2 reflects the characteristics of the study population.

Demographic Characters	Frequency	%
Gender		
Male	206	100
Female		
Age		
20 or under		
21- 30	34	16.5
31- 40	95	46.1
41 -50	65	31.6
51- 60	12	5.8
Highest Level of Education		
None		
Can read and write	6	2.9
Primary school	78	37.9
Secondary school	113	54.9
Higher Education	9	4.4
Experince in beekeeping (Years)		
<5	14	8.0
6–10	45	25.9
11–15	77	44.3
>16	38	21.8
No. of Hives		
<20		
>20<50	13	7.5
>50<100	51	29.3
>100	110	63.2
Internet Knowledge		
Very poor	14	8.0
Poor	19	10.9
Moderate	50	28.7
Good	59	33.9
Very good	32	18.4
Smartphones		
Yes	145	83.3
No	29	16.7

It has been reported from gender wise frequency analysis of the data that 100 % of the sample comprises of male beekeeper's. As per the frequency of age 115 person of the sample i.e. 50.9% belongs to the age group of 26 years to 33 years while in the age bracket of 18 years to 25 years there were 56 respondents that becomes 24.8%. In the age brackets of 34 years to 41 years the number of respondents was 34 which are 15% of the total sample. Whereas 15 respondents were from the age group of 42 years to 49 years i.e. 6.6% and 6 respondents belong to the age bracket which is greater than 50 i.e. 2.7% which is the lowest one. Another demographic aspect catered in this study is the beekeepers' level of education. Respondents were asked to specify their education level. As shown in Table 4.1, about two thirds (54.6%) have a secondary school degree, while 37.4. % have a primary school degree. Respondents were asked to specify their beekeeping level. As shown in Table 4.1, majority beekeepers have more than 11 years of experience (44.3 %). Respondents were asked to specify their number of hives. As shown in Table 4.1, about two thirds (63.2%) have more than 100 boxes. Respondents were asked to specify their Internet knowledge. The majority of beekeepers (33.8%) had good computer experience. Respondents were asked to specify whether they own a smartphone or not. Majority of the beekeepers (83.3 %) are using smartphones. This finding indicates that there is a high usage of internet and smartphones amongst the sample. Over than 70% of the sample have a high level of Internet knowledge and beekeeping experiences. Consequently, this result has a significant effect on beekeeper' intention to IIoT technology.

3.10 Data Collection

The data was collected through questionnaire. There were two parts in questionnaire. In first part, demographic information has been asked from respondent such as age, gender, education, beekeeping experience, internet knowledge and use of smartphone. In second part, questions of performance expectancy, effort expectancy, social influence, facilitating conditions, behavioral intension and use behavior have been asked from respondents. The questionnaire consists of a set of 5 type Likert-scale. Data was collected through the adapted questionnaire added in the appendix A.

3.11 Research Instrument

Based on information gathered from the literature review in UTAUT studies, and keeping in mind the research questions, the researcher was able to design and develop a questionnaire instrument to answer the research questions and concerns. The questionnaire was pre-tested and modified before distribution for data collection. In summary, the procedure of the questionnaire data collection includes these steps: designing and development the questionnaire; pre-testing and modifying; and producing the urdu version of the questionnaire for collecting the research data. The following subsections will describe these steps in more details.

3.1.1.1 Questionnaire design and development.

The questionnaire method was the main method used to collect the primary data in this study. Therefore, the questionnaire was developed, based on various UTAUT studies to choose the best questions to determine the actual usage and intention to use IIoT technology. The questionnaire was divided into different sections for easy reading and completion. The researcher used a Likert scale with five levels of possible answer with respect to the UTAUT model (from Strongly Disagree to Strongly Agree) according to the measurement scales adapted from Davis (1989). A Likert scale is appropriate when the research needs to measure the respondent’s attitude towards constructs (McDaniel & Gates, 2006) (see Appendix A and B). The design of the research questionnaire consists of three pages and a cover letter, which explained the aims of the study and contact details for the researcher and the supervisors’ team. At the beginning of the questionnaire, the researcher explained the purpose of the survey and directions for filling out the questionnaire through the cover page which was created to inform the participants of the aims and importance of the current research. The questionnaire was written carefully using clear and simple language to encourage participants to partake and express their viewpoint freely, and emphasized the privacy and confidentiality measures that were put in place. The questionnaire consists of five parts. Part one collected demographic information about the respondents. Part two of the survey included mutable choices questions that were designed to collect additional information about the respondent's computer and Internet experience. Part three contained UTAUT model statements which measure the attitude towards IIoT technology and describe participants' perceptions it in Pakistan. All the UTAUT constructs were measured according to a five point Likert-type scale. Possible responses included: 1 = strongly disagree; 2 = disagree; 3 = neutral; 4 = agree; 5 = strongly agree. Table 4.5 presents a summary of items that were adapted in this study for the UTAUT model.

3.1.1.2 Questionnaire pre-testing and modifying.

Pre-testing of the research questionnaire is highly recommended to ensure that the questionnaire items are clear and understood by any normal respondent (Sekaran, 2003). Pre-testing was conducted to minimize the causes of measurement errors and to attain content reliability and validity (Hair, Black, Babin, Anderson, & Tatham, 2006). In the current study, the research questionnaire was pre-tested using the expert review technique (Sekaran, 2003). The validity of the instrument was checked in different ways. First, the questions used in the measurement of the research model were based on validated items from previous studies (Aladwani, 2006; Carter & Belanger, 2005; Cheong & Park, 2005; Hess, Wigang, Mann, & Walter, 2007; Kripanont, 2007; Taylor & Todd, 1995a, 1995b; Venkatesh & Davis, 2000; Venkatesh et al., 2003). However, the survey questions were paraphrased to suit the research object (that is, some wording was modified to fit the current research object and aims). The second part of the instrument validity testing consisted of the researcher sending the questionnaire to two researchers (PhD Professors) who have extensive knowledge of beekeeping have a sound knowledge of Urdu, which is also their mother tongue. They were requested to review and answer both versions (English and Urdu) of the instrument and provide feedback on the sufficiency, simplicity, and clarity of the instrument. The feedback from the PhD researchers recommended small changes of the wording; splitting up and changing the order of some questions were also recommended changes. The draft questionnaire was revised as per their comments and the final survey questionnaire was presented and approved. Finally, questionnaires were distributed to all beekeepers.

3.1.1.3 Urdu translation for the research questionnaire.

Urdu is the national language of Pakistan and the original version of the research questionnaire was in English, so the questionnaire had to be translated into Urdu. Sekaran (2003) emphasized the importance of choosing a clear and easily understood questionnaire language that is on a level participant will be able to understand. In this case, the researcher followed the back translation procedure. Back translation has become an in-demand methodology in academic translation and among professional studies. It is a useful method to translate questionnaires, surveys, and research instruments. Back translation is a technique used when a translated document is translated back into the original language, in this case, English. It provides extra quality checks and verifies whether the translation covers all aspects of the original (Ozolins, 2008). Consequently, the translation process used in this study includes the following steps. The original version of the questionnaire in English was translated by the researcher into Urdu. The translated Urdu version and the original English version were sent to a PhD scholar who is a linguist and specialized in writing Urdu. He reviewed both versions and provided feedback on the adequacy, sufficiency, clarity, and simplicity of the instrument. The researcher updated the urdu version from the previous step and sent it to another PhD scholar, also a linguist, to translate it back to the original language, English. Finally, the researcher compared the two English versions of the questionnaire to check for any inconsistencies, mistranslations, or problems with meaning. As result of this final step, the two versions were highly identical, which confirmed the efficiency of the translation process and the quality of the Urdu version.

3.12 Data Analysis

Once the data will be collected through questionnaire, the study made use of descriptive analysis as well as inferential analysis, such as frequencies, means, standard deviations, correlation analysis and regression analysis. The data was analyzed for correlation and regression. Data for the study was collected using already developed and validated scales. SPSS 21 was used to analyze the data. Cronbach alpha was calculated using reliability analysis. Descriptive statistics were calculated. Correlation, regression, mediation and moderation analysis were performed to confirm the hypothesis. Further, Preacher & Hayes (2008) in SPSS 21 was used to run mediation. Correlation analysis is performed to check the strength and direction of relationship between predictor and outcome variable whereas regression analysis is performed to inspect that how much variance in outcome variable is expected because of predictor.

CHAPTER 4: DATA ANALYSIS AND DISCUSSIONS

This chapter presents the analysis and findings of the quantitative data collected from the survey questionnaires. Descriptive data analysis was chosen as an appropriate way to analyses the descriptive questionnaire data. Frequency and percentage were calculated for each variable. This chapter also presents the details and results of the analysis of the measurement scales utilized in the questionnaire to test the constructs proposed in the conceptual model. In the results, Statistical Package for Social Science (SPSS) was used for data analysis.

4.1 Descriptive Statistics

The details about the data collected in this research investigation are presented in the table below "Descriptive Statistics".

Demographic Characters	Frequency	%
Gender		
Male	206	100
Female		
Age		
20 or under		
21- 30	34	16.5
31- 40	95	46.1
41 -50	65	31.6
51- 60	12	5.8
Highest Level of Education		
None		
Can read and write	5	2.9
Primary school	65	37.4
Secondary school	95	54.6
Higher Education	9	5.2
Experince in beekeeping (Years)		
<5		
6–10	14	8.0
11–15	45	25.9
>16	77	44.3
	38	21.8
No. of Hives		
<20		
>20<50	13	7.5
>50<100	51	29.3
>100	110	63.2
Internet Knowledge		
Very poor	14	8.0
Poor	19	10.9
Moderate	50	28.7
Good	59	33.9
Very good	32	18.4
Smartphones		
Yes	145	83.3
No	29	16.7

4.1.1 Age and Gender

As shown in Table 4.1, all beekeepers (100%) were male. Also, the age distribution shows that about half of respondents (46.1%) were aged 31 to 40 and the second group were aged 41 to 50 (31.6%). The percentage of the 21 to 30-year-old age group was 16.5% and the percentage of those who were older than 50 years was 5.8%. Finally, no beekeeper was of the first age group 20 or younger than 20 years old.

4.1.2 Education level.

Respondents were asked to specify their education level. As shown in Table 4.1, about two thirds (54.6%) have a secondary school degree, while 37.4. % have a primary school degree.

4.1.3 Experience in Beekeeping

Respondents were asked to specify their beekeeping level. As shown in Table 4.1, majority beekeepers have more than 11 years of experience (44.3 %).

4.1.4 No. of Hives

Respondents were asked to specify their number of hives. As shown in Table 4.1, about two thirds (63.2%) have more than 100 boxes.

4.1.5 Internet knowledge

Respondents were asked to specify their Internet knowledge. The majority of beekeepers (33.8%) had good computer experience.

4.1.6 Smartphones

Respondents were asked to specify whether they own a smartphone or not. Majority of the beekeepers (83.3 %) are using smartphones. This finding indicates that there is a high usage of internet and smartphones amongst the sample. Over than 70% of the sample have a high level of Internet knowledge and beekeeping experiences. Consequently, this result has a significant effect on beekeeper' intention to IIoT technology.

4.2 Measurement Scale Analysis

4.2.1 Reliability

The reliability of a measure refers to the degree to which the instrument is free of random error. It is concerned with the consistency and stability of the measurement.

In the current study, there were six independent scales and two independent scales used in the questionnaire to measure the constructs of the proposed UTAUT model. The independent scales are: Performance Expectancy (PE); Effort Expectancy (EE); Social Influence (SI) and Facilitating Conditions (FC). The dependent scales are: Behavioral Intention (BI); and use behaviour (UB) to IIoT technology. To prove that the set of scales captures the meaning of the model constructs consistently and accurately, a scale reliability analysis was performed to assess the internal consistency and item-total correlations.

Internal consistency reliability is a frequently used type of reliability in the IS domain (Sekaran, 2003). It refers to the degree to which responses are consistent across the items (variables) within a single measurement scale (Kline, 2005). In this study, Cronbach' s coefficient alphas, which are calculated based on average inter-item correlations, were used to measure internal consistency. As stated by Straub (1989 p. 151), "high correlations between alternative measures or large Cronbach' s alphas are usually signs that the measures are reliable". Cronbach's coefficient alpha value was assessed to examine the internal research consistency of measuring (Field, 2005; Hinton, Brownlow, McMurray, & Cozens, 2004; Straub, Boudreau, & Gefen, 2004). Hinton et al. (2004) propose four degrees of reliability scale: excellent (0.90 and above); high (0.70 to 0.90); high moderate (0.50 to 0.70); and low (0.50 and below). The reliability values reported in Straub et al.'s (2004) study should be equal to or above 0.70 for a confirmatory study. Pallant (2005) states that Cronbach's coefficient alphas of 0.70 and above are deemed acceptable. Moreover, Hair et al. (2006) mentioned that construct reliability should be 0.7 or higher to indicate adequate convergence or internal consistency (Hair et al., 2006). According to the current realest model as well as Venkatesh et al. (2003), the construct constituting the UTAUT should have a good internal consistency with a reported Cronbach's alpha (α) value greater than 0.70. In this study, there were eight scales used in the survey questionnaire to measure the constructs proposed in the model, namely performance expectancy (PE), effort expectancy (EE), social influence (SI), facilitating condition (FC), behavioral intention (BI), and use behaviour (UB). To prove that those scales satisfied the model constructs consistently and accurately, a scale reliability analysis was performed to assess the internal consistency. A reliability coefficient was run on SPSS for each set of constructs and the results are presented in Table 7.1, which shows the Cronbach's alpha (α) value for each variable. The results of the analysis show that all of the constructs got a high reliability of more than 0.7. Cronbach's α value result varied between 0.73 for use behaviour and 0.95 for the facilitating condition. Overall, the result shows that all alpha values of the study instrument are reliable and exhibit appropriate construct reliability.

Variable	Cronbach Alpha	No. of items
PerfomanceExpectancy	0.835	5
Effort Expectancy	0.812	4
Social Influence	0.805	4
Facilitating Conditions	0.846	4
Behavioral Intention	0.817	3
Use Behaviour	0.810	3

Table 4.2 Reliability Analysis

4.2.2 Correlation Analysis

In order to check the relationship between two variables and to indicate either the two variables are moving in similar or opposing direction correlation analysis is used. The difference between regression and correlation is that in regression we measure the causal linkages for the variables under examination. Positive values denote the degree to which value enhancement of either of the variables differ with one other while zero correlation is not included. The correlation analysis is a widely used coefficient for assessing correlation among relationships. Correlation coefficient is examined through Pearson correction analysis. Reliance between two quantities is commonly calculated through this technique. The range of correlation values is from -1.00 to +1.00. In which +1.00 values represent positive correlation. However, 0 values of correlation mean there exists no correlation among the variables.

4.2.3 Validity

Construct validity is defined as the degree to which an operational measure correlates with the theoretical concept being investigated. It provides the researcher with assurance that the research's instrument truly measures what it is intended to be measured (Gable, 1993; Netemeyer, Bearden & Sharma, 2003; Turocy, 2002). According to Turocy (2002), factor analysis is most often associated with construct validity and considered one of the analytic tools to assess construct validity. Factor analysis can be used to "examine empirically the interrelationships among the items and to identify clusters of items that share sufficient variation to justify their existence as a factor or construct to be measured by the instrument" (Gable, 1993, p. 108).

4.2.3.1 Coding of Performance Expectancy Variable

Construct	Variable Code	Questionnaire Statement
Performance Expectancy (PE)	PE1	I would find the use of IIoT useful in my day to day work.
	PE2	I think using IIoT would make my bee protection more cost effective.
	PE3	I find IIoT useful to acquire data faster.
	PE4	I think IIoT would speed up my work completion.
	PE5	Using IIoT helps me overall in my apicultural activity and increase my Productivity.

4.2.3.2 Coding of Effort Expectancy Variable

Construct	Variable Code	Questionnaire Statement
Effort Expectancy (EE)	EE1	The use of IIOT would be simple and understandable for me.

	EE2	I believe use of IIoT would be easy for me to learn.
	EE3	My interaction with IIoT is not be frustrating.
	EE4	It will be easy for me to become skillful at using IIoT.

4.2.3.3 Coding of Facilitating Condition Variable

Construct	Variable Code	Questionnaire Statement
Facilitating Condition (FC)	FC1	My smartphone and internet coverage are sufficient to use IIoT.
	FC2	I have the resources necessary to use IIoT.
	FC3	I have the knowledge necessary to use IIoT.
	FC4	There is a specific person or group available for assistance with any technical problems I may encounter.

4.2.3.4 Coding of Social Influence Variable

Construct	Variable Code	Questionnaire Statement
Social Influence (SI)	SI1	Beekeepers who are friends of mine think it makes sense to use IIoT
	SI2	The People, who have influence on my behavior think that I should use IIoT
	SI3	The People who are important to me think that I should use IIoT
	SI4	I would use IIoT if my fellow beekeepers/colleagues used it.

4.2.3.5 Coding of Behavioral Intention Variable

Construct	Variable Code	Questionnaire Statement
Behavioral Intention (BI)	BI1	I plan to use IIoT in the next two months.
	BI2	I intend to use IIoT in the future
	BI3	I will suggest the use of IIoT to other beekeepers

4.2.3.6 Coding of Use Behavior Variable

Construct	Variable Code	Questionnaire Statement
Use Behavior (UB)	UB1	I can use all relevant IIoT-related applications.
	UB2	I have a clear idea how to use IIoT.
	UB3	I really want to use IIoT to perform my beekeeping activities.

4.3 Regression Analysis

Regression analysis for prediction and calculation of the relationship among variables is widely used. The regression analysis reveals the judgment and forecast about Y from the values of X. On the other hand, correlation analysis shows how strong is the relationship between X and Y variables. The regression analysis is used to measure the dependence of one variable on the other variable. If linear regression is found among two variables Regression analysis help to explain it well.

Hypothesis	R-Square	β	Sig	Result
PE → BI	**0.24**	**0.49**	**0.00**	**Supported**
EE → BI	**0.17**	**0.41**	**0.00**	**Supported**
SI →BI	**0.12**	**0.34**	**0.00**	**Supported**
FC→ BI	**0.20**	**0.45**	**0.00**	**Supported**

BI → UB	**0.30**	**0.55**	**0.00**	**Supported**

4.3.2 Mediation of behavioral Intention between PE and UB

	Effect	SE	Boot LLCI	Boot ULCI
Indirect Effect	**0.38**	**0.06**	**0.27**	**0.51**

Getting regression results under the mediation analysis, it was found that Performance Expectancy positively affected Use Behavior with (R2 0.45, p<0.05). Therefore, hypotheses 1 is substantiated which stated PE has significant influence on Beekeepers. The total, direct and indirect effects can be observed in table. The total (0.507) and direct effect (0.124) came out to be significant at p<0.05. Whereas, the effect size in the presence of the mediating variable i.e. BI turned out to be 0.38 with no zero value lying between ULCI (0.27) and LLCI (0.51). Consistent with Preacher and Hayes, (2004), the presence of a non-zero value between the upper and lower boot limits demonstrates that the mediating variable mediates the independent-dependent variable relationship.

4.3.2 Mediation of behavioral Intention between EE and UB

	Effect	SE	Boot LLCI	Boot ULCI
Indirect Effect	**0.28**	**0.45**	**0.20**	**0.37**

Getting regression results under the mediation analysis, it was found that Effort Expectancy positively affected Use Behavior with (R2 0.345, p<0.05). Therefore, hypotheses 2 is substantiated which stated EE has significant influence on Beekeepers. The total, direct and indirect effects can be observed in table. The total

(0.53) and direct effect (0.24) came out to be significant at p<0.05. Whereas, the effect size in the presence of the mediating variable i.e. BI turned out to be 0.28 with no zero value lying between ULCI (0.20) and LLCI (0.37). Consistent with Preacher and Hayes, (2004), the presence of a non-zero value between the upper and lower boot limits demonstrates that the mediating variable mediates the independent-dependent variable relationship.

4.3.3 Mediation of behavioral Intention between FC and UB

	Effect	SE	Boot LLCI	Boot ULCI
Indirect Effect	**0.23**	**0.04**	**0.15**	**0.31**

Getting regression results under the mediation analysis, it was found that Facilitating Conditions positively affected Use Behavior with (R2 0.29, p<0.05). Therefore, hypotheses 3 is substantiated which stated FC has significant influence on Beekeepers. The total, direct and indirect effects can be observed in table. The total (0.67) and direct effect (0.44) came out to be significant at p<0.05. Whereas, the effect size in the presence of the mediating variable i.e. BI turned out to be 0.23 with no zero value lying between ULCI (0.15) and LLCI (0.31). Consistent with Preacher and Hayes, (2004), the presence of a non-zero value between the upper and lower boot limits demonstrates that the mediating variable mediates the independent-dependent variable relationship.

4.3.4 Mediation of behavioral Intention between SI and UB

	Effect	SE	Boot LLCI	Boot ULCI
Indirect Effect	**0.28**	**0.04**	**0.19**	**0.38**

Getting regression results under the mediation analysis, it was found that Social Influence positively affected Use Behavior with (R2 0.18, p<0.05). Therefore, hypotheses 4 is substantiated which stated SI has significant influence on Beekeepers. The total, direct and indirect effects can be observed in table. The total (0.44) and direct effect (0.15) came out to be significant at $p<0.05$. Whereas, the effect size in the presence of the mediating variable i.e. BI turned out to be 0.28 with no zero value lying between ULCI (0.19) and LLCI (0.38). Consistent with Preacher and Hayes, (2004), the presence of a non-zero value between the upper and lower boot limits demonstrates that the mediating variable mediates the independent-dependent variable relationship.

4.3.5 Moderation Analysis for Age between PE and BI

	t	LLCI	ULCI
Age x PE	**2.38**	**0.25**	**0.27**

From the above table: moderation of Age between PE and BI. It is mentioned in the above table that Age does moderates the relationship between PE and BI. Thus H5 i.e.: Age of the beekeepers have significant moderating role on the relationship of PE and BI.

4.3.6 Moderation Analysis for Age between EE and BI

	t	LLCI	ULCI
Age x EE	**2.69**	**0.043**	**0.27**

From the above table: moderation of Age between EE and BI. It is mentioned in the above table that Age does moderates the relationship between EE and BI. Thus H5 i.e.: Age of the beekeepers have significant moderating role on the relationship of EE and BI.

4.3.7 Moderation Analysis for Age between FC and BI

	t	LLCI	ULCI
Age x FC	**1.65**	**-0.01**	**0.21**

From the above table: moderation of Age between FC and BI. It is mentioned in the above table that Age does NOT moderates the relationship between FC and BI. Thus H6 i.e.: Age of the beekeepers have no significant moderating role on the relationship of FC and BI.

4.3.8 Moderation Analysis for Age between SI and BI

	t	LLCI	ULCI
Age x SI	**1.53**	**-0.03**	**0.28**

From the above table: moderation of Age between SI and BI. It is mentioned in the above table that Age does NOT moderates the relationship between SI and BI. Thus H7 i.e.: Age of the beekeepers have no significant moderating role on the relationship of SI and BI.

4.3.9 Moderation Analysis for Experience between PE and BI

	t	LLCI	ULCI
Experience x PE	**0.138**	**-0.10**	**0.12**

From the above table: moderation of beekeeping experience between PE and BI. It is mentioned in the above table that Experience does NOT moderates the relationship between PE and BI. Thus H8 i.e.: Beekeeping experience of the beekeepers have no significant moderating role on the relationship of PE and BI.

4.3.10 Moderation Analysis for Experience between EE and BI

	t	LLCI	ULCI
Experience x EE	**0.45**	**-0.08**	**0.18**

From the above table: moderation of beekeeping experience between EE and BI. It is mentioned in the above table that experience does NOT moderates the relationship between EE and BI. Thus H9 i.e.: Beekeeping experience of the beekeepers have no significant moderating role on the relationship of EE and BI.

4.3.11 Moderation Analysis for Experience between FC and BI

	t	LLCI	ULCI
Experience x FC	**0.18**	**-0.03**	**0.17**

From the above table: moderation of beekeeping experience between FC and BI. It is mentioned in the above table that experience does NOT moderates the relationship between FC and BI. Thus H10 i.e.: Beekeeping experience of the beekeepers have no significant moderating role on the relationship of FC and BI.

4.3.12 Moderation Analysis for Experience between SI and BI

	t	LLCI	ULCI
Experience x SI	**1.21**	**-0.05**	**0.23**

From the above table: moderation of beekeeping experience between SI and BI. It is mentioned in the above table that experience does NOT moderates the relationship between SI and BI. Thus H11 i.e.: Beekeeping experience of the beekeepers have no significant moderating role on the relationship of SI and BI.

4.4 Hypotheses Result

I. PE has a positive influence on the intention to use IIoT.
II. EE has a positive influence on the intention to use IIoT.
III. SI has a positive influence on the intention to use IIoT.
IV. FC has a positive influence on the intention to use IIoT.
V. BI positively affects the relationship between all UTAUT factors (PE EE FC SI) and intention to use IIoT.
VI. Age Moderates the relationship between PE, EE and BI

CHAPTER 5: DISCUSSION

This chapter holds the discussion on the results brought forward after the analysis of the study.

5.1 The influence of Performance Expectancy on Behavioral Intention

According to previous reviews, many studies have shown that the higher the user's performance expectancy, the stronger the use intension (Venkatesh et al., 2003; Gao & Deng, 2012). In this study, the performance expectancy does have a significant influence on the intention to use Industrial Internet of Things.

5.2 The influence of Effort Expectancy on Behavioral Intention

In the theory of innovation diffusion, it was mentioned that if the innovations are more complicated, the speed of adoption will be slower (Rogers, 2003). Meanwhile, Venkatesh et al. (2003) also pointed out in the UTAUT model that the more complex the system or technology, the lower the user's intention to use it. The results of the study are consistent with the two theories, which show that the effort expectancy has an indirect influence on the use intention. The easier the use of IIoT, the higher the degree of user acceptance.

5.3 The influence of Facilitating Condition on Behavioral Intention

As mentioned previously, the facilitating conditions in this study refer to the degree to which users perceive that they can gain the knowledge and skills from organizational and technical infrastructure to support the use of new technologies. Facilitating conditions depend to a large extent on the indicators such as perceived behavioral control and compatibility (Venkatesh et al, 2003). According to the result of study, the beekeepers supposes that they get guidance and help regarding how to use IIoT from the system and user's guide. This shows that the people with higher education levels are more conscious and better understand how to find and obtain guidance and help in the use of IIoT. Further, the effective use of IIoT depends on whether the users have knowledge and skills in using IIoT. In other words, if users believe that they have the knowledge and skills, they can quickly adapt to the use of technology.

5.4 The influence of Social Influence on Behavioral Intention

Referring to both the interpersonal channels in the theory of innovation diffusion and the social influence in the UTAUT model, it was mentioned that personal behaviour is more or less affected by people around them, e.g., friends, colleagues, family, etc. (Rogers, 2003; Venkatesh et al., 2003). Similarly, according to the results of the study, the social influence has significant impact on the user's intention to use IIoT technology, which is consistent with the research hypothesis (H3). The result is contrary to the previous study (Hsu et al., 2014; Li et al., 2018. It is not strange that people are not affected by the opinions of others and accept the advice of those they trust. This indicates that the people are more affected by the people surrounding. This may be due to that they want to be more integrated into the group and have more commonalities with the people surrounding. The moderating effect of the age on the social influence in other age groups are not significant in this study.

5.5 Answering RQs.

5.5.1 Performance expectancy (PE).

The research result supports the hypothesis H1 which states that performance expectancy (PE) positively predicts behavioral intention (BI) to use Industrial Internet of Things. The effect of performance expectancy (PE) on behavioral intention (BI) was significant and strong and that definitely reflects the perceived benefits obtained from using IIoT in Apiculture Industry of Pakistan. This result is consistent with previous researches findings (Al-Qeisi, 2009; Garfield, 2005; Louho, Kallioja, & Oittinen, 2006; Rosen, 2005; Schaper & Pervan, 2004; Venkatesh et al., 2003; Zhou, Lu, & Wang, 2010).

5.5.2 Effort expectancy (EE).

The effort expectancy (EE) variable in this study was defined as the degree of ease associated with the use of IIoT in Apiculture Industry of Pakistan. It was measured by the perception of ease of learning and using these systems, as well as how much effort should be spent to use these systems. The link between effort expectancy (EE) and behavioural intention (BI) was significant and supported by the research finding

Consequently, this finding is consistent with the results of other studies which also confirmed that effort expectancy has a strong effect on use intention (Birth & Irvine, 2009; Helaiel, 2009; Louho et al., 2006; Rosen, 2005; Venkatesh et al., 2003.

5.5.3 Social influence.

The social influence (SI) construct in this study was defined as the extent to which an individual perceives others' opinions are important in one's decision to use IIoT technology. It was measured by the perception of how social communications affect users' intentions to use of IIoT. The study result revealed the significant impact of social influence on behavioral intention (BI) to use IIoT. This result contradicts previous findings reported in several studies (Davis, Bagozzi, & Warshaw, 1989; Karahanna & Straub, 1999; Rosen, 2005; Taylor and Todd, 1995c; Venkatesh & Davis, 2000; Venkatesh et al. 2003). Moreover, this result indicates that the use of IIoT technology is not a personal and individual issue, one affected by social influence. Venkatesh et al. (2003) confirms that the usage of a system depends on individual user's beliefs, rather than on others' opinions or advices.

5.5.4 Facilitating conditions (FC).

In this study, facilitating conditions (FC) refers to the availability of technological and organizational resources that are used to support the use of IIoT system (Venkatesh et al., 2003). It was measured by assessing the perception of accessing the required resources, the necessary knowledge, and the technical support needed to use e-government services systems. The study results confirmed that facilitating conditions (FC) have a direct and significant effect on usage behavior (USE) of IIoT technology. With respect to the beekeeping, facilitating conditions include ICT infrastructure of government sectors, Internet connectivity, the accessibility and reliability of government websites, technical support services, and any other available services to assist individuals to adopt and use IIoT technology. Therefore, it is necessary to improve facilitating conditions in terms of both technological and human resources in order to improve and increase the adoption of IIoT technology. This result was comparable with other empirical studies (Helaiel, 2009; Hung et al., 2006; Taylor & Todd, 1995a; Venkatesh et al., 2003; Zhou et al., 2010).

5.5.5 Age impact.

With respect to the moderating effect of age, in this study, age moderated the relationship between performance expectancy (PE), and effort expectancy (EE) on behaviour intention (BI). There are several possible explanations for this result. For instance, older users, as late adopters of computer technology, are less familiar with the Internet and technology compared with the younger generation who have grown up in the Internet age and technological revolution. Also, in the past, computer devices, communication facilities, and Internet services were less common and expensive, and only traditional methods were available. In fact, the moderating effect of age was reported in many studies (including Morris & Venkatesh, 2000; Morris, Wu, & Finnegan, 2005; Venkatesh et al., 2000; and Venkatesh et al., 2003).

10.2.1.4.3 Beekeeping experience impact.

According to Venkatesh et al. (2003), beekeeping experience is considered one of the important factors that can affects behavior intention (BI). In this study, internet experience does not moderate the relationship between performance expectancy (PE), and effort expectancy (EE) on behavior intention (BI) or any other UTAUT factors. These results are in line with the popular belief that the experienced user's adoption uptake is always higher than those inexperienced users. Also, it confirmed that the effect of effort expectancy (EE) is stronger for inexperienced users, which was expected, due to their lack of Internet experience. The results suggest the need for provision of easy, simple, and uncomplicated e-services; this will decrease the effect of effort expectancy (EE) by inexperienced users and increase the adoption level of IIoT. The literature reported that, in an online context, experienced users are more likely to adopt new information systems more than inexperienced users.

CHAPTER 6: CONCLUSION

As it is evident, the focal objective of this research is to find out the beekeeper' intention to use IIoT technology as a necessary and fundamental prerequisite for the implementation of smart beekeeping in Pakistan. The supported hypotheses accentuated and proved the positive impacts of performance expectancy, effort expectancy, social influence, and facilitating conditions on the intention to use IIoT technology. Moreover, the important factor was the significant mediating impact of behavioral intention on the actual use of IoT technology which is also positive. The rejected hypotheses proved no effect of age on the PE-BI, EE-BI, SI-BI and FC-BI. The research concludes that any planning for smart beekeeping, which do not pay enough attention to the five above factors, could potentially fall short and do not reach its predefined goals. Therefore, a sound IT plan for the promotion of smart beekeeping be considered at priority. Then the state's apicultural policymakers should set the IIoT promotion stage for the promotion of smart beekeeping by paying attention and justifying the benefits that the beekeepers can achieve in respect to optimal performance, less effort, satisfaction of their personal characteristics in using technology, ease of access and use of technology even in far and remote corners of the country. Once these issues are fulfilled, the bedrock for the promotion of smart beekeeping based on the UTAUT model can be laid.

6.1. Limitations and Future Research Directions

One of the preliminary limitations of the research was the application of only one model (the UTAUT model) in this research. There are numerous technology adoption models, therefore the authors recommend to the future researchers of technology usage and acceptance to test other proposed models for IoT for the same contexts. Moreover, the collected data in this research—like most of the researches on the technology adoption—are based on the self-assertion of the beekeepers. Such an approach has a fundamental shortage that the research conveys the mental perceptions of the beekeepers from their usage and adoption of technology. Furthermore, the approach in this research is statistical, hence it is recommended to use other approaches such as Fuzzy approaches which do not need as much certainty as the statistical methods [27]. Finally, the research is carried out in

Pakistan which is a developing country thus it is recommended to test the presented model of the research in a developed country to verify or moderate the results for a universal usage of IoT in apiculture

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APENDIX A

QUESTIONNAIRE

NUST College of Electrical and Mechanical Engineering
Department of Engineering Management

I am a MS research student at NUST-EME University Rawalpindi conducting a study to Investigate Barriers in Implementation of Industrial Internet of Things (IIoT) in Apiculture of Pakistan. The research title is:

Identification of Barriers in Implementation of Industrial Internet of Things (IIoT) in Pakistan: A Case of Apiculture

I would be very grateful if you fill out this questionnaire. Your participation is voluntary. If you do not wish to participate, simply discard the questionnaire. Responses will be completely anonymous; your name will not appear anywhere on the survey. Completing and returning the questionnaire constitutes your consent to participate. All of the information you kindly provide will be treated as completely confidential and it will not be possible for anyone to identify the information you supply.
The questionnaire will only take 10-15 minutes of your time to fill out. Your corporation is highly appreciated and will contribute to the success of this study.
If you have any questions or concerns,
Please contact me at **akhanzada.em18ceme@student.nust.edu.pk.**

Thank you
Amna Khanzada

Part 1: Social demographic characteristics of beekeepers (Please tick the appropriate answer)

1. **Gender:**

    - ☐ Female
    - ☐ Male

2. **Age:**

    - ☐ 20 or under
    - ☐ 21- 30
    - ☐ 31- 40
    - ☐ 41 -50
    - ☐ 51- 60

3. **Highest level of education:**

    - ☐ None
    - ☐ Can read and write
    - ☐ Primary school
    - ☐ Secondary school
    - ☐ Higher Education

4. **Experience in beekeeping (years):**

    - ☐ <5
    - ☐ 6–10
    - ☐ 11–15
    - ☐ >16

5. **How many hives do you currently have?**

    - ☐ <20
    - ☐ >20<50
    - ☐ >50<100
    - ☐ >100

6. **What is your average monthly income?**

    - ☐ Below 10,000 Rupees
    - ☐ 10,000-15,000
    - ☐ 16,000-25,000
    - ☐ 26,000-35,000
    - ☐ 35,000-above

Part 2: Internet Knowledge and Use of Smartphones.

7. How to you describe your Internet knowledge?

☐ Very poor
☐ Poor
☐ Moderate
☐ Good
☐ Very good

8. How long have you been using Internet?

☐ Don’t use
☐ Less than 1 year
☐ 1-3 years
☐ More than 3 years

9. -Are you a smartphone user?

☐ Yes
☐ No

Part 3: Examines Beekeeper´s Evaluation of the Items.

- UTAUT Model Questions:
Using a rating scale of 1 to 5, please circle the number that indicates your level of disagreement/agreement with the following statements

1	**Statements**					
Performance Expectancy (PE)		**Strongly disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
PE1	I would find the use of IIoT useful in my day to day work.	**1**	**2**	**3**	**4**	**5**
PE2	I think using IIoT would make my bee protection more cost effective.	**1**	**2**	**3**	**4**	**5**
PE3	I find IIoT useful to acquire data faster.	**1**	**2**	**3**	**4**	**5**

PE4	I think IIoT would speed up my work completion.	1	2	3	4	5
PE5	Using IIoT helps me overall in my apicultural activity and increase my Productivity.	1	2	3	4	5
Effort Expectancy (EE)						
EE1	The use of IIOT would be simple and understandable for me.	1	2	3	4	5
EE2	I believe use of IIoT would be easy for me to learn.	1	2	3	4	5
EE3	My interaction with IIoT is not be frustrating.	1	2	3	4	5
EE4	It will be easy for me to become skillful at using IIoT.	1	2	3	4	5
Social Influence (SI)						
SI1	Beekeepers who are friends of mine think it makes sense to use IIoT.	1	2	3	4	5
SI2	The People, who have influence on my behavior think that I should use IIoT.	1	2	3	4	5
SI3	The People who are important to me think that I should use IIoT	1	2	3	4	5
SI4	I would use IIoT if my fellow beekeepers/colleagues used it.	1	2	3	4	5
Facilitating Conditions(FC)						
FC1	My smartphone and internet coverage are sufficient to use IIoT.	1	2	3	4	5
FC2	I have the resources necessary to use IIoT.	1	2	3	4	5
FC3	I have the knowledge necessary to use IIoT.	1	2	3	4	5

FC4	There is a specific person or group available for assistance with any technical problems I may encounter.	**1**	**2**	**3**	**4**	**5**
Behavioral Intension (BI)						
BI1	I plan to use IIoT in the next two months.	**1**	**2**	**3**	**4**	**5**
BI2	I intend to use IIoT in the future	**1**	**2**	**3**	**4**	**5**
BI3	I will suggest the use of IIoT to other beekeepers	**1**	**2**	**3**	**4**	**5**
Use Behavior (UB)						
UB1	I can use all relevant IIoT-related applications.	**1**	**2**	**3**	**4**	**5**
UB2	I have a clear idea how to use IIoT.	**1**	**2**	**3**	**4**	**5**
UB3	I really want to use IIoT to perform my beekeeping activities.	**1**	**2**	**3**	**4**	**5**

APENDIX B