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The Application of Collaborative Robots in Garment Factories

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139 Pages

In response to the development of Industry 4.0 (I4.0), the last few decades witnessed a tremendous increase in innovative applications for the fashion industry. Among these are collaborative robots (Cobots), a new robot model from I4.0 technology, which can function with workers without safety fencing to improve safety and productivity in the manufacturing sectors (Perez et al., 2019). However, current research on Cobots in garment factories has been limited (Lee et al., 2021). Vietnam's textile and garment industry had more than 10,000 enterprises in 2017 and $36.14 billion in 2018 in export turnover as one of the top four Asian countries for garment manufacturing (Thang et al., 2019). Hence, Vietnam's textile and garment industry has incurred a massive portion of labor and faces enormous challenges and opportunities in I4.0. Using robots can diminish the advantage of cheap worker resources, while it also can improve competitiveness capacities for textile and garment manufacturers (Nhabe Corporation, 2019). Therefore, this study aimed to understand and predict garment employees' cognitive, social, and psychological perspectives as well as behavioral intentions towards Cobot implementations in Vietnam. Based on the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003) and the modified UTAUT model from Boer and Astrom (2017), the relationship between performance expectancy, effort expectancy, social influence, facilitating conditions, trust, anxiety, personal innovativeness, and behavioral intentions associated with Cobots were examined. The proposed model for this study was used to explore the acceptance

level of Cobot applications based on employees' perspectives in Vietnamese garment factories. Data were collected via a Qualtrics survey from a sample of employees working in garment factories in Vietnam during February 2022. Participants were recruited for this study using a snowball sampling approach based on the network from the author's previous working experience in Vietnam. Of the 286 participants invited to participate in the survey, 275 responded providing a response rate of 96.2%. Of these surveys, 198 were completed and deemed usable for further analysis.

Two phases of data analysis were conducted: preliminary analysis and acceptance model testing. First, a preliminary analysis, qualitative, labeled each response's keywords and systematically categorized them. These categories were based on keywords to determine the tasks Cobots could do in the garment factory's process. Second, acceptance model testing, descriptive analysis, tested for normality using Q-Q scatterplots, principal components analysis, internal reliability assessment using Cronbach's *alpha* coefficients, correlation analysis, and simple regression. These analyses were conducted using SPSS version 28.0.

The findings from this study confirmed elements of the original UTAUT model by Venkatesh et al. (2003). Performance expectancy, effort expectancy, social influence, and facilitating conditions positively affected the garment employees' intentions toward Cobot implementation. Additionally, results about trust in Cobots, anxiety, and personal innovativeness were consistent with Boer and Astrom's (2017) study, indicating these were crucial factors to predict garment employees' willingness to collaborate with Cobots in the near future. Trust in Cobots also had a positive impact on respondents' intentions. Personal innovativeness was a positive determinant of performance expectancy and effort expectancy, while anxiety was a negative determinant of performance expectancy and effort expectancy.

The present study provides valuable insights into robotics development, especially Cobots, and attributes to professionals and academic literature. Regarding professionals, this study found the acceptance level of Cobot applications based on Vietnamese garment employees’ intentions. Therefore, Cobot companies, application partners, technology programmers, and manufacturers can benefit from the acceptance level of Cobot’s applications to implement Cobots to maximize the advantage of using Cobots in garment manufacturing. If implementing Cobots’ in Vietnamese garment factories increases significantly, the garment industry can grow economically as well as sustainably. In relationship to the academic literature, findings from this study fill a gap in the literature concerning positive employees’ intentions towards adopting Cobots’ applications in the core manufacturing processes of garment factories. In addition, this study provides theoretical and empirical contributions by developing and validating the UTAUT model with additional antecedents, anxiety, personal innovativeness, and trust. The extended version of the UTAUT model with anxiety, personal innovativeness, and trust provide a more in-depth understanding of factors influencing the acceptance and use of Cobots.

KEYWORDS: Industry 4.0, collaborative robots, Cobots, UTAUT model, performance expectancy, effort expectancy, social influence, facilitating conditions, behavioral intention, trust in Cobots, personal innovativeness, anxiety

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CHAPTER I: INTRODUCTION

The Application of Collaborative Robots in Garment Factories

Stepping into the 21st century, when many manufacturers are exposed to a wide range of state-of-the-art approaches to broaden their business, Industry 4.0 (I4.0) has sparked a revolution in science and manufacturing fields. I4.0 offers a wide variety of new technologies central to many businesses, including robotics, intelligent manufacturing, augmented and virtual reality, and artificial intelligence (AI) (Jin & Shin, 2021). The smart production, logistics, networks, and the Internet of Things (IoT) in contemporary goods are attributed to the transformation of current value chains and the emergence of new, innovative business models. Above new technologies also made the smart factory an essential element of future smart infrastructures. From this new infrastructure perspective, several benefits and profits may arise (Mohamed, 2018). In the fashion industry, I4.0 aims to utilize productivity, environmental sustainability, and hyper-personalization because it currently solves a variety of severe issues in the fashion industry, such as unmatched consumer demand and supply, environmental pollution, and dissatisfaction of customers with fashion products and services (Jin & Shin, 2021). Therefore, robotics, intelligent manufacturing, 3D printing and knitting, virtual and augmented reality, and AI are the most significant applications of I4.0 in this industry (Jin & Shin, 2021).

Regarding robotics and intelligent manufacturing sectors, collaborative robots (Cobots) in many industries have become universal due to their positive effects on profit and sustainability. Cobots, a new robot model of I4.0 technology, can share physical tasks with workers in an uncaged environment to reduce errors and waste and improve productivity, flexibility, and agility (Karre et al., 2017; Perez et al., 2019). Cobots help manufacturers reduce operation costs and waste, offer a safe, healthy working environment, and ensure human rights issues for employees. For example, BWIndustrie, an industrial small- and medium-sized enterprise in France, applied Cobots from Universal Robots in machine tending, material removal, and quality inspection (Dilmegani, 2021). Its return on investment (ROI) was less than 12 months, and profit increased to reach 5.6 billion Euros annually. In addition, the *ALPHA* Corporation improved its productivity of the automobile key molding process by 20%, using Cobots for material handling and machine tending (Dilmegani, 2021). The Ministry of Industry and Trade of Vietnam noted Cobots provide endless benefits, including increasing productivity, output quality, and workers' well-being. These are primary conditions for Vietnam to meet the needs of modern businesses and remain competitive (Vietnam Industry Agency, 2018). For example, garment workers continuously work overtime to meet customers' demands and increase pre-consumer waste in production. Thus, if workers collaborate with robots, the product defects rate may decrease, since robots can work under pressure for many hours without human physical and mental effects. Overall, the invention of Cobots is one of the most outstanding achievements of I4.0 and an essential sustainable approach to minimize future negative aspects of the fashion industry.

However, manufacturers have some potential challenges when adopting new technology, like Cobots, including challenges, such as technological and economic issues, and social and political problems. For instance, when adopting this new Cobot approach, qualified workers could become controversial because they need to learn how to solve problems, analyze failure, deal with constant changes, and complete new tasks, while Cobots work with employees (Mohamed, 2018). Furthermore, the application of Cobots depends on many factors related to the size of the company's manufacturing from small to medium to large. As a result, integrating Cobots takes time and includes many initial risks—unless careful preparations are made.

During 2020, Vietnam gradually improved its manufacturing sector to 16.69% of the gross domestic product (GDP) (*Vietnam Economic News*, 2021). Among many manufacturing industries, Vietnam's textile and garment industry plays a pivotal role in developing international economic integration with more than 10,000 enterprises in 2017. This industry has grown from $5.85 billion in 2006 to $36.14 billion in 2018 in export turnover (Thang et al., 2019). Therefore, Vietnam's textile and garment industry has siezed a massive portion of labor, and faced enormous challenges and opportunities in I4.0. With a high degree of automation, using robots can make this labor-intensive industry lose the advantage of cheap, worker resources (Nhabe Corporation, 2019). However, the I4.0 improves competitiveness capacities for textile and garment manufacturers by applying new platform technologies, such as large databases, cloud computing, IoT, 3D printing, biotechnology, new material technology, and robotics (Thang et al., 2019). More importantly, textile and garment enterprises in Vietnam continue to enhance and train higher value skills for human resources to serve the application of I4.0 and balance the employment rate (Phong & Doan, 2019).

Universal Robots, an important company to create versatile Cobot technology, decided to work with Vietnam's government to expand the presence of Cobots in many manufacturing areas to keep pace with I4.0. For example, Universal Robots distributed Cobots to Servo Dynamics Engineering and Tan Phat Automation JSC to meet Cobot demand (Universal Robots, n.d.-b). Cobots are deployed in many industries, including automotive, electronics, footwear, textile, garment, and food. For example, Meiko Trading and Engineering Co., Ltd realized the benefits of Cobots to improve productivity and worker safety (Universal Robots, n.d.-b). In the fashion industry, Vietnam's textile and garment companies have improved production efficiency, quality, cutting and cutting operation time, and production costs. Therefore, investment in robots at many production stages ensures sustainable development, meets quality of orders, improves worker satisfaction, and increases customer demands (Phong & Doan, 2019).

Furthermore, some empirical research exists about application of Cobots in many manufacturing industries, such as automotive, food, and electronics (Jin & Shin, 2021). However, at present, academia has not yet wholly explored how Cobots can be applied and their impact in garment factories, based on employees' perspectives. Research of Cobot applications in garment factories is still in the beginning stage. Particularly, previous studies (Cruickshank, 2017; Grieco et al., 2017; Lee et al., 2021; Nhabe Corporation, 2019) mainly mention the background of Cobots and why they should be applied in the fashion industry. Vietnam offers potential outsourcing for many famous brands globally with thousands of textile and garment factories. Therefore, a significant opportunity prevails to understand the relationship between Cobot factors and adoption intention in garment factories in Vietnam.

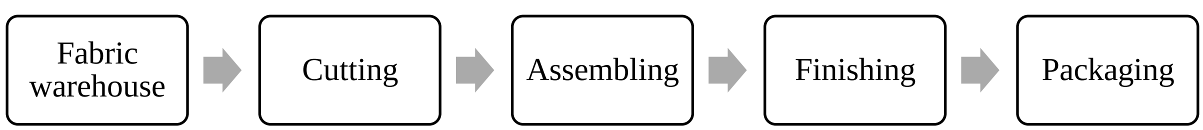
The Unified Theory of Acceptance and Use of Technology (UTAUT)is one of the most influential models to examine the level of users' technology acceptance and their intention to adopt new information technology and systems (Momani, 2020). The original UTAUT of Venkatesh (2003) explains 70% of how people adopt and use various technologies in different contexts (Tosuntas et al., 2014). Thus, the basic four factors for UTAUT include performance expectancy, effort expectancy, social influence, and facilitating conditions—meaningful predictors for behavioral intention in the acceptance of new technology (Pradeep et al., 2015). However, still some empirical doubts remain about the original UTAUT's capability to evaluate individual technology acceptance (Chao, 2019). Thus, UTAUT has been extended by increasing the number of external variables, such as self-efficacy, satisfaction, and trust (Chao, 2019). In this study, the original UTAUT is used as a theoretical framework and modified to add three additional variables to enhance evaluation in testing determinants toward Cobot applications and influence employee behavioral intention in the garment industry. First, anxiety can lead to negative performance because people become afraid and disappointed when their satisfaction cannot be reached (Boer & Astrom, 2018). Second, some researchers found personal innovativeness affects effort expectancy because it comes from the unwillingness to try new things. It is much easier and more productive to introduce innovation to people who are willing to test new things with a positive attitude and high ability (Lu et al., 2005). Third, the concept of trust in robotics has become broad, and the relationship between trust and robot usage is significant for human-robot interaction related to behaviors (Langer et al., 2019). Therefore, trust should be adopted in the UTAUT model. These factors are evaluated by people currently working or previously worked in Vietnam's garment factories. To the best of the author's knowledge, this is the first study to integrate the UTAUT model with Cobot applications to examine factors that influence the adoption of Cobots and the feasibility of Cobots application in the garment factory's manufacturing process, as shown in Figure 1.

The purpose of this study is to understand and predict garment employees' cognitive, social, and psychological perspectives, as well as behavioral intentions towards Cobot implementation in Vietnam. A preliminary study was conducted to develop scenarios that illustrate how collaborative robots can be applicable to the production process in garment factories. Considering the vital role of employees in the adoption of Cobots for their garment factory's implementation, the Unified Theory of Acceptance and Use of Technology by Venkatesh et al. (2003) as a theoretical framework is employed. Three additional constructs are included in the theoretical model to explore the acceptance level of Cobot applications based on employees' intentions in Vietnamese garment factories. Five key constructs were adopted from the original UTAUT model of Venkatesh et al. (2003)—performance expectancy, effort expectancy, social influence, facilitating conditions, and behavioral intention. Three additional variables, including trust in Cobots, anxiety, and personal innovativeness, were added, based on Boer and Astrom's (2017) research, which has the same objectives regarding robots.

Regarding the implication of Cobots in business, the present study proposes suggestions to companies that invent Cobots, application partners, programming developers, and Vietnam apparel manufacturers to make better decisions in building future manufacturing strategies. Regarding academic research, this study empirically examines the extended UTAUT model with three additional variables for Cobot adoption: anxiety, personal innovativeness, and trust. The findings from employees' intentions towards adopting Cobots' applications in the core manufacturing processes of garment factories contributed to the development and validation of the extended UTAUT model. Future researchers can refer to this model to evaluate the acceptance of new technologies related to robotics.

Figure 1

Basic Garment Factory's Process



Definitions

Industry 4.0: The fourth industrial revolution has brought a wide variety of new technologies central to any discussion, including robotics, intelligent manufacturing, augmented and virtual reality, and artificial intelligence (AI) (Jin & Shin, 2021).

Collaborative robots: Cobots, a new robot model from I4.0 technology, can function together with workers without safety fencing to improve safety and productivity in the manufacturing sectors (Perez et al., 2019).

UTAUT Model: The Unified Theory of Acceptance and Use of Technology model is used to explain user perception and acceptance behavior toward new technologies. It is a useful tool to help managers to understand the factors of acceptance of design strategies in business, training, and marketing compatible with their users. The four core predictors of technology acceptance are performance expectancy, effort expectancy, social influence, and facilitating conditions (Venkatesh et al., 2003).

Performance expectancy: "The degree to which an individual believes using the system will help attain gains in job performance" (Venkatesh et al., 2003, p. 447).

Effort expectancy: The level of ease of use related to the use of a new technology system (Venkatesh et al., 2003).

Social influence: "The degree to which an individual perceives important others believe the individual should use the new system" (Venkatesh et al., 2003, p. 451).

Behavioral intention: "The expectation of user's intention to perform plans and decisions regarding the use of technology" (Momani, 2020, p. 84).

Trust of Cobots: The degree of Cobot trustworthiness to determine how users place their trust in a Cobot system (Ozcan et al., 2021).

Anxiety: Anxiety is a negative emotion causing people to lose their focus, fear damage or unexpected satisfaction, or unable to perform tasks well (Gunasinghe & Nanayakkara, 2021).

Facilitating conditions: "The degree an individual believes an organizational and technical infrastructure exists to support the use of the system" (Venkatesh et al., 2003, p. 453).

Personal innovativeness: The willingness of an individual to try new technology (Agarwal & Prasad, 1998).

CHAPTER II: LITERATURE REVIEW

Industrial Revolution 4.0 in Manufacturing Industries

Nowadays, I4.0 is well-known as the fourth industrial revolution in business and manufacturing. Many new technology trends and advanced manufacturing systems in I4.0 include digitalization, AI, IoT, augmented reality, and robotics to improve productivity and working conditions. These things reshape and transform many business models and manufacturing versions to create the latest breakthroughs in development and competition in many areas in industry. For example, NASA's official website in 2017 showed "Laser-targeting A.I. Yields More Mars Science," NASA's Curiosity Mars rover used AI to zap dozens of laser targets on the red planet. When the ground team lost contact with the spacecraft, it became a frequent science tool (NASA Science, 2017).

Another example is a professional massage chair at a lower cost by Lemobar, a Fujian Lemobar IoT company's trademark. It is integrated with fragmented waiting scenarios to maximize comfort and enjoyment. Surprisingly, Lemobar became the first brand in the shared massage chair market, with more than 110,000 devices sold, and 600,000 people use daily in more than 450 cities (Jiang et al., 2020). Moreover, there are many other successes in the application of I4.0, such as the blockchain technology by Maersk, selling "air as a service" in a business model innovation by Kaeser Kompressoren, and Airbus' industrial glasses by integrating sensors into tools and machines to reduce errors and improve safety (Buntz, 2017).

Furthermore, the ubiquity of I4.0 has brought significant innovations in mass manufacturing, particularly in the textile and fashion industry, to produce everyday goods, such as footwear, apparel, bags, and fabrics. These have changed traditional factories to be innovative models in every process. According to Burke et al. (2020), in a smart factory, autonomous robots execute manufacturing and warehouse operations at minimal cost with high accuracy. Besides, maintenance personnel or pick-and-place tasks can be assisted by augmented reality or advanced sensors that can help track and monitor real-time movement, locations, and environmental conditions to minimize errors and improve quality and safety. In fashion manufacturing, luxury leather goods producer, Bottega Veneta, applies a uniform data model called “decision support system” in the production process to collect and present an enormous amount of data related to logistics information, such as customer data, timelines, feedback data, and production cycles. This experimental system helps the production planner make better decisions by visually presenting data with automatically generated and optimized scenarios (Grieco et al.,2017). Moreover, Uniqlo’s flagship warehouse uses two-armed robots to pick up T-shirts and boxes. This task has replaced human workers by nearly 90%. Another famous fashion brand, Gap, plans to deploy 106 robots to pick and sort goods in 10 robotic warehouses near Nashville, Tennessee, and 20 near Columbus, Ohio (Warren, 2020). This project speeded reduction of human contact during the coronavirus pandemic (Dastin, 2020).

In conclusion, with these positive approaches, more and more companies realize the significance of I4.0 to invest in sustainability. This trend can become a critical factor for companies to expand their competitive share in business and attract investments.

Cobots in Many Manufacturing Industries

One of the most significant inventions in I4.0 is Cobots. Peshkin et al. (1999), professors from Northwestern University, invented a Cobot which can safely interact with humans in shared work, simultaneously, without physical separation. This human and robot interface provides a beneficial symbiotic collaboration, which aims to improve control, safety, productivity, significant materials, and energy savings, and reduce risks, time, and waste compared to traditionally manual and robot-reluctant models. Therefore, in the industrial robotics market, the Cobots segment currently reaches $0.65 billion, with continuing growth predicted to $12.48 billion by 2026, at a compound annual growth rate (CAGR) of 44.8% from 2019 to 2026 (Allied Market Research, 2020).

Djuric et al. (2016) compared traditional industrial robots and Cobots, shown inTable 1. This table reveals the advantages of Cobots over traditional versions. For example, Cobots can easily be relocated because they are small and can safely work with humans with frequent changes. Meanwhile, conventional industrial robots are installed in fixed areas and not easily moved because of weight and high-risk levels when working with humans. Djuric et al. also mentioned Cobots are multi-disciplinary tools, including risk assessment, safety, usability, layout, economics, functionality, operational, collaboration, and environmental for manufacturing, service, and medicine, as shown in Figure 2. Currently, many robotic companies compete to deploy Cobots in the commercial market. They have different degrees of freedom (DOF) and characteristics, such as Yumi from ABB Frida, BioRob Arm of Bionic Robotics, Apas of Bosch, CR-35iA of Fanuc, UR3, 5, 10 from Universal Robots, and Baxter of Rethink Robotics. Thus, manufacturers and organizations have many choices when requesting the best Cobots for their factories, based on their business plans and visions.

Regarding the application of Cobots in many industries, Universal Robots, one of the biggest robotics companies in the world, noticed their Cobots could be activated in assembly, dispensing, finishing, machine tending, material handling, removal, quality inspection, welding, and many other processing tasks. They attach flexible automation to manufacturers of all sizes. First, Cobots can pick up and put objects in the correct positions, so factories can apply them to packaging and palletizing with repetitive processes.

Table 1

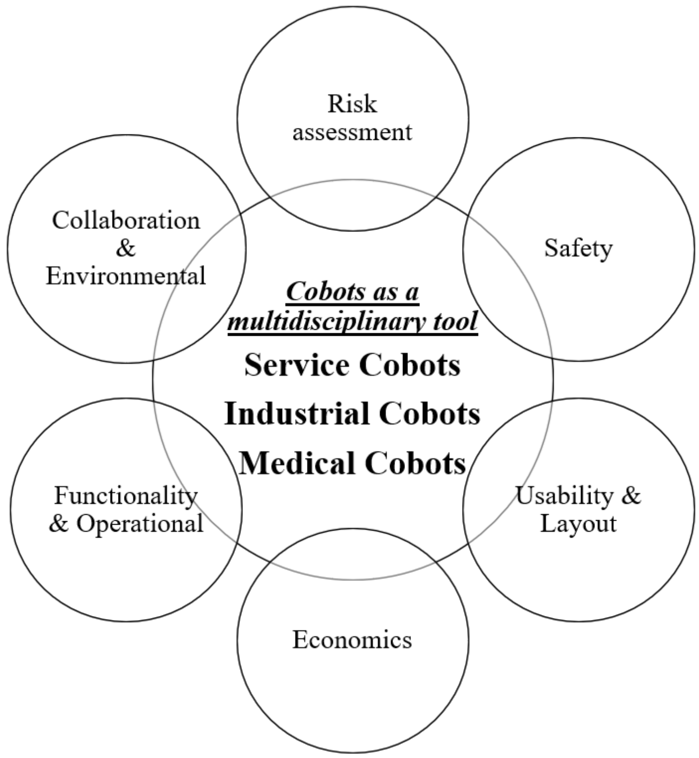
Comparison between the traditional industrial robots and Cobots

Traditional Industrial Robots	Cobots
Fixed installation	Flexibly relocated
Periodic, repeatable tasks, infrequently change	Frequent task changes, tasks infrequently repeated
Online and offline programming	Online instructed and supported offline methods
Not easy to teach	Easy to teach
Rarely interaction with the worker, only if being programmed	Frequent interaction with the worker, even force/ precision assistance
The worker and robot separated through the safety fence	Workspace sharing with worker
Cannot interact with people safely	Interact with people safely
Profitable only with medium to large lot size	Profitable even at a small lot size
Small or big and fast	Small and slow
Cannot reduce cost and footprint to justify new applications	Reduce cost and footprint to justify new applications
Not requested risk assessment	Requested risk assessment
Usually, 6 axes with the last three intersecting in the wrist	Usually, 6 and 7 axes with many offsets

Note. Table from Djuric et al. (2016).

Figure *2*

Cobots as a Multi-Disciplinary Tool



Note. Cobots in manufacturing, service, and medical applications from Djuric et al. (2016).

Second, they can load/unload machines, such as computer numerical control (CNC), injection molding, press brakes, and stamping presses to mitigate accidental injuries, while working with heavy, dirty, dangerous machinery. Third, in the finishing processes, such as polishing or deburring, Cobots attach to the internal force sensors to control the amount of force running across the material's surface. Finally, Cobots are equipped with a UR+-certified vision camera to capture and analyze images that do not meet product requirements. In addition, the e-series Cobots ensure consistent flow and precise placement to reduce waste and scraps. Robots can also replace human operators by handling dangerous tasks for a long time; thus, improving workplace safety. Moreover, they can limit the force, reduce the mode when people are in the robot's area zone, and automatically resume full speed when people leave. Furthermore, they tend to reduce processing times, and increase production speed and quality by shortening product life cycles and balancing seasonal peaks. Cobots are small and lightweight for easy, fast installation and movement. Therefore, they have lower operating costs with the most rapid average payback period of 195 days in the robot industry (Universal Robots, n.d.-a). According to Sonnenberg (2019), experts forecast an increase of 40% in efficiency, if Cobots are implemented as a sustainable, long-term system. In general, Cobots can maximize flexibility, processing implementation, and productivity in many production areas, due to reduced downtime and higher load capacity. Also, they can use appropriate grippers to avoid accidents and reduce energy drain of human operators. For instance, manufacturers require workers to work overtime or under physical strain during peak production to improve productivity. Workers may make more errors, experience injuries, or become ill. Therefore, Cobots can support or replace workers to complete tasks without mistakes over a long time to save costs caused by sick leave, overtime, and workforce injuries. Taking the LBR IIWA from Kuka as an example, Cobots can work in many processes like humans for unergonomic and monotonous tasks, such as detecting correction and required installation position when assembling individual parts quickly and precisely. Moreover, Cobots can react and adapt to humans in specific work areas (Sonnonberg, 2019). Although there are always limitations when implementing Cobots in different industries, based on manufacturers' demands with different sizes and functions Cobots can easily adapt. Besides, it is not easy to compute how much Cobots increase efficiency because of the various situations and scales from different companies and industries (Raha, 2020).

When it comes to safety between Cobots and humans in the same working area, Franklin et al. (2020) divided Cobots into four types: Safety-rated monitored stop, Hand guiding, Speed and separation monitoring, Power and force limiting. These systems help detect humans and control Cobots' motion and speed. They can force automatically slow or full speed, or even stop. Cobots determine a safe separation distance for application, based on the relative location, speed, and movements of humans and robot within the workspace.

However, the safety rating for Cobots does not reach 100%. They should follow and be evaluated by voluntary industry consensus standards, technical reports, and specifications, such as ANSI/RIA R15.06-2012, ISO 10218-1,2:2011 to ensure effectiveness of Cobots as much as possible. For example, Procter & Gamble (P&G) implemented a Cobot with a "power and force limiting" system to stack boxes on a pallet, but P&G had to install a particular safety device around the gripper to reduce Cobot risks. A hazard might be identified when a worker removes a full pallet or inserts an empty pallet into the system. Workers could come into contact with the robot's arm movements. Thus, any organizations or companies deploying Cobots should fully understand the requirements of given standards and report unsafe movements by Cobots to keep workers safe.

With the Cobots' positive advantages, they have recently been beneficial in many manufacturing industries and have attracted tremendous investments in their development. A variety of companies and science organizations have executed various experiments to demonstrate practical applications. Typically, the symbiotic collaborative robot approach in the aerospace manufacturing industry combines a safety system, a Cobot named ABB IRB 2600, a controller, and a metrological system to increase productivity and safety. This cobot showed the overall collaborative process saves 25% time and 30% of non-recurrent costs compared to the current manual process (Perez et al., 2020).

Current Situation in the Garment Industry

The garment industry faces many controversial problems, but of primary concern are the endless working hours. Menke (2017) noticed the textile workers' average working hours range from 10 to 18 hours per day to 80 hours per week, while they also must work additional overtime hours if the company needs to meet a production deadline. Although these long working hours and poor working conditions are strict, they ensure economic stability for developing countries and meet the world's demand for more materials. From the garment workers' perspectives, they have no choice but to remain in their jobs. In spite of the fact the industry abuses them mentally and physically, they need the income to maintain their livestyles and families. Consequently, this factor negatively affects human health and sustainable development of garment factories in the fashion industry, resulting in a lack of available labor force. If workers experience prolonged sitting or standing to complete the work, they are likely to be careless and inattentive caused by eyestrain, backach, or wrist joint problems. By virtue of Cobots, these issues can be solved to meet worker demands and customer expectations. Cobots can support workers in ergonomic tasks under pressure for an extended period.

The phenomenon of pre-consumer waste has created another severe impact on the fashion industry in several dimensions. First, this waste will be released into the environment and cause pollution unless the company provides correct treatment. Moreover, companies can lose profits from waste, if they do not have recycling plans. According to Berthon (2016), this waste is created in the manufacturing process, such as garment-cutting, printing trials, errors in assembling, or ends of rolls. Around 750,000 tons of material are diverted annually in the production process and recycled into new materials by companies, such as Martex Fiber in the United States. Nevertheless, in Australia, pre-consumer waste go directly to landfills. To address this issue, Cobots can be employed to minimize the amount of waste during production. They can work with low errors because their progress is based on a fixed program without human mental effects.

While operating machines in the garment factories, many hazards may occur and cause harm to operators. Hearing loss is the first problem that usually occurs with heavy noise-making machines, such as industrial sewing machines or cutters. Moreover, puncture injury to some part of a worker's body, including fingers, feet, or eyes, is one of the most common injury situations. For example, broken parts of machines or excessive dust can enter the eyes if operators do not wear safety glasses. According to Calvin and Joseph (2006), nearly 50% of a total of 89 interviewed operators reported a puncture wound to the distal phalanx of the fingers by needles during stitching. Moreover, unsafe conditions like the absence of machine guards accounted for 38% of total accidents. Calvin and Joseph also mentioned that accidents in garment manufacturing resulted from poor housekeeping, awkward working postures, heavy manual lifting, faulty machines, and a lack of safety awareness by both workers and employers (Calvin & Joseph, 2006). To minimize these accidents, some safety standards are applied to Cobots, based on comprehensive risk assessments (Lange, 2020). For example, safety sensors and automatic mode adjustments help Cobots and humans work together without a safety fence to ensure the highest safety conditions. Whenever workers join in the working zone, Cobots' sensors and visual cameras turn on to adjust the machine's speed and even stop immediately, if needed (Lange, 2020). Therefore, the integration of Cobots' applications and safety devices in the garment industry can be promoted to allow manufacturers list Cobots in their investment plan to improve workspace quality (Lange, 2020).

Application of Cobots in the Garment Industry

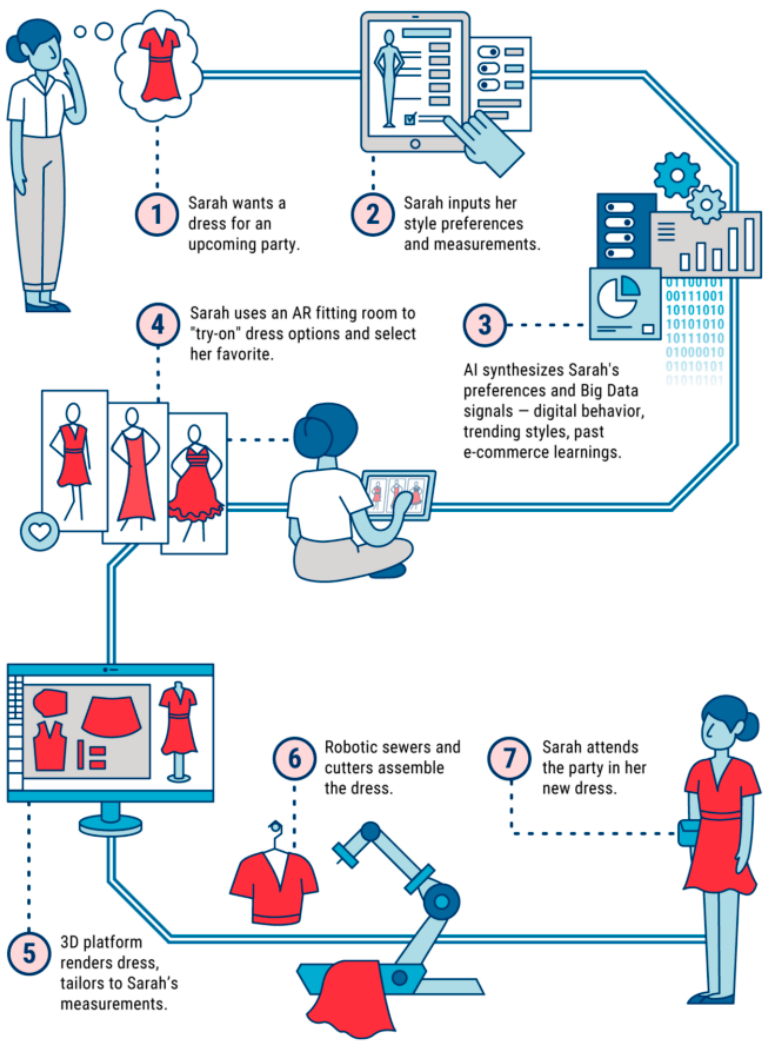
Cobots are a component of I4.0 automation. This manufacturing automation phenomenon initially arose from customer demands to increase quantity and style of fashion items. Garment manufacturing is a labor-intensive, mass-produced industry to ensure supply to the market as quickly as possible. This is the reason many fashion brands are selecting factories in developing countries because of lower wages to save production costs. However, in the sustainable development of garment factories, an automated manufacturing transformation is necessary. This is the facilitator for balancing market demand and making the entire product's lifecycle more transparent (Lee et al., 2021). On the other hand, escalating this automated manufacturing on a larger scale has some barriers, due to clothing inconsistencies in production, such as sizing, styles, and materials. More to the point, the investment needed to build automated facilities in the production system is high and requires a long-term plan for a successful ROI.

Meanwhile, a cheap workforce is still affordable (Lee et al., 2021). Therefore, some garment manufacturers prefer to implement manual processes or industrial machines in their end-to-end processes. Operators work directly with industrial machines and the quality of the product relies on the level of workers' skills. For example, in the fabric section, workers use fabric-inspection machines to inspect for defects, fabric-spreading machines to spread fabrics with many layers to prepare for cutting, and cutting machines including hand machines or laser machines to cut fabrics into pieces. Especially when assembling, sewing machines are used to complete the full garment and play an essential part in a product's quality. According to the global industrial sewing machines market share in 2018, based on operation analysis, manual sewing machines garnered a majority of the market share at 72.4%, triple the total of automatic and computer-controlled sewing machines (*Fortune Business Insights*, n.d.). Lee et al. (2021)

also mentioned it is impossible to have more than 95% of automation at the production site because garments change quickly in styles and forms. As a result, the fashion industry is one of the slowest to transition to automated processes. Nevertheless, manufacturers cannot ignore important technological developments. They must consider applying Cobots under the control of a human workforce to bring instant clothing production and delivery to the future (Figure 3).

Figure 3

Scheme of the Impact of Technology on the Fashion Industry



Note. Image from Lee et al. (2021, p.2)

In the robotic market, some types of Cobots are designed to adapt to specific functions in the garment and textile factories. The UR10 robotic arm of Universal Robots is from the SMEW Textile Machinery Pvt. Ltd. since January 2017. This Cobot is used for pick-and-place applications. Although this Cobot is new to the workforce, the simplicity and non-fencing requirements bring satisfaction to staff, while working together to complete work easier and faster. SMEW's most significant result was increased productivity from 30 pieces to 90 pieces weekly—a 300% boost in production over eight months. Thus, they can recapture the Cobot investment in less than a year (Universal Robots, n.d.-c). Using this example, Cobots can also handle items in the right position. Manufacturers can use this function to pick up and place garment pieces in the production lines to ensure health of workers, if they must carry heavy items or work longer hours.

Garment Industry in Vietnam

Vietnam is the second-largest garment producer in Asia and the fifth-largest garment and textile supplier globally (Better Work Vietnam, 2020). In Vietnam, there are 2,500 enterprises in 6,000 textile and garment enterprises exporting their products to international markets. Approximately 2.5 million people are currently serving in this industry to meet the high demand by customers (Do, 2017). In 2020, Vietnam had a decrease of 11% compared to 2019 because of the COVID-19 pandemic, with approximately a total export revenue of US$ 35.2 billion in textiles and garments (Better Work Vietnam, 2020). Some well-known fashion brands, such as Nike, Puma, Levi Strauss, Gap, H&M, and Zara chose Vietnam for their supply. In Vietnam, factories owned solely or partially by foreign firms through joint ventures take 75% of exported garments. As a result, foreign firms are significant factors in developing the garment industry (Do, 2017).

Currently, Cut-Make-Trim (CMT) is still the most popular model; more than 65% of garment factories in Vietnam contract with buyers to cut the fabric, make, and trim garments. Meanwhile, buyers provide the product specifications and inputs for factories to follow (Nguyen et al., 2018). Generally, there are five basic stages in garment factories, starting with the fabric warehouse where materials are stored and prepared, based on the customers' orders. Second, these materials are moved to the cutting department to spread the fabrics, cut the fabrics, bundle, and number-cut panels. Third, the assembling department stitches the cutting panels to make full garments. Each worker handles some operations, depending on the breakdown of styles. Fourth, the finishing department has the responsibility to complete the garment pieces and check quality during ironing, folding, label-attaching, and buttoning. Finally, the packaging department manages the number of garment pieces to ensure the number of orders, packages the boxes, and ships them to customers. With this model, Vietnamese manufacturers have important responsibilities to control variable expenditures, such as operating costs and labor costs, to ensure benefits for workers and the company. Therefore, this pressure easily leads to poor working conditions, including overtime, wage deductions, training elimination, or up-skilling time for employees. These are also common features of the garment manufacturing industry in Vietnam (Nguyen et al., 2018).

Shifting the textiles and garment industry to I4.0 is a considerable challenge for many manufacturers in Vietnam. It requires a high degree of automation by deploying robots, while Vietnam's textile and garment industry is a labor-intensive industry. Therefore, Vietnam is losing the advantages of low-cost human resources. In a recent report, the International Labor Organization mentioned 86% of Vietnamese workers in this industry face high unemployment, due to replacement by machines and other technological impacts of I4.0 (Nhabe Corporation, 2019). In Vietnam, this industry stands at the crossroads of development because the labor cost in Vietnam is still not cheaper than found in other developing countries, such as Laos, Cambodia, and Bangladesh. Meanwhile, technology investment is also not as high as in developed countries. As a result, if Vietnam's textile and garment industry does not have any comprehensive strategies and methodical investments, these difficulties will leave this industry's development behind (Nhabe Corporation, 2019). Training workers' knowledge and skills capable of mastering the new I4.0 technology, like artificial intelligence, robots, and 3D, is vital to avoid the increased unemployment rate and help Vietnam's textile and garment industry adapt to I4.0 (Phong & Doan, 2019).

More to the point, Sai Gon Giai Phong Online noted more than 300 Vietnamese garment enterprises have been keeping pace with I4.0 by adopting modern technology to increase productivity and quality, assisting with executive decision-making, and reducing time and production costs (Phong & Doan, 2019). For example, the Garment No.10 Corporation (Garco No.10) applied new information technology software in management and production. As a result, it has raised productivity by 52%, while reducing wasted goods rate to 8%. Additionally, employees' working hours were reduced by one hour per day, and their income increased by 10% so they work less and earn more (Phong & Doan, 2019). According to Mr. Le Tien Truong, vice chairman of the Vietnam Textile and Apparel Association, "many garment enterprises are investing in automation by robots in complicated stages to gain high precision, reduce labor costs, and pay attention to sustainable development" (Phong & Doan, 2019). For instance, Hyosung TNC, a Korean textile company, has deployed intelligent manufacturing systems in its spandex factories in Vietnam to collect and analyze data for the entire process from raw material input to shipment (Phong & Doan, 2019). There is also a machine vision system using a high-speed camera to identify product defects for consistent product quality (Friedman, 2019).

Regarding the application of Cobots in Vietnam, the government is highly focused on developing initiatives and legislation to keep pace with I4.0 compared to other Southeast Asian countries, like Singapore, which has led in robot density with 488 units per 10,000 employees or Thailand with 45 units (Vietnam Industry Agency, 2018). Universal Robots participated in the Vietnam Manufacturing Expo 2018 to introduce their “e-series” Cobots with broader applications, usability, and faster deployment to expand in Vietnam. Typically, Meiko Trading and Engineering Co., Ltd. in Vietnam uses Cobots in repetitive and sophisticated tasks to improve productivity, work satisfaction, and ease of use in the company. They realized the advantages of Cobots from their flexibility, safety, and small carbon footprint (Vietnam Industry Agency, 2018). According to Universal Robots, the Cobots sold in Vietnam has reached the original target, since Cobots appeared in 2016 in Vietnam (Vietnam Industry Agency, 2018). Universal Robots realized that Vietnam is a high potential market with a fast-growing automation sector worth $184.5 million in 2021 (Vietnam Industry Agency, 2018). As a result, they have advised Vietnamese manufacturers to implement Cobots as an effective solution in their production plans to improve human skills and productivity, and avoid labor shortages (*Vietnam Economic News*, 2021). Also, they are rushing to make Cobots an expanding strategy in Vietnam to help Vietnam attain the pace of I4.0 (Vietnam Industry Agency, 2018).

Nowadays, Cobots are more productive, safe, and versatile to move from repetitive, low-value tasks to higher-value ones. Universal Robots believes their Cobots are more affordable, lightweight, and flexible to increase ROI for manufacturing investors. Therefore, Universal Robots also expect Vietnam to lower autonomous barriers because of cost and complexity, and realize higher efficiency and effective utilization of Cobots deployed in manufacturing areas (*Vietnam Economic News*, 2021).

Theorical Framework

In researching individual acceptance behavior of new technology systems, UTAUT can be popular, due to the integration and development of many technology acceptance theories by adopting the most useful constructs from other, older theories as a unified form (Momani, 2020). UTAUT was developed by Venkatesh and his research group in 2003 by reviewing the differences and similarities of eight theories of technology acceptance: Theory of Reasoned Action (TRA), Theory of Planned Behavior (TPB), Technology Acceptance Model (TAM), the combined form of TAM and TPB (C-TAM-TPB), Model of Personal Computer Utilization (MPCU), Innovation Diffusion Theory (IDT), Motivational Model (MM), and the Social Cognitive Theory (SCT). All are unified into a model as shown in Table 2 (Momani, 2020; Venkatesh et al., 2003). These eight models explain 17% to 53% of the variance in behavioral intention (Venkatesh et al., 2003). Venkatesh developed the operations for each theory because each has its limitations and strengths, shown in Table 3 (Momani, 2020). Overall, UTAUT can be used to understand the acceptance level and usage of new technology (Boer & Astrom, 2017).

Table 2

Eight theories in the UTAUT model

Category	Abbr.	8 frameworks of 14 core constructs were unified into UTAUT's independent variables	4 UTAUT's independent variables			
			Performance expectancy	**Effort expectancy**	**Social influence**	**Facilitating conditions**
Technology adoption models	TAM	Technology Acceptance Model: TAM was designed to predict information technology acceptance and usage on the job with core constructs: perceived usefulness, perceived ease of use, and subjective norm (Venkatesh et al., 2003).	Perceived usefulness	Perceived ease of use		
	MPCU	Model of PC Utilization It is revived largely from Triandis' (1977) theory of human behavior, this model presents a competing perspective to that proposed by TRA and TPB with core constructs: job fit, complexity, long-term consequences, affect towards use, social	Job-fit	Complexity	Social factors	Facilitating conditions

Category	**Abbr.**	**8 frameworks of 14 core constructs were unified into UTAUT's independent variables**	**4 UTAUT's independent variables**			
			Performance expectancy	**Effort expectancy**	**Social influence**	**Facilitating conditions**
		factors, and facilitating conditions (Venkatesh et al., 2003).				
	C-TAM-TPB	Combined TAM and TPB: This model combines the predictors of TPB with perceived usefulness from TAM to provide a hybrid model with core constructs: attitude toward behavior, subjective norm, perceived behavioral control, and perceived usefulness (Venkatesh et al., 2003).	Perceived usefulness		Subjective norm	
	MM	Motivation Model: A significant body of research in psychology has supported general	Extrinsic motivation			

Category	Abbr.	8 frameworks of 14 core constructs were unified into UTAUT's independent variables	4 UTAUT's independent variables			
			Performance expectancy	**Effort expectancy**	**Social influence**	**Facilitating conditions**
		motivation theory as an explanation for behavior with core constructs: extrinsic motivation and intrinsic motivation (Venkatesh et al., 2003).				
Psychology theories	TPB	Theory of Planned Behavior: TPB added the construct of perceived behavioral control to extend TRA. Perceived behavioral control is theorized to be an additional determinant of intention and behavior with core constructs: attitude toward behavior, subjective norm, and perceived behavioral control (Venkatesh et al., 2003).			Subjective norm	Perceived behavioral control

Category	Abbr.	8 frameworks of 14 core constructs were unified into UTAUT's independent variables	4 UTAUT's independent variables			
			Performance expectancy	**Effort expectancy**	**Social influence**	**Facilitating conditions**
	TRA	Theory of Reasoned Action: TRA is one of the most fundamental and influential theories of human behavior to predict a wide range of behaviors toward individual acceptance of technology with core constructs: attitude toward behavior, and subjective norm (Venkatesh et al., 2003).			Subjective norm	
	SCT	Social Cognitive Theory: The nature of the model allowed it to be extended to acceptance and use of information technology in general with core constructs: outcome expectations-	Outcome expectations			

Category	Abbr.	8 frameworks of 14 core constructs were unified into UTAUT's independent variables	4 UTAUT's independent variables			
			Performance expectancy	**Effort expectancy**	**Social influence**	**Facilitating conditions**
		performance, outcome expectations-personal, self-efficacy, affect, anxiety (Venkatesh et al., 2003).				
Sociology theory	IDT	Innovation Diffusion Theory: It is grounded in sociology to study a variety of innovations, ranging from agricultural tools to organizational innovation with core constructs: relative advantage, ease of use, image, compatibility, perceived behavioral controls, visibility, results demonstrability, voluntariness to use (Venkatesh et al., 2003).	Relative advantage	Ease of use	Image	Compatibility & perceived behavioral controls

Note. The table is based on the study of Venkatesh et al. (2003) and Herndon, N. J. (2019)

Table 3

Summary of the strengths and weaknesses points of the most important technology acceptance theories

Theory	Developer and year	Field of development Social	Strengths	Weaknesses
TRA	Aizen and Fishbein, 1980	Social Psychology	It is one of the most fundamental theories of human behavior and is designed to explain virtually any human behavior.	It is general, corresponded, and doesn't refer to other variables that affect behavioral intention like fear, threat, mood, or previous experience.
TPB	Aizen, 1985	Social Psychology	It is successfully applied to the understanding of individual acceptance and usage of many different technologies.	It suggests that the behaviors are already planned, and it does not refer to other variables that affect behavioral intention.
DTPB	Taylor and Todd, 1995	Social Psychology	It is expanded by including some factors from the IDT model. This expansion makes the model more managerially relevant in influencing adoption and usage.	It is identical to TPB. It decomposes the constructs of TPB and still suggests that the behaviors are planned before.

Theory	Developer and year	Field of development Social	Strengths	Weaknesses
TAM	Davis, 1986	IT Field	It is a powerful model for technology applications. It replaced TRA's attitude toward behavior with two technology acceptance measures: perceived usefulness and the perceived case of use. It is less general than TRA and TPB.	It doesn't include the TRA's subjective norms. It does not provide any feedback on some factors like integration, flexibility, completeness of information, and information currency. It does not specify how expectancies are influencing the behavior.
TAM2	Venkatesh and Davis, 2000	IT Field	It explains perceived usefulness and perceived case of use in terms of social influence. It includes subjective norms. It explains the changes in acceptance over time as users gain experience in using technology.	As an extension to TAM. It does not specify how expectancies are influencing the behavior. Also, it cannot predict the user's behavior within culture.

Theory	Developer and year	Field of development Social	Strengths	Weaknesses
C.TAM-TPB	Taylor and Todd, 1995	IT Field	It combines the TPB model from the social psychology field with TAM from the IT field to get better use of TB in technology acceptance.	TAM constructs are not fully reflected. The factor of behaviors planning is not stated. It still does not pay attention to fear or threat concerning use.
MPCU	Triandis, 1979	IT Field	It is suitable to predict individual acceptance of many technologies. It is successful in understanding and explaining the usage behavior with a voluntary causative.	The complexity factor has computer and technology usage and an indirect impact on perceived short-term consequences.
IDT	Rogers, 1983	Social Science	It can study any kind of innovation. It explains and predicts the rates of the adoption factors of innovation.	It is general. It doesn't indicate how the attitude impacts accepting or rejecting the decisions, or how innovation factors affect decisions.

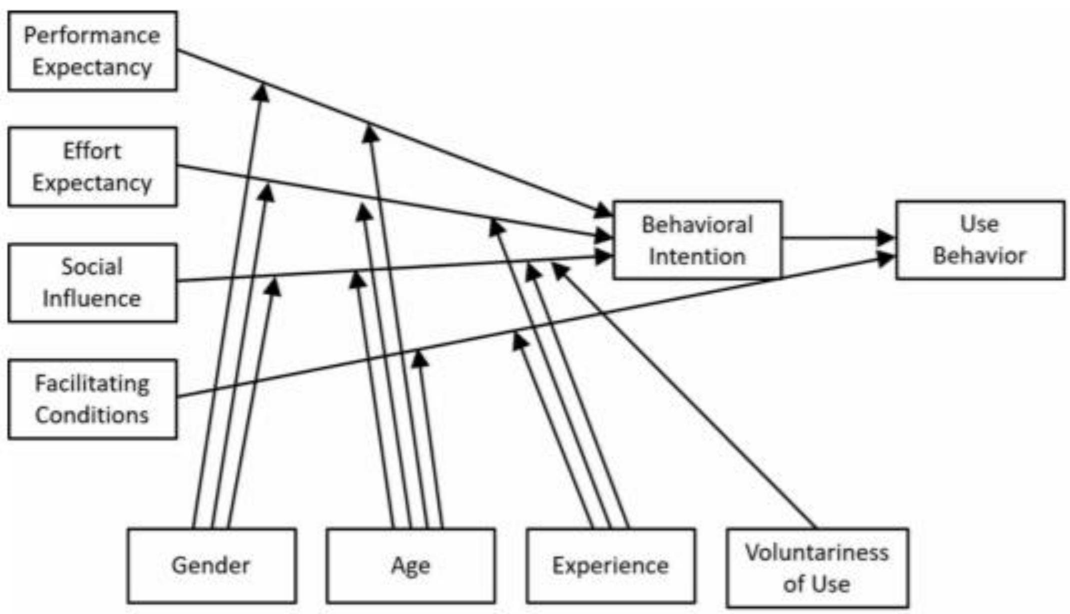
Theory	**Developer and year**	**Field of development Social**	**Strengths**	**Weaknesses**
MM	Deci and Ryan, 1985	Social Psychology	It has many applications in motivational studies, learning, and health care. It can be applied to understanding new technology adoption and use.	It still needs many factors to be adopted by it to become more suitable to study technology usage.

Note. Table from Momani (2020).

The UTAUT model has four main components: performance expectancy, effort expectancy, social influence, and facilitating conditions directly affecting behavioral intention. These four components are influenced by moderating variables, including experience, age, gender, and voluntary usage. In addition, there are two direct determinants of usage behavior: behavioral intention and facilitating conditions (Momani, 2020; Boer & Astrom, 2017). The basic UTAUT model is shown in Figure 4.

Figure *4*

UTAUT model



Note. Image from Venkatesh et al. (2003).

This UTAUT model has been used in empirical research toward new technology, and the number of studies in this sector increases annually (Momani, 2020). For example, in 2007, the UTAUT model was applied to internet banking technology. AbuShanab and Pearson (2007) created a questionnaire survey and distributed it to 940 customers in three banks in Jordan. They found a significant relationship between performance expectancy, effort expectancy, social influence, and behavioral intention. These components covered the variance to predict the intention in adopting internet banking (AbuShanab & Person, 2007). Another example in 2018 added enjoyment expectancy as a new construct to the UTAUT model to clarify the expected effect of the enjoyment factor on the adoption and acceptance of social commerce. This study proved that enjoyment is a new measurement variable in the UTAUT model to predict behavioral intention to use social commerce (Momani et al., 2018).

From this UTAUT analysis, this model can help predict behavioral intention and usage behavior to adopt Cobots as modern new technology for garment factories because of the increase of Cobot implementation in garment factories integrating I4.0, as mentioned in the literature review. Moreover, Boer and Astrom (2017) noted anxiety, trust, and personal innovativeness could be attributed to acceptance of new technology, such as robotics. The concern of potential challenges would be more severe for anxious people. Meanwhile, trust and personal innovativeness affect users' willingness to take risks with new technology. In conclusion, this UTAUT model plays a pivotal role in developing a conceptual model to predict user's intentions toward Cobot applications. This covers most different technology acceptance theories and has the most significant predictive power (Boer & Astrom, 2017). Based on Boer and Astrom's (2017) conceptual model about the acceptance of robotics in a home environment, this study uses the same context to follow their model. It added some new variables to match the study's purpose. First, performance expectancy, effort expectancy, trust, facilitating conditions, and social influence are the five main independent determinants directly influencing behavioral intention. Second, anxiety and personal innovativeness are new antecedents affecting performance expectancy and effort expectancy. Trust, anxiety, and personal innovativeness are three new variables compared to the original UTAUT model by Venkatesh et al. (2003).

Performance Expectancy

Performance expectancy is “the degree to which an individual believes using the system will help him or her attain gains in job performance” (Venkatesh et al., 2003, p. 447). This variable results from the following acceptance models: perceived usefulness of TAM, extrinsic motivation of MM, job fit of MPCU, the relative advantage of IDT, and outcome expectations of SCT (Venkatesh et al., 2003). Based on points of measurement involuntary and mandatory settings consistent with previous model tests, Venkatesh et al. (2003) mentioned the performance expectancy construct is “the strongest predictor of intention.” Findings by Zhou et al. (2010) noticed user adoption behavior of mobile banking, defined as behavioral intention, was affected by performance expectancy. This showed if mobile banking enables users to accomplish their expectancy more quickly, users will have positive behavior intentions to adopt mobile banking (Zhou et al., 2010). In addition, perceived usefulness, or performance expectancy, modified the elderly users’ intentions to study the acceptance of assistive social robots (Heerink et al., 2010). Meanwhile, Cobots are one robotics application, the same as the assistive social robot’s context. Therefore, it can be applicable to this finding to prove that performance expectancy positively influences behavioral intention, as this hypothesis:

H1: Performance expectancy has a positive influence on behavioral intention toward the acceptance of Cobots in garment factories.

Effort Expectancy

Effort expectancy is “the degree of ease associated with the use of the system” (Venkatesh et al., 2003, p. 450) and directly influences behavioral intention. This variable resulted from the perceived ease of use of TAM, the complexity of MPCU, and the ease of use of IDT in several previous acceptance models (Venkatesh et al., 2003). The influence of effort expectancy on behavioral intention has been analyzed by Venkatesh et al. (2003). They suggested effort expectancy has a significant effect in the early stage of a new behavior but is reduced by instrumentality concerns. In another context, Abu-Shahab et al. (2010) proved that effort expectancy was involved in the behavior intention of internet banking adoption in Jordan. Heerink et al.'s (2010) study also showed if elderly users feel comfortable using assistive robots for perceived ease of use, they have a positive intention to adopt these robots. Perceived ease of use is the root construct of effort expectancy (Venkatesh et al., 2003). Therefore, the following hypothesis is developed:

H2: Effort expectancy has a positive influence on behavioral intention toward the acceptance of Cobots in garment factories.

Social Influence

Social influence is "the degree to which an individual perceives that important others believe he or she should use the new system" (Venkatesh et al., 2003, p. 451). Social influence is represented as a subjective norm from TRA, TAM, TPB, and C-TAM-TPB, and social factors for MPCU and image for IDT developed this variable, a direct determinant of behavioral intention (Venkatesh et al., 2003). Like performance expectancy and effort expectancy, social influence has been researched in new technological contexts in the study of Zhou et al. (2010). This showed social influence is involved in user adoption of mobile banking positively, described as behavioral intention (Zhou et al., 2010).

H3: Social influence positively affects behavioral intention toward the acceptance of Cobots in garment factories.

Trust of Cobots

The concept of trust in robotics has broaden when discussing factors that affect user motivation and interaction success. Trust between robots and users plays a pivotal role in human-robot interactions related to behaviors (Langer et al., 2019). Furthermore, trust has been investigated in much research within the context of autonomous vehicles and assistive social robots for rehabilitation (Ozcan et al., 2021). Ozcan et al. foundfactors that influence the trust attribution towards Cobots were a set of non-verbal behaviors on the Cobots platform. Trust evaluated the degree of Cobot's trustworthiness to see how users place their trust in new technology because Cobots work directly with factory workers (Ozcan et al., 2021). Therefore, it is essential to input trust as a new construct to the UTAUT model in this study.

In other words, trust is described as the willingness to take risks (Boer & Astrom, 2018). The influence of trust on behavior intention is examined in some research. For example, Abu-Shanab et al. (2010) mentioned that potential risks or disconnection of the respondent's funds affected trust in the acceptance level of internet banking in Jordan. Thus, these factors can change the level of trust to influence behavioral intention (Abu-Shanab et al., 2010). Graff et al. (2017) found if users believe they have the skills to work with robots, their feeling of trust will increase for adopting a social robot in their home environment. Their study proved that trust provides users a high intention to have a social robot. As a result, trust impacts positively behavioral intention (Boer & Astrom, 2018; Graff et al., 2017). Thus, the following hypothesis is proposed:

H4: Trust has a positive influence on the behavioral intention toward Cobot implementation.

Facilitating Conditions

Facilitating conditions is the "the degree to which an individual believes an organizational and technical infrastructure exists to support the use of the system" (Venkatesh et al., 2003, p. 453) and contribute to three different constructs: perceived behavioral control of TPBI, DTPB, C-TAM-TPB; facilitating conditions of MPCU; and compatibility of IDT (Venkatesh et al., 2003). For example, facilitating conditions are the technical infrastructure, such as internet connectivity or the availability of technical experts to support students when they have issues in using mobile devices. Therefore, facilitating conditions can be administrative, organizational, or technical support, knowledge, and other resources to support the implementation of new technology (Nikou & Economides, 2017). Implementation of Cobots in garment factories may have a similar context as this example. Specifically, the facilitating conditions in this study can be workers' knowledge, the infrastructure resources of factories, or the availability of specific groups in the factories to support workers when working with Cobots.

Based on the findings of the original UTAUT model by Venkatesh et al. (2003), this variable influences usage behavior instead of behavioral intention. However, some studies found no correlation in this relationship, but other studies mention it can be a significant correlation. There are mixed findings on the relationship between facilitating conditions and behavioral intention (Dwivedi et al., 2019; Venkatesh et al., 2016; Williams et al., 2015). According to Herndon (2019), there is a positive influence of facilitating conditions on behavioral intention. If there are necessary resources and knowledge, and support from the administration of the university and professors, students will have greater intentions in the use of Canvas, a learning management system. Herndon mentioned this result was consistent with the findings by Dwivedi et al. (2019) that support a positive relationship between facilitating conditions and behavioral intentions. A study by Dwivedi et al. proved that facilitating conditions, such as help desks or training programs, affect positively an individual's intention to use the technology. Therefore, the facilitating conditions in this study can influence behavioral intention, and this hypothesis is proposed:

H5: Facilitating conditions affect positively behavioral intentions toward the acceptance of Cobots in garment factories.

Anxiety

Anxiety appears when people fear that expected satisfaction is deprived, leading to the concern of potential obstacles that may occur in the future, whether real or imagined. According to Boer and Astrom (2018), anxiety can negatively affect a new technology's performance in the context of robots because robots brought a feeling of concerns that could happen to users. Besides, Heerink et al. (2010) also proved that anxiety alters perceived usefulness when the acceptance of assistive social agents by elderly users was studied. According to Brohl et al. (2016), a research model was constructed in relation to the cooperation of robot manufacturers, users of industrial robots, and employers who work with robots. Their findings showed anxiety affects perceived ease of use in the TAM model. If robots were not easy to use or understandable, employees would be afraid of making mistakes, while working with robots. Meanwhile, perceived ease of use involves effort expectancy (Venkatesh et al., 2003). Therefore, anxiety can change the effort expectancy of the UTAUT model (Brohl et al., 2016; Boer & Astrom, 2018).

Anxiety can also come from the challenges in deploying Cobots as a new technology in garment factories. Although Cobots can bring numerous benefits for manufacturers, the deployment of Cobots requires many conditions to make it successful, based on the company's budget. The technological impediments remain to interrupt the flexibility of automation (Mattos et al., 2020). The variety of styles and sizes of garment products change seasonally and are attached to manufactured garment products. The existing technology cannot complete some garment constructions via automatic assembling machines, so factory managers must rely on workers collaborating with these machines to maintain flexible operations and complete complicated, high-quality constructions (Mattos et al., 2020). For example, some sensitive fabrics like silk need the dexterity and precision of humans in drafting and stitching. As automated machines, robots can handle mundane and repetitive tasks to allow workers more time to focus on specific tasks.

More to the point, the high upfront cost of automation is one of the fundamental barriers in the garment industry. Manufacturers think about their thin margins and transactional relationships, resulting in fear of large investments. Any large investments with more than six months' ROI are limited, even refused, mostly because of a lack of proof of efficiency. Besides, copycats in the fashion industry happen quickly. If any automation models can bring positive results, manufacturers copy these models in their factories to create high competition. More to the point, high comprehensiveness leads to huge investments in production automation. For example, efficiency cannot be observed with only one sewing machine assembling and the factory needs to substitute all in at least one production line to show improvement (Mattos et al., 2020). Furthermore, according to SHD logistics (n.d.), the high cost also comes from training fees for employees who will use the automated machines. During the training period, workers cannot make products that benefit the company. They are paid only for their working time. In the long term, keeping experienced workers plays an essential role to avoid re-training new employees to maintain the machines.

Equally important, workers' skills become a headline in Cobot deployment. Mattos et al. (2020) indicated deskilling and upskilling might occur simultaneously in the apparel industry, if state-of-the-art technologies, like Cobots, are applied. Currently, skillful stitching needs to be decreased by new technology, while operating machines need upskilling to operate multiple machines in the process. Some brands noted finding skilled workers in machine programming and maintenance in developing countries with low wages is more challenging. Therefore, transformation to technology-intensive can change many brands' decisions to outsource; thus, impacting the garment's price. Manufacturers in developing countries should connect closely with brands to discuss technology updating and develop better machinery programs suitable to the order numbers and fashion trends. Cobots' flexibility is highly valued since emplyees can update programs easily to adapt to new tasks. Overall, findings reveal anxiety is based on potential challenges coming from Cobot deployment and affecting users' expectations. Therefore, the following hypotheses are suggested:

H6: Anxiety has a negative influence on performance expectancy toward the acceptance of Cobot implementation in garment factories.

H7: Anxiety has a negative influence on effort expectancy toward the acceptance of Cobot implementation in garment factories.

Personal Innovativeness

Personal innovativeness is the willingness of an individual to try new technology (Agarwal & Prasad, 1998). Lu et al. (2005) described if people liked to try new technology as a high level of innovativeness, they would be more willing to adopt new changes of innovative technology and have more ability to deal with uncertain things than lower-level people. Therefore, these people would believe the new technology was easy and understandable enough to learn as a feature of effect expectancy. Moreover, Graaf et al. (2017) noted people feel they are more innovative in interacting with social robots in their home because robots were more enjoyable, safe, and inexpensive, related to the characteristic of performance expectancy. Thus, personal innovativeness can positively affect perceived ease of use and usefulness. These hypotheses are developed:

H8: Personal innovativeness has a positive influence on performance expectancy toward the acceptance of Cobot implementation in garment factories.

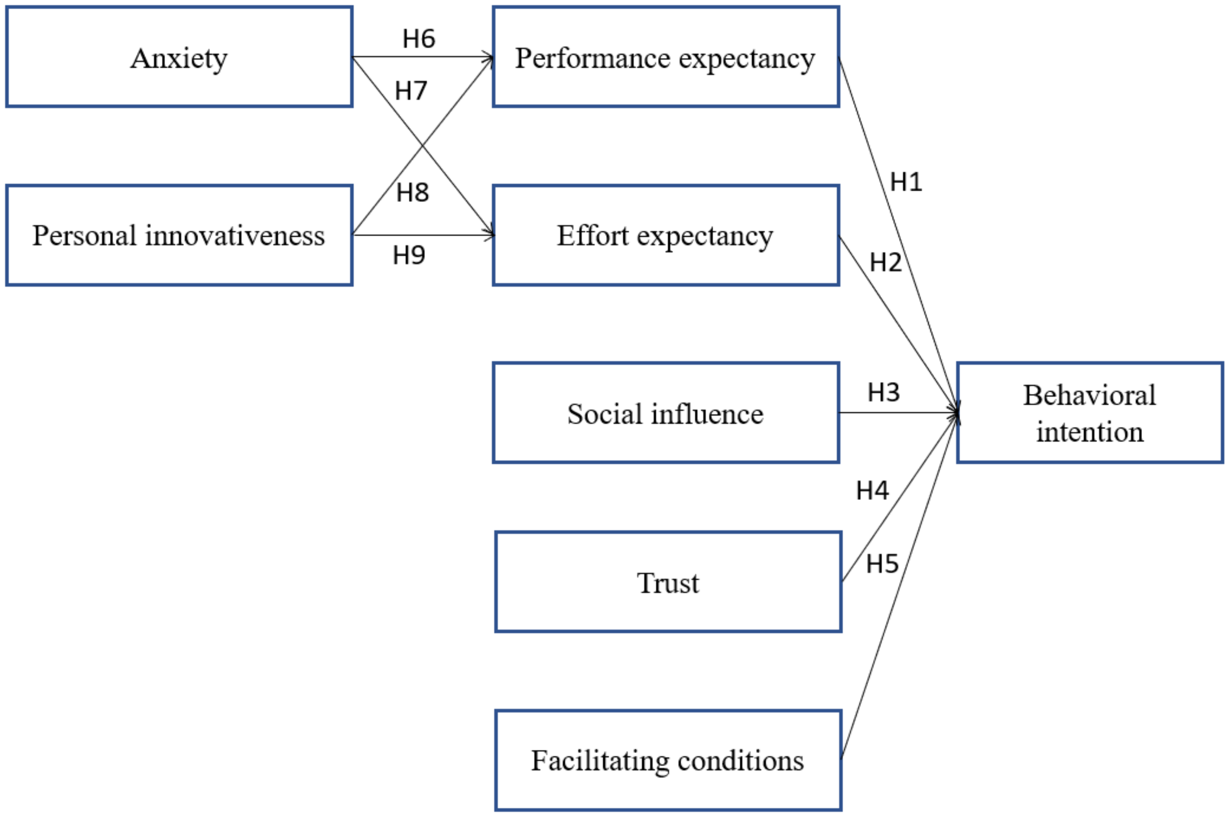
H9: Personal innovativeness has a positive influence on effect expectancy toward the acceptance of Cobot implementation in garment factories.

Behavioral Intention

Behavioral intention is “the expectation of the user’s intention to perform plans and decisions regarding the use of technology” (Momani, 2020). Based on the literature review, the behavioral intention toward Cobot applications is directly affected by performance expectancy, effort expectancy, social influence, trust, and facilitating conditions.

Figure ***5***

UTAUT model for collaborative robots in garment factories


Anxiety
H6
Performance expectancy
H7
H8
Personal innovativeness
H9
Effort expectancy
H1
H2
H3
Social influence
Behavioral intention
H4
Trust
H5
Facilitating conditions

CHAPTER III: METHODOLOGY

This chapter provides a detailed description of sampling, instruments, procedure, data collection, and data analysis for each phase of the study. Phase 1 is the preliminary study related to potential Cobot implementations in garment production. Phase 1 developed the scenarios used in the survey to measure the variables for the UTAUT model. Phase 2 explains the acceptance level of Cobots, based on the UTAUT theoretical framework. The research hypotheses of the proposed model (Figure 6) were tested in Phase 2.

Phase 1: Preliminary Study

Sampling

A preliminary study was conducted to determine the tasks Cobots could do in a garment factory's process. This preliminary study elicited a range of scenarios that illustrate how Cobots can apply to the garment production process. The number of participants was 29 people currently working or used to work in garment factories in Vietnam with management responsibilities, who understand English. About 90% of the participants had working experience of more than four years in the garment industry and worked in factories with more than 20 production lines and 50,000 garments monthly. Therefore, their comprehensive experiences and visions could cover the garment factories' entire process in detail. These participants were recruited to the study using a snowball sampling approach, based on the network of the researcher's previous working experience via a network with participants through previous jobs in Vietnam.

Procedure

After receiving approval from the Institutional Review Board (IRB) (Appendix A), respondents were contacted twice via email for 10 days. The first email invitation letter covered the purpose of the study, a hyperlink to the survey, potential implications, requested participation, and assured confidentiality. Respondents were directed to a survey by clicking on the URL. About five days after the first invitation, a second email was sent to thank those who responded and remind those who had not responded to complete the survey. The survey link was sent to participants with an informed consent form embedded on the first page of their survey. All information related to the participants was guaranteed confidential per the informed consent in Appendix C, which also stated the purpose of the study. No risks were associated. Participants had the option to continue the survey or discontinue participation by choosing "Yes, I am willing to participate in this study" or "No, I am NOT willing to participate in this study."

Instrument

Based on relevant literature regarding the new technology adoption and the researcher's knowledge, a questionnaire survey was designed in two parts. The first part included multiple-choice questions relating to how long participants worked in the garment industry, the number of production lines and workers in their factory, and where they learned about Cobots. Then, regardless of their understanding of Cobots, the researcher introduced the definition and applications of Cobots to assure understanding of these terms in the survey. It is assumed they were considering the adoption of Cobots in their factory. The second part consisted of open-ended questions about the steps Cobots could complete during each stage of the apparel manufacturing process: fabric warehouse, cutting, assembling, finishing, and packaging. The survey could take 20 to 30 minutes to complete and was administered online by the Qualtrics system to ensure anonymous information for participants.

Data Collection and Data Analysis

The data in the preliminary study was exported from Qualtrics. The first part used Statistical Package for the Social Sciences statistics (SPSS) version 28.0 to analyze the quantitative data. The research data analysis consisted of descriptive analysis: frequency and percentages. The researcher analyzed the data in the second part by labeling each answer's keywords and systematically categorizing, based on these keywords to understand the Cobot applications in the garment factories in Vietnam. First, the researcher read the complete responses and highlighted keywords in each answer. Then, the researcher applied codes to excerpts, following with grouping codes so keywords had the same meaning grouped according to themes. Finally, interpretations were made, based on themes to obtain the findings that fit well to the tasks the Cobots can do in each factory stage.

Phase 2: Acceptance Model Testing

Sampling

Using a snowball sampling approach, employees currently working in the garment factories in Vietnam at any production job position were invited to the study. The present study used these employees because they could clearly understand the process and current situation related to infrastructure and workers' behavior in the garment industry in Vietnam, as well as knowledge of English. They are the leading resource in the factory, working with new technology if applicable. Therefore, manufacturers who own garment factories should significantly pay attention to employees' behavior intentions to produce manufacturing strategies when applying new technology, especially Cobots.

Procedure

Based on findings from the preliminary study, this researcher developed the scenarios and questionnaire. After receiving approval from IRB (Appendix B), the same procedure was used as completed for the preliminary study. Respondents were contacted twice via email over 10 days (Appendix F and Appendix G). All information related to the participants was guaranteed in the informed consent agreement regarding the purpose of the study as shown in Appendix D.

Instrument

An online survey was created, based on the literature review and the preliminary study. Due to the limitations of this researcher's Cobot knowledge and out-of-date knowledge of Vietnamese garment factories, the qualitative results for the preliminary study were used to generate scenarios where Cobots could be applied in garment factories. Moreover, an Application Engineer in a well-known global Cobots company and the researcher's friends, who have great experience in the Vietnamese garment industry advised the researcher during the development of the scenarios. There were 11 sections in this survey. Section A is demographic information, including the employee's position in the company, gender, working experience, factory production lines, average capacity, and the number of workers. Section B measures the current implementation of I4.0 in each company process using multiple-choice and open-ended questions. Section C consists of multiple-choice and open-ended questions about the participant's understanding of Cobots. The following sections measure the variable of the UTAUT-proposed model: performance expectancy in section D; effort expectancy in section E; social influence in section F; behavioral intention in section G; anxiety in section H; trust in section I; personal innovativeness in section J; and facilitating conditions as section K. The items for each section were adopted from the original UTAUT model by Venkatesh et al. (2003) and Boer and Astrom's (2017) study as shown in Table 4. Venkatesh et al. (2003) used partial least squares to examine the reliability and validity of measurement. They indicated validity is acceptable with .70 or higher loading for all loading patterns. Accordingly, this study has all acceptable internal reliabilities greater than .70 (Venkatesh et al., 2003). For Boer and Astrom's

(2017) study, there were significant correlations between constructs to ensure the strength of the relationships between variables. Its constructs were considered reliable by Cronbach's *alpha* measurement.

All variables were measured using a 7-point Likert-type scale as shown in Appendix E from 1 (Strongly disagree) to 7 (Strongly agree) as used in the study by Venkatesh et al. (2003). The study was conducted in Vietnam in the context of garment factory employees, so there are two language versions: Vietnamese and English for Vietnamese participants and overseas participants currently working in garment factories in Vietnam, respectively. The questionnaire in this study was first developed in English and then translated into Vietnamese by a Vietnamese garment employee with good working experience, a high English level, and a Bachelor's degree related to the garment industry. Then, the questionnaire survey was translated back to English by another Vietnamese garment employee, whose credentials were confirmed by this researcher to ensure translation equivalence. This activity helped respondents thoroughly understand the survey's statements so they could respond.

Table 4

Measurement items

Variables	**Code**	**Measurement items**	**Source**
Performance Expectancy (PE)	PE1	I would find Cobots are useful in my factory.	Venkatesh et al. (2003)
	PE2	Using Cobots enables me to accomplish tasks more quickly.	
	PE3	Using Cobots would increase productivity.	

Variables	Code	Measurement items	Source
	PE4	If I use Cobots, I will spend less time on routine job tasks.	Boer & Astrom (2017)
	PE5	Cobots should replace human labor, if this is more effective/ productive.	
Effort Expectancy (EE)	EE1	I expect my interactions with Cobots would be clear and understandable.	Venkatesh et al. (2003)
	EE2	Learning to operate Cobots is easy for me.	
	EE3	It would be easy for me to become skillful at using Cobots.	
	EE4	I believe Cobots are easy to use in my factory.	
Social Influence (SI)	SI1	People who influence my behavior think that I should collaborate with Cobots.	Venkatesh et al. (2003)
	SI2	People who are important to me think that I should collaborate with Cobots.	
	SI3	The senior management of my factory has been helpful in the use of Cobots.	

Variables	Code	Measurement items	Source
	SI4	In general, my factory supports the use of Cobots.	
Behavioral Intention (BI)	BI1	I predict that my factory will implement Cobots in the near future.	Venkatesh et al. (2003)
	BI2	I intend to use Cobots in the near future.	
	BI3	I plan to use Cobots in my factory in the near future.	
Anxiety (ANX)	ANX1	It scares me to think that I could lose my job by Cobot's applications.	Venkatesh et al. (2003)
	ANX2	I hesitate to work with Cobots for fear of making mistakes I cannot correct.	
	ANX3	I feel apprehensive that Cobots take over many things in my job.	
	ANX4	Cobots are intimidating to me.	
Trust to Cobots (TC)	TC1	I find products made by Cobots reliable.	Boer & Astrom (2017)
	TC2	Cobots are reliable.	
	TC3	I would trust the work completed by Cobots.	

Variables	**Code**	**Measurement items**	**Source**
	TC4	Cobots will keep human interests in mind.	
Personal Innovativeness (PI)	PI1	Among my co-workers, I am usually the first to try out new technologies.	Boer & Astrom (2017)
	PI2	If I heard about Cobots, I would look for ways to experiment with them.	
	PI3	In general, I am hesitant to try out Cobots.	
	PI4	I like to experiment with Cobots.	
Facilitating Conditions (FC)	FC1	I have the resources necessary to use Cobots.	Venkatesh et al. (2003)
	FC2	I have the knowledge necessary to use Cobots.	
	FC3	Cobots are not compatible with other automatic industrial machines I use.	
	FC4	Given the resources, opportunities, and knowledge, it takes to use Cobots, it would be easy for me to use Cobots.	

Variables	Code	Measurement items	Source
	FC5	I think that using Cobots fits well with the way I like to work.	
	FC6	Using Cobots is compatible with all aspects of my work.	

Table 4. Continued

Data Collection and Data Analysis

The statistical analyses, including descriptive statistics, normality, factor analysis, Cronbach's *alpha*, correlation analysis, and simple regression, were conducted using the SPSS version 28.0. Descriptive statistics included mean, standard deviation, frequency, and percentages. The normality test in SPSS explained whether the sample data were normally distributed using Q-Q scatterplots. Exploratory factor analysis (EFA) is a statistical method to examine the dimensionality of the variables in the study. Each construct's internal reliability was measured by calculating Cronbach's *alpha*. In addition, correlation analysis was used to evaluate causal relationships among the variables. Finally, simple regression analysis was conducted to examine the causal relationships between independent and dependent variables.

CHAPTER IV: RESULTS

Phase 1: Preliminary study

Thirty-three employees currently working or who used to work in the garment factories were invited to participate in the online survey. A total of 29 responses were returned for a response rate of 87.87%, and these same 29 completed responses were used for the data analyses. All respondents held a position as manager or higher in the factories (*n=29*). Over two-thirds of the respondents had working experience greater than 10 years. The majority of respondents worked in factories with fewer than 100 production lines and produced more than1,000,000 garments monthly. Moreover, a majority of respondents heard of Cobots and knew many Cobot companies globally. In this study, their responses indicated the tasks that Cobots could work on at each stage of the garment factory's process. First, most respondents noticed that Cobots could load and unload fabric rolls and other material boxes between racks in the fabric warehouse. Then, more than one-third of the respondents agreed that Cobots could be used for fabric inspection. However, some respondents explained it was more expensive to have Cobots attached with visual sensors to identify fabric defects than manual labor cost for this task. Second, Cobots could collaborate with spreading machines, cutting machines, and numbering machines in the cutting section. This point was described by a majority of respondents to spread and cut fabrics, numbering, and bundling the cut pieces. Third, in the assembling stage, two-thirds of the respondents had concerns about the type of products and operations Cobots could achieve. They agreed Cobots could assemble cutting pieces for simple styles, such as T-shirts. However, for operations that required higher skills, Cobots could not replace workers. Therefore, the scenario in this study was divided into types of products—easy level to skillful level—in the assembling section (T-shirt < legging < jacket), denoting higher skillful assembling operations and lower tasks that Cobots could complete. In the finishing stage, a majority of respondents agreed that Cobots were useful to move garment pieces quickly between areas, including folding, ironing, quality inspection, labeling, and buttoning. In addition, two-thirds of the respondents added some tasks that Cobots could complete with high precision: folding and ironing step-by-step, labeling, and arranging pieces in boxes. Finally, loading boxes showed respondents' most significant agreement percentage with 96.55% in the packaging section. Some tasks that Cobots could do were added, based on external opinions from an engineer in a Cobot company or workers with much experience in the garment factory. Overall, the results of this preliminary study were the excellent facilitator of a given scenario in the survey (see Table 5) to help respondents in the main study understand the common Cobot applications during each stage of a garment factory's process.

Table 5

Cobots scenario in garment factories.

	Tasks	**How Cobots work**
Fabric warehouse	Arrange fabrics between the racks for checking and inventory	Cobots are designed with moving parts at the bottom that can move materials in and out in a certain area along the same route. Cobots can adjust height to place materials in high positions that humans cannot touch. Its loading is up to 20 kg

<table>
<tr><th></th><th colspan="2">Tasks</th><th>How Cobots work</th></tr>
<tr><td>Cutting</td><td colspan="2">1. Move fabrics from fabric warehouse to cutting section
2. Spread and smooth fabrics
3. Cut fabrics based on the marker
4. Bundle fabric after cutting
5. Numbering
6. Move cut panels to the assembling section</td><td>Cobot’s arms are designed with moving parts at the bottom to move on the cutting table to spread and cut fabric, based on the marker set in the program. Also, Cobots are attached to the vision camera to recognize the barcode sticker on the fabric for bundling and numbering correctly</td></tr>
<tr><td rowspan="2">Assembling (3 popular garments with complex level increased: T-shirt < Legging < Hoodie jacket)</td><td>T-shirt or Tanktop</td><td>1. Join shoulder lines
2. Attach neck and armhole binding with folder
3. Close side seam with side label
4. Mark and set label to back neckline
5. Set sleeve to the body if required
6. Invert hem
7. Tack neck tape ends</td><td rowspan="2">Cobot’s arms work with industrial machines, such as sewing machines, overlock machines, tacking machines, etc. to complete tasks. Cobots pick up garment pieces, place them in the machines and operate, based on the setup program, and take them out from the machines. Workers have to arrange garment pieces in the right position on the table to let Cobots pick up easily. As a result, the percentage of tasks that Cobots</td></tr>
<tr><td>Legging</td><td>1. Measure and cut elastic
2. Join elastic ends</td></tr>
</table>

	Tasks		How Cobots work
		3. Join waistband ends 4. Join front rise and front rise 5. Close inseam continuously 6. Attach care label 7. Tack crotch 8. Heat transfer label	can handle depends on the complication of styles. It decreases if there are more difficult tasks. Cobots can handle approximately 72.7% of tasks in a total operation breakdown for tank tops and T-shirts, 61.5% for leggings, and 52.9% for jackets. Therefore, the jacket has more difficult tasks than T-shirts and leggings. Cobots handle fewer tasks than others
	Jacket	1. Tack excess thread on the center hood 2. Buttonhole hood 3. Trim left and right interlining 4. Mark placement on Kangaroo pocket before set 5. Mark Kangaroo pocket placement on front body 6. Bartack Kangaroo pocket 4 times 7. Mark front center and cut 8. Join 3 pieces waistband 9. Overlock waistband edge with notches	

	Tasks		How Cobots work
		10. Measure and cut drawstring 11. Join shoulder 12. Set sleeve 13. Close side seam 14. Set waistband open 15. Overlock front and waistband edge 16. Tack hood to neckline 3 times with mark 17. Set hood to the body	
Finishing	1. Move garment pieces from cutting to finishing section 2. Ironing 3. Hand tag attaching 4. Folding 5. Put garments in polybags 6. Close poly bags 7. Put poly bags into the boxes		Cobot's arms are designed with moving parts at the bottom and work with iron machines to move and iron garments. Also, Cobots are attached to the vision camera to recognize the barcode on the garments for folding and tag attaching correctly
Packaging	1. Move boxes from finishing to packaging section 2. Close boxes		Cobot's arms are designed with moving parts at the bottom to move garments and boxes between

	Tasks	How Cobots work
	3. Move boxes to shipping area	areas. As a result, Cobots can handle 60% of total tasks of the finishing section with loading under 20 kgs per round

Phase 2: The Acceptance Model Testing

Sample Characteristics

The 286 employees currently working in the garment factories in Vietnam were invited to join the online survey. A total of 275 responses were returned for a response rate of 96.15%. After excluding questionnaires with missing data, 198 completed responses were used for data analyses.

Sample Demographics

Table 6 summarizes the demographic profiles of the sample through gender, position in the company, working experience, and factory size where currently working. Respondents were 71.72% female and 26.26% male. In the garment industry in Vietnam, there are about 80% females in the total of 2.5 million workers because the specific characteristics of tasks require care with details and do not require much strength (Nguyen et al., 2018). About one-third of the respondents (26.77%) were garment workers in the garment factories, followed by engineers 18.69%. Approximately 17.68% of respondents held other positions, such as merchandisers, technical designers, and quality assurance employees. The majority of respondents had working experience within 10 years (89.41%). Greater than two-thirds of the respondents were working in factories with fewer than 100 production lines (87.94%) and can produce over 1,000,000 garments monthly (97.47%).

Table 6

Respondents' demographic data (n=198)

Items and description		**Demographic score**	
		Frequency[a]	**Percent**[b]
Gender			
	Female	142	71.72%
	Male	52	26.26%
Position in the company			
	Garment worker	53	26.77%
	Line leader	6	3.03%
	Technician	27	13.64%
	Engineer	37	18.69%
	Junior manager	25	12.63%
	Senior manager	11	5.56%
	Director	1	0.51%
	Other position	35	17.68%
The working experience period			
	1 – 5 years	127	64.15%
	6– 10 years	50	25.26%
	11 – 15 years	5	2.54%
	16– 20 years	6	3.04%

Items and description		Demographic score	
		Frequency[a]	Percent[b]
	21 – 25 years	2	1.02%
	26 – 30 years	2	1.02%
The number of average production lines in your factory			
	1 – 50 lines	130	65.66%
	51 – 100 lines	44	22.22%
	101 – 150 lines	12	0.06%
	151– 200 lines	0	0.00%
	201 – 250 lines	4	0.02%
The number of average monthly capacity in your factory			
	0 – 1,000 (pieces/month)	13	6.57%
	1,001 – 10,000 (pieces/month)	26	13.13%
	10,001 – 50,000 (pieces/month)	30	15.15%
	50,001 – 100,000 (pieces/month)	23	11.62%
	100,001 – 500,000 (pieces/month)	24	12.12%
	500,001 – 1,000,000 (pieces/month)	21	10.61%
	Over 1,000,000 (pieces/month)	56	28.28%
The number of workers in your factory			
	0 – 100 workers	19	9.6%
	101 – 500 workers	31	15.66%
	501 – 1,000 workers	25	12.63%
	1,001 – 5,000 workers	45	22.73%

Items and description		Demographic score	
		Frequency[a]	Percent[b]
	5,001 – 10,000 workers	26	13.13%
	10,001 – 50,000 workers	18	9.09%
	Over 50,000 workers	28	14.14%

Note:

[a]Sum of frequency may not equal the sample (n=198), due to non-responses.

[b]Sum of percent may not equal 100, due to non-responses.

Knowledge of I4.0 Practices

The majority of participants (74.75%) had heard about I4.0 (see Table 7). There are a rich variety of informational sources where respondents learned about I4.0. About 30% of the respondents knew the term “I4.0” through co-workers, Facebook (29.29%), websites (27.78%), or news on television (27.78%). However, 23.74% of respondents had never learned the term “I4.0.”

Table 7

Results of the respondents’ knowledge of I4.0 practices (n=198)

Items and description	Knowledge of I4.0 practices score	
	Frequency[a]	Percent[b]
Heard about the “I4.0”		
Yes	148	74.75%

Items and description	Knowledge of I4.0 practices score	
	Frequency[a]	**Percent[b]**
No	47	23.74%
<u>Where have you heard about "I4.0"?</u>		
Never heard of I4.0 before	47	23.74%
Co-workers	59	29.80%
Facebook	58	29.29%
Family and relatives	6	3.03%
Friends	41	20.71%
Groups related to innovation and new technology adoption	43	21.72%
Instagram	5	2.53%
Industrial exhibitions	36	18.18%
Linkedln	19	9.60%
Neighbors	1	0.51%
Newspaper or magazine articles	48	24.24%
News on television	55	27.78%
Technology events	51	25.76%
Twitter	3	1.52%
Youtube	38	19.19%
Websites	55	27.78%
Other sources	2	1.01%

Note:

Items and description	Knowledge of I4.0 practices score	
	Frequency[a]	Percent[b]

[a,b] Sum of percent may not equal 100, due to non-responses.

[a,b] Respondents could check more than one option.

Knowledge of Cobots

Within the sample, about half of the respondents (55.56%) had not known the term "Cobots," and 89.90% of respondents did not know the name of any Cobot companies in the world (see Table 8). However, approximately 13.3% of respondents had heard "Cobots" through news on the television, co-workers (11.62%), or technology events (10.64%). Because Cobots are a type of new technology and have not been applied widely in the garment factories in Vietnam, a majority of respondents never had the chance to work with Cobots.

Table 8

Results of respondents' knowledge of Cobots (n=198)

Items and description	Knowledge of Cobots score	
	Frequency[a]	Percent[b]
Heard about the word "Cobots"		
Yes	86	43.43%
No	110	55.56%
Where have you heard about "Cobots"?		

Items and description	Knowledge of Cobots score	
	Frequency[a]	Percent[b]
Never heard of I4.0 before	110	53.56%
Co-workers	23	11.62%
Facebook	12	6.06%
Family and relatives	2	1.01%
Friends	13	6.57%
Groups related to innovation and new technology adoption	16	8.08%
Instagram	0	0.00%
Industrial exhibitions	21	10.61%
Linkedln	6	3.03%
Neighbors	0	0.00%
Newspaper or magazine articles	16	8.08%
News on television	26	13.13%
Technology events	21	10.61%
Twitter	0	0.00%
Youtube	13	6.57%
Websites	12	6.06%
Other sources	4	2.02%
Do you know any Cobots companies around the world?		
Yes	15	7.58%
No	178	89.90%

Items and description	**Knowledge of Cobots score**	
	Frequency[a]	**Percent[b]**
Have worked with Cobots?		
Yes	7	3.65%
No	186	93.94%

Note:

[a,b] Sum of percent may not equal 100 due to non-responses.

[a,b] Respondents could check more than one option.

Data Analysis, Including Normality, Reliability, Factor Analysis, and Correlation

To clarify whether multi-item measurement variables have underlying dimensions, eight variables of the UTAUT-proposed model were tested by the principal components analysis with varimax rotation. One was the minimum eigenvalue to determine the number of factors for each variable. Cronbach's standardized *alpha* of .70 was used to ensure the internal reliability for each variable (Peterson, 1994). Mean scores for multiple items of each variable were also reported. The results of factor analysis and the detailed description orf each item is shown from Tables 9–16.

Test for Normality

Q-Q scatterplots in SPSS version 28 were used to test data normality (Harris, 2016). While some slight deviations existed, the majority of plots remained close to the line denoting normality of the data was acceptable (Harris, 2016). Based on Harris (2016), the normality of data in this study was reasonably met because the majority of spots held closely to the line with some slight variations in the upper and lower ends for all variables as shown in Figure 6–12.

Figure *6*

Q-Q scatterplots for normality for Performance Expectancy

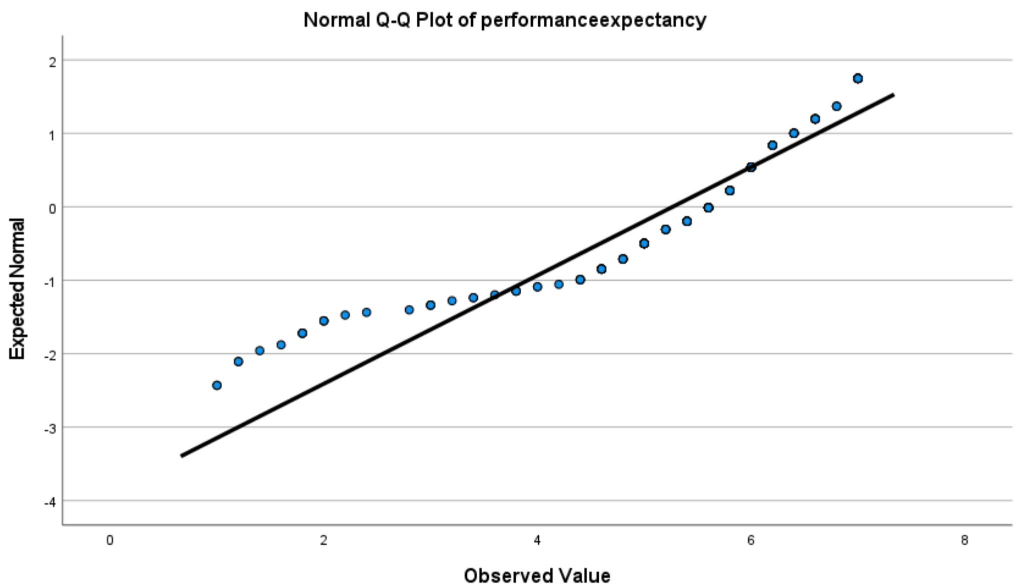


Figure 7

Q-Q scatterplots for normality for Effort Expectancy

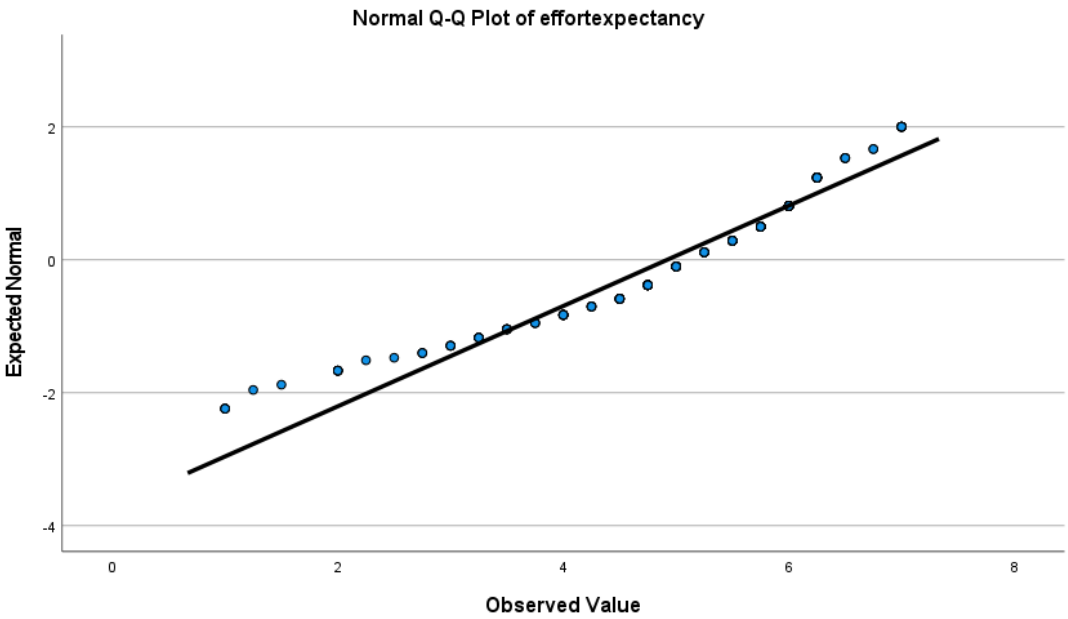


Figure *8*

Q-Q scatterplots for normality for Social Influence

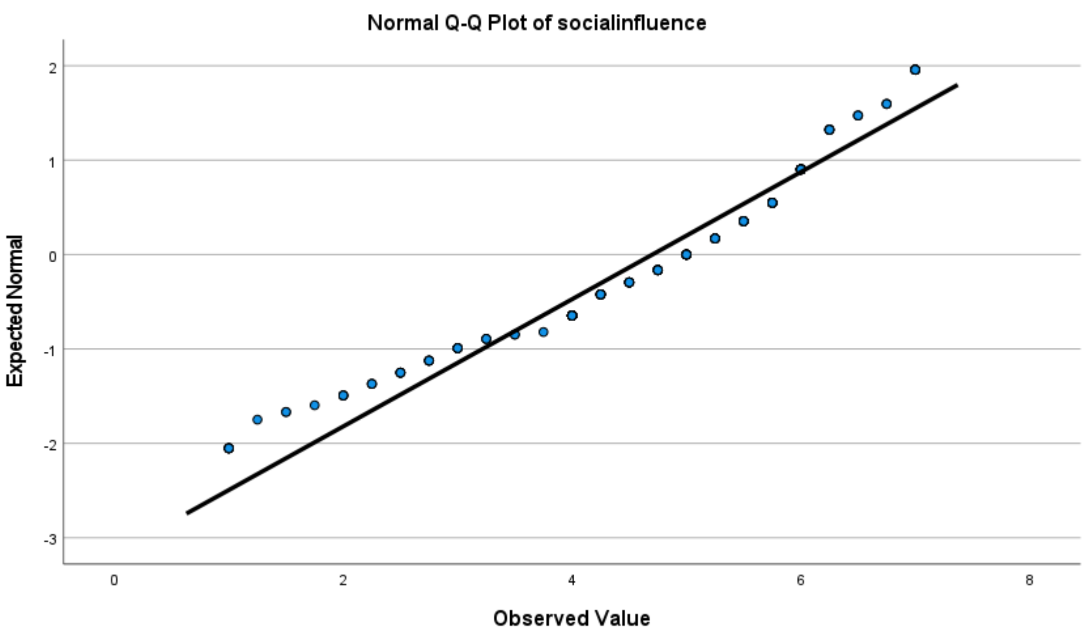


Figure ***9***

Q-Q scatterplots for normality for Behavioral Intention

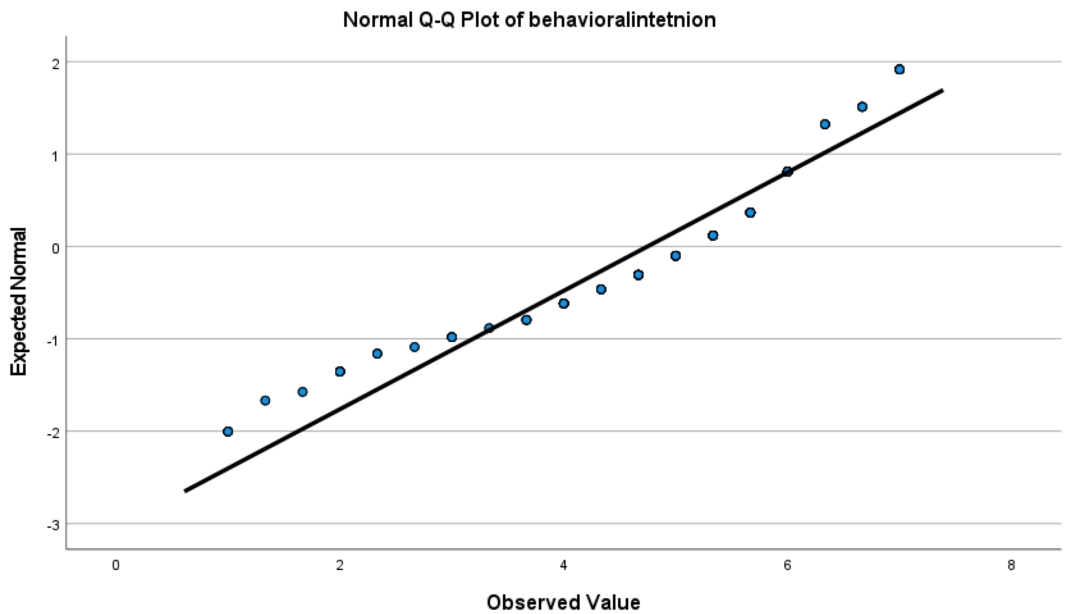


Figure ***10***

Q-Q scatterplots for normality for Anxiety

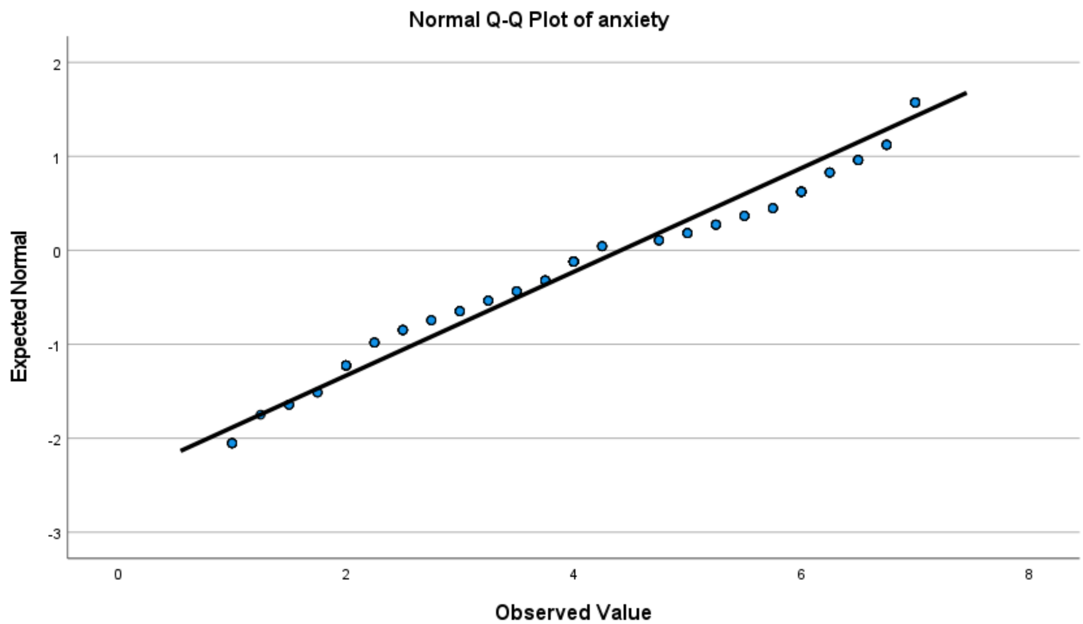


Figure *11*

Q-Q scatterplots for normality for Trust to Cobots

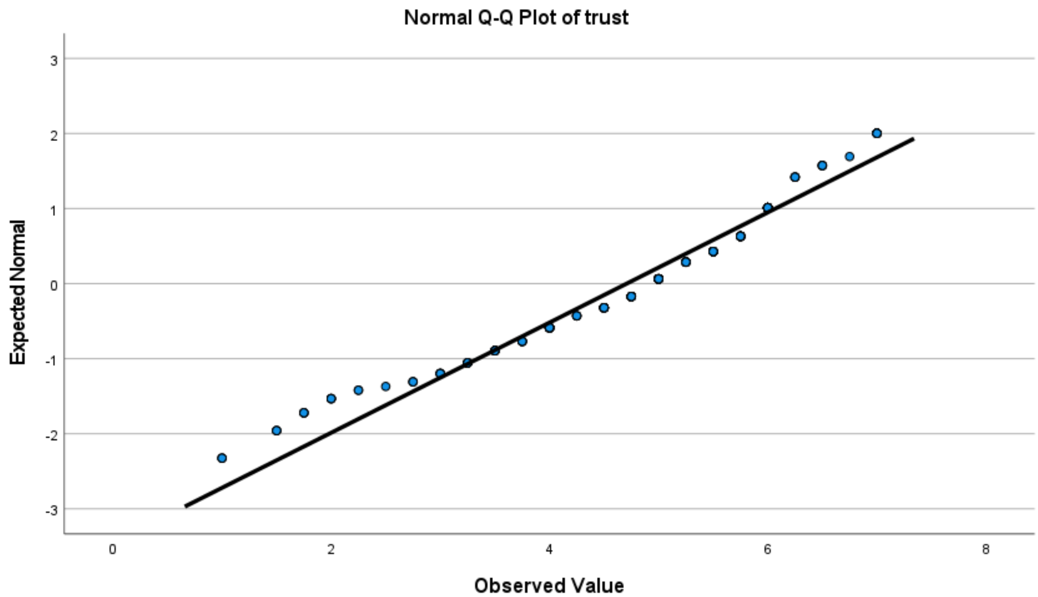


Figure *12*

Q-Q scatterplots for normality for Personal Innovativeness

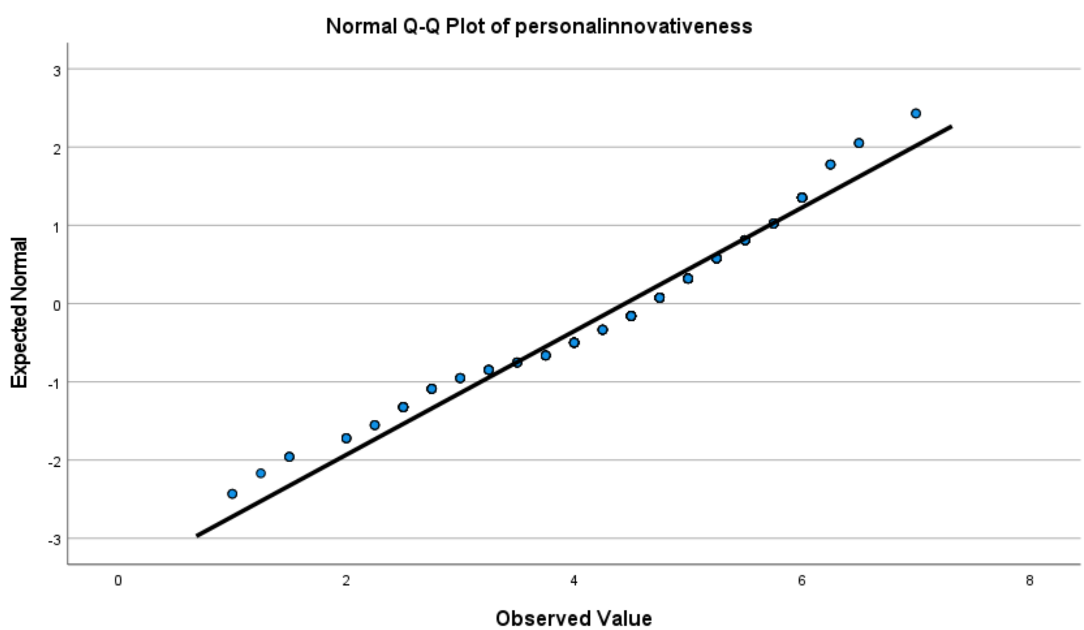
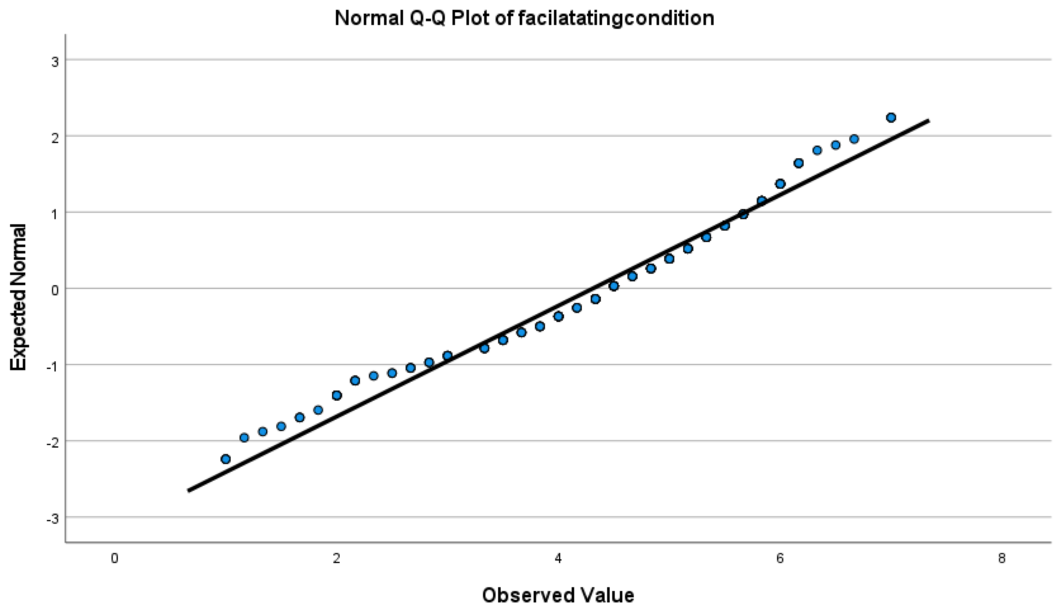


Figure *13*

Q-Q scatterplots for normality for Facilitating Conditions



Performance Expectancy

Five items were identified as one factor: Performance Expectancy. Its eigenvalue was 3.74 and explained 74.75% of the variance. Factor loading ranged from .76 to .90, and Cronbach's *alpha* of these items was .91. This factor was used to measure the degree to which garment employees believe in the Cobots' performance. Overall, respondents in this study slightly agreed that Cobots were useful in their factories (M=5.17 on a scale of 1 being strongly disagree to 7 being strongly agree, SD=1.633) and helped them improve productivity and spend less time on job tasks to complete the tasks quicker. Participants indicated that if Cobots were more effective, they should replace workers.

Table 9

Results of factor analysis and descriptive statistics of performance expectancy toward the acceptance of Cobots implementation in garment factories (n=198)

Variable title and measurement items	Descriptive and factor analysis		
	Mean[a]	SD	Factor loading
Performance expectancy (PE)			
I would find Cobots are useful in my factory	5.17	1.63	0.86
Using Cobots enables me to accomplish tasks more quickly	5.31	1.57	0.90
Using Cobots would increase the productivity	5.41	1.54	0.90
If I use Cobots, I will spend less time on routine job tasks	5.38	1.52	0.90
Cobots should replace human labor if this is more effective/productive	5.05	1.60	0.76
Eigenvalue = 3.74			
Cronbach's *alpha* = 0.91			
Total variance explained = 74.75%			

Note: [a]Item scores range from 1 (strongly disagree) to 7 (strongly agree)

Effort Expectancy

Four items of effort expectancy were identified as one factor, indicating uni-dimensionality. Its eigenvalue was 2.96 and explained 73.89% of the variance. Factor loadings ranged from .81 to .89, and Cronbach's *alpha* of these items was .88. This described the level of ease of use related to Cobot usage, that the respondents' interactions with Cobots would be clear and understandable, and the easiness of learning to operate Cobots and becoming skillful at using Cobots in their factories. The respondents were neutral or slightly agreed that interactions with Cobots would be clear and understandable, and Cobots were easy to use in their factories. It also noted it was easy to learn to operate Cobots and become skillful using Cobots.

Table 10

Results of factor analysis and descriptive statistics of effort expectancy toward the acceptance of Cobots implementation in garment factories (n=198)

Variable title and measurement items	**Descriptive and factor analysis**		
	Mean[a]	**SD**	**Factor loading**
Effort expectancy (EE)			
I expect my interaction with Cobots would be clear and understandable	5.37	1.50	.81
Learning to operate Cobots is easy for me	4.89	1.55	.89
It would be easy for me to become skillful at using Cobots	4.78	1.56	.89
I believe Cobots are easy to use in my factory	4.64	1.56	.86
Eigenvalue = 2.96			
Cronbach's *alpha* = .88			
Total variance explained = 73.89%			

Note: [a]Item scores range from 1 (strongly disagree) to 7 (strongly agree).

Social Influence

Four items of social influence were identified as one factor, indicating uni-dimensionality. The eigenvalue was 3.22 and explained 80.59% of the variance. Factor loadings ranged from .86 to .93, and Cronbach's *alpha* for these items was .92. It was used to measure the degree to which social circumstances affect the respondent's perceptions of working with Cobots. Overall, respondents slightly agreed the social factors supported them to collaborate with Cobots, such as people influencing or important to respondents or the senior managers in the factory.

Table 11

Results of factor analysis and descriptive statistics of social influence toward the acceptance of Cobots implementation in garment factories (n=198)

Variable title and measurement items	**Descriptive and factor analysis**		
	Mean[a]	**SD**	**Factor loading**
Social Influence (SI)			
People who influence my behavior think that I should collaborate with Cobots	4.62	1.63	.86
People who are important to me think that I should collaborate with Cobots	4.64	1.66	.93
The senior management of my factory has been helpful in the use of Cobots	4.85	1.71	.90

In general, my factory supports the use of Cobots	4.70	1.62	.91
Eigenvalue = 3.22			
Cronbach's *alpha* = .92			
Total variance explained = 80.59%			

Note: [a]Item scores range from 1 (strongly disagree) to 7 (strongly agree).

Behavioral Intention

Three items of behavioral intention were identified as one factor. The eigenvalue was 2.68 and explained 89.17% of the variance. Factor loadings ranged from .92 to .96, and Cronbach's *alpha* for these items was .94. Behavioral intention represented the willingness of respondents to work with Cobots or agree with Cobot implementation in their factory in the near future. It included the respondents' prediction of the adoption of Cobots, and their intention and plan to use Cobots. In general, respondents slightly agreed about using Cobots in the near future.

Table 12

Results of factor analysis and descriptive statistics of behavioral intention toward the acceptance of Cobots implementation in garment factories (n=198)

Variable title and measurement items	**Descriptive and factor analysis**		
	Mean[a]	**SD**	**Factor loading**
Behavioral Intention (BI)			
I predict that my factory will implement Cobots in the near future	4.61	1.57	.92

I intend to use Cobots in the near future	4.84	1.66	.96
I plan to use Cobots in my factory in the near future	4.79	1.73	.96
Eigenvalue = 2.68			
Cronbach's *alpha* = .94			
Total variance explained = 89.17%			

Note: [a]Item scores range from 1 (strongly disagree) to 7 (strongly agree)

Anxiety

Four items for anxiety were identified as one factor, indicating uni-dimensionality. Its eigenvalue was 3.47 and explained 86.85% of the variance. Factor loadings ranged from .91 to .95, and Cronbach's *alpha* for these items was .95 to measure the level of anxiety the respondents had about collaborating with Cobots. In general, respondents have slight concerns about losing jobs, fear of making mistakes, intimidation by Cobots, and overactivity of Cobots for their jobs.

Table 13

Results of factor analysis and descriptive statistics of anxiety toward the acceptance of Cobots implementation in garment factories (n=198)

Variable title and measurement items	**Descriptive and factor analysis**		
	Mean[a]	**SD**	**Factor loading**
Anxiety (ANX)			
It scares me to think that I could lose my jobs by Cobots application	4.58	1.88	.91

I hesitate to work with Cobots for fear of making mistakes I cannot correct	4.57	1.88	.93
I feel apprehensive that Cobots take over many things in my job	4.43	1.95	.95
Cobots are intimidating to me	4.08	2.06	.94
Eigenvalue = 3.47			
Cronbach's *alpha* = .95			
Total variance explained = 86.85%			

Note: [a]Item scores range from 1 (strongly disagree) to 7 (strongly agree).

Trust in Cobots

Four items of trust in Cobots were identified as one factor, indicating uni-dimensionality. Its eigenvalue was 3.30 and explained 82.49% of the variance. Factor loadings ranged from .85 to .94, and Cronbach's *alpha* for these items was .93. Trust represented the degree to which the respondents trust Cobots in their factory. In general, respondents agreed that Cobots were reliable to make products and stimulate their interest.

Table 14

Results of factor analysis and descriptive statistics of trust toward the acceptance of Cobots implementation in garment factories (n=198)

Variable title and measurement items	**Descriptive and factor analysis**		
	Mean[a]	**SD**	**Factor loading**
Trust to Cobots (TC)			

I find products made by Cobots reliable	4.72	1.43	.92
Cobots are reliable	4.73	1.47	.94
I would trust the work completed by Cobots	4.65	1.52	.93
Cobots will keep human interests in mind	4.74	1.59	.85
Eigenvalue = 3.30			
Cronbach's *alpha* = .93			
Total variance explained = 82.49%			

Note: [a]Item scores range from 1 (strongly disagree) to 7 (strongly agree)

Personal Innovativeness

Three items of personal innovativeness were identified as one factor, indicating uni-dimensionality. Its eigenvalue was 2.54 and explained 84.55% of the variance. Factor loadings ranged from .88 to .95. Cronbach's *alpha* for these items was .91 and measured the willingness of respondents to try new technologies. However, one item, "In general, I am hesitant to try out Cobots," revealed low internal consistency within a factor. Therefore, this item was excluded from further analysis. In general, respondents were slightly willing to be the first ones to try new things. They liked to experiment with Cobots or look for opportunities to experiment with Cobots, if they had heard about them.

Table 15

Results of factor analysis and descriptive statistics of personal innovativeness toward the acceptance of Cobots implementation in garment factories (n=198)

Variable title and measurement items	**Descriptive and factor analysis**

	Mean[a]	SD	Factor loading
Personal Innovativeness (PI)			
Among my co-workers, I am usually the first to try out new technologies	4.28	1.79	.88
If I heard about Cobots, I would look for ways to experiment with it	4.63	1.74	.95
I like to experiment with Cobots	4.73	1.84	.93
Eigenvalue = 2.54			
Cronbach's *alpha* = .91			
Total variance explained = 84.55%			

Note: [a]Item scores range from 1 (strongly disagree) to 7 (strongly agree).

Facilitating Conditions

Six items of effort expectancy were identified as one factor, indicating uni-dimensionality, where the eigenvalue was 4.36 and explained 72.65% of the variance. Factor loadings ranged from .86 to .88, and Cronbach's *alpha* for these items was .92. In general, the respondents were neutral or slightly agreed they had the necessary resources and knowledge to use Cobots and the compatibility of Cobots, compared to all aspects of respondents' working.

Table 16

Results of factor analysis and descriptive statistics of facilitating conditions toward the acceptance of Cobots implementation in garment factories (n=198)

Variable title and measurement items	**Descriptive and factor analysis**		
	Mean[a]	**SD**	**Factor loading**
Facilitating conditions (FC)			
I have the resources necessary to use Cobots	4.35	1.65	.87
I have the knowledge necessary to use Cobots	4.18	1.67	.86
Cobots is not compatible with other automatic industrial machines I use.	4.04	1.56	.78
Given the resources, opportunities, knowledge it takes to use Cobots, it would be easy for me to use Cobots	4.53	1.67	.86
I think that using Cobots fit well with the way I like to work	4.54	1.53	.86
Using Cobots is compatible with all aspects of my work	4.24	1.61	.88
Eigenvalue = 4.36			
Cronbach's *alpha* = .92			
Total variance explained = 72.65%			

Note: [a]Item scores range from 1 (strongly disagree) to 7 (strongly agree).

Correlation Among Research Variables

Table 17 presented the correlations among research variables. Pearson correlations were used to examine if significant associations exist among the variables for the proposed model: performance expectancy, effort expectancy, social influence, behavioral intention, anxiety, trust of Cobots, personal innovativeness, and facilitating conditions. All correlations were significant for the hypothesized relationships (*p < .001)*.

Table 17

Correlation matrix for research variables (n=198)

Variables	ANX	PI	PE	EE	SI	FC	TC	BI
ANX	1.00							
PI	-.41**	1.00						
PE	-.32**	.45**	1.00					
EE	-.33**	.58**	.67**	1.00				
SI	-.33**	.66**	.54**	.77**	1.00			
FC	-.40**	.80**	.46**	.63**	.69**	1.00		
TC	-.41**	.71**	.53**	.66**	.69**	.69**	1.00	
BI	-.47**	.75**	.53**	.70**	.74**	.69**	.70**	1.00

Note:

PE: Performance Expectancy, EE: Effort Expectancy, SI: Social Influence, FC: Facilitating Conditions, TC: Trust to Cobots, BI: Behavioral Intention.

** Correlation is significant at $p < .01$.

Hypotheses Testing

***H1: Performance expectancy has a positive influence on behavioral intentions toward the acceptance of Cobots in garment factories*.**

Results showed performance expectancy positively influenced behavioral intentions toward acceptance of Cobots in garment factories ($\beta = .53, p < .001$), supporting H1 (see Table

18). This means when garment employees had greater expectations toward Cobot performance, they were more likely to use Cobots.

H2: Effort expectancy has a positive influence on behavioral intentions toward the acceptance of Cobots in garment factories.

Results showed effort expectancy positively affected behavioral intentions toward acceptance of Cobots in garment factories ($\beta = .70, p < .001$), supporting H2 (see Table 18). This means when garment employees had greater expectations toward Cobot efforts, they were more likely to use Cobots.

H3: Social influence positively affects behavioral intentions toward the acceptance of Cobots in garment factories.

Results showed social influence positively affected behavioral intentions toward acceptance of Cobots in garment factories ($\beta = .74, p < .001$), supporting H3 (see Table 18). This means when coworkers, factories, or someone important to garment employees suggested they used Cobots, their intentions to use Cobots would increase.

H4: Trust has a positive influence on the behavioral intentions toward Cobot implementation.

Results showed trust positively affected behavioral intentions toward acceptance of Cobots in garment factories ($\beta = .70, p < .001$), supporting H4 (see Table 18). This means when garment employees had more trust in Cobots, they were more likely to intend or plan to use Cobots in the near future.

H5: Facilitating conditions affect positively behavioral intentions toward the acceptance of Cobots in garment factories.

Results showed facilitating conditions positively affected behavioral intentions toward acceptance of Cobots in garment factories ($\beta = .69, p < .001$), supporting H5 (see Table 18).

This means when garment employees received more resources, knowledge, and opportunities related to Cobots, they would have a greater intention to use Cobots.

H6: Anxiety has a negative influence on performance expectancy toward acceptance of Cobot implementation in garment factories.

Results showed anxiety negatively affected performance expectancy toward acceptance of Cobots in garment factories ($\beta = -.32, p < .001$), supporting H6 (see Table 18). When employees had a greater feeling of concern about Cobot's performance, their expectations for Cobots might decrease.

H7: Anxiety has a negative influence on effort expectancy toward acceptance of Cobot implementation in garment factories.

Results showed anxiety negatively affected effort expectancy toward acceptance of Cobot implementation ($\beta = -.33, p < .001$), supporting H7 (see Table 18). This means when garment employees were more anxious about Cobots, they would feel less inclined to use Cobots.

H8: Personal innovativeness has a positive influence on performance expectancy toward acceptance of Cobot implementation in garment factories.

Results showed personal innovativeness positively affected performance expectancy toward acceptance of Cobot implementation in garment factories ($\beta = .45, p < .001$), supporting H8 (see Table 18). This means when workers were willing to try new things, such as Cobots, they were likely to have a greater confidence in Cobot performance.

H9: Personal innovativeness has a positive influence on effort expectancy toward acceptance of Cobot implementation in garment factories.

Results showed personal innovativeness positively affected effort expectancy toward the acceptance of Cobot implementation in garment factories ($\beta = .58, p < .001$), supporting H9 (see

Table 18). This means when workers were willing to try new things, such as Cobots, they would feel more confident about using Cobots.

Table 38

Simple Regression Analyses: Testing Hypotheses

Dependent variable **Independent variable**	***F*-value**	**R^2**	***B***	***SE***	***β***	***t***
Behavioral intention (H1)						
Performance expectancy	77.30	.28	.61	.07	.53	8.79^{***}
Behavioral intention (H2)						
Effort expectancy	184.58	.49	.82	.06	.70	13.59^{***}
Behavioral intention (H3)						
Social influence	240.41	.55	.78	.05	.74	15.51^{***}
Behavioral intention (H4)						
Trust to Cobots	192.46	.50	.81	.06	.70	13.87^{***}
Behavioral intention (H5)						
Facilitating conditions	176.41	.47	.78	.06	.69	13.28^{***}
Performance expectancy (H6)						
Anxiety	22.22	.10	-.24	.05	-.32	-4.71^{***}
Effort expectancy (H7)						
Anxiety	23.11	.11	-.24	.05	-.33	-4.81^{***}
Performance expectancy (H8)						
Personal innovativeness	48.50	.20	.48	.07	.45	6.96^{***}
Effort expectancy (H9)						

Dependent variable						
Independent variable	***F*-value**	**R^2**	***B***	***SE***	***β***	***t***
Personal innovativeness	96.56	.33	.60	.06	.58	9.83***

***p < .001

CHAPTER V: DISCUSSIONS

In the current ready-to-wear apparel industry, fashion brands are trending global outsourcing to developing countries, due to inexpensive costs and favorable business environments. Vietnam is one of the most attractive developing countries because it consists of massive low-wage labor, cheap power costs like electricity, and safe political situations (Hertveldt, 2020). However, the development of I4.0 is shifting the apparel industry globally to automation and robotics. Vietnam cannot deny the role I4.0 plays in industrialization and modernization to be more competitive when compared to other countries (Nguyen et al., 2019). The apparel industry is the main sector contributing to economic development in Vietnam. The findings in this study showed more than 50% of the employees in garment factories in Vietnam have heard about I4.0 and worked with automatic industrial machines as the application of I4.0 within the past five years. More than 80% of female workers are employed in garment factories. Hence, this percentage of female workers represents a significant portion of the total number of workers (Nguyen et al., 2018).

According to Nguyen et al. (2019), most Vietnamese apparel factories were using outdated technologies up to at least a decade ago. The level of backwardness in Vietnam is too high compared with garment enterprises globally (Nguyen et al., 2019). This fact reflects why approximately half of the total respondents have not heard about Cobots as a new technology of I4.0, as shown in this study. Therefore, there is a need to narrow the technology gap for Vietnamese garment enterprises.

According to the simple regression analysis results, all suggested hypotheses were supported, based on the proposed UTAUT model. First, Venkatesh et al. (2003) mentioned if the respondents' performance expectancy and effort expectancy are high, their intentions are high for using new technologies. The higher the performance expectancy towards the application of Cobots the garment workers had, the better the acceptance of Cobots. This also means performance expectancy was an excellent predictor affecting positively the respondents' intentions to collaborate with Cobots in garment factories. They believed Cobots could bring higher productivity to the factories and help workers spend less time on job tasks by completing these tasks quicker. In addition, they agreed it is possible to allow Cobots to take over workers' positions, if Cobots are more effective than workers. Similar to performance expectancy, the findings of effort expectancy in this study were the same as the findings in the original UTAUT model of Venkatesh et al. (2003). The respondents had more intentions towards the implementation of Cobots, if the effort expectancy was high. This means the garment employees will plan or intend to use Cobots in the near future, if they feel Cobots are easy to use, understandable, and clear. In the context of garment factories in Vietnam, the respondents slightly believed learning to operate Cobots and becoming skillful in using Cobots were easy options for them.

Venkatesh et al. (2003) noticed the personal behavior of users is affected by people who are significant to them, such as friends, family, colleagues, and co-workers. People's opinions can motivate or discourage others from using new technology. According to the results of this study, social influence was consistent with the findings by Venkatesh et al. (2003). People who are important to the respondents or influence their intentions play a vital role in making decisions to use Cobots. In this study, the respondents agreed they are encouraged to use Cobots. Moreover, if senior management and others in the factory can support them in using Cobots, they are more willing to use Cobots in the near future.

As mentioned in the literature review, facilitating conditions refer to the degree to which respondents can gain advantages from the factory to support respondents to use Cobots. The findings in this study indicated, if garment employees can obtain resources, opportunities, and the knowledge necessary to use Cobots, they will have greater intentions to use Cobots because they will have fewer difficulties and will overcome any challenges, while working with Cobots. In other words, if the respondents believe they have sufficient knowledge and skills, they can quickly adopt Cobots. They also agreed that using Cobots was compatible with their working habits; therefore, they may not need time to adjust. Overall, improving the facilitating conditions in garment factories for Cobot implementation helps increase garment employees' intentions to use Cobots. Training workers to use Cobots carefully and the availability of technical groups to fix Cobot problems should be the focus when applying Cobots in these factories.

Findings from this study mentioned the higher the personal innovativeness, the better performance expectancy and effort expectancy towards Cobots, which leads to the greater intention to use Cobots. If the respondents were innovative and liked to try new things, they would be more inclined to use Cobots because they believed in the Cobots' performance and the ease of using Cobots. Therefore, Cobot developers, application partners, technology programmers, and garment manufacturers, together, should analyze the current situations in each garment factory because each factory has a different layout, infrastructure, main garment styles, and budget. This joint effort can find innovative points to update Cobot functions as a highlight to attract garment employees' intentions because garment employees are critical laborers working with Cobots directly in the factories. For example, the loading of Cobots should be increased to load more products together, or the programming of Cobots should be enhanced to inspect garment quality.

Regardingtrust in Cobots, respondents in this study agreed that Cobots are reliable in making products and completing work. According to Universal Robots (n.d.a), Cobots complete tasks consistently and repeatedly, based on programming by technology programmers. They can repeat their movements for many hours with the same precision. Hence, Cobots can gain trust from garment employees. In addition, Cobots can keep human interest in mind because Cobots are an innovative technology that update daily. When employees have a higher trust in Cobots, their intention to use Cobots will increase because Cobots may reach or exceed their expectations.

As mentioned in the literature review, anxiety is a natural human reaction when people fear their satisfaction is in danger. In this study, anxiety was found to negatively influence the performance and effort expectations of garment employees. The respondents agreed Cobots made them fearful of losing their jobs because Cobots can take over many jobs in factories. They also hesitated to work with Cobots because they were afraid they could not fix mistakes or problems when working with Cobots. They believed in the Cobots' performance and efforts positively; however, if Cobots can handle many tasks, they may intimidate the employees who would then have less intentions to use Cobots. This problem will be a big challenge for garment manufacturers when applying Cobots in the factories. They need to build intelligent strategies to avoid human replacement by Cobots. According to Mattos et al. (2020), employees in manufacturing have been deskilling and upskilling, when adopting the application of I4.0 which means garment employees might be deskilling for repeatable tasks, while upskilling for complicated tasks related to highly skilled experiences or technology tasks like fixing or controlling the machines. Overall, training workers are necessary to integrate new technologies, if Cobots are adopted in the garment factories.

CHAPTER VI: SUMMARY AND RECOMMENDATIONS

Conclusions

Regarding the development of I4.0, the increase in new technology in robotics is obvious (Boer & Astrom, 2017). However, the Vietnam garment industry faces many challenges from I4.0 because Vietnam is a labor-intensive industry (Nhabe Corporation, 2019). Balancing the low-price labor advantages and the integration of I4.0 is a priority for Vietnamese garment manufacturers. The employees' intentions towards Cobots is essential to allowing garment manufacturers to make decisions in infrastructure investments in the near future. Therefore, the present study aimed to determine the acceptance level of Cobot applications, based on employees' intentions in the Vietnam apparel manufacturing sector.

The primary source for the proposed model in this study is the UTAUT model by Venkatesh et al. (2003), used in many research studies related to the acceptance of new technology. Additional variables for the model were added, based on research by Boer and Astrom (2017), inspired by the original UTAUT model of Venkatesh et al. (2017) to reflect the context of Cobots. This study indicated that performance expectancy, effort expectancy, social influence, and facilitating conditions positively influence behavioral intentions, as in the original UTAUT model. These findings were supported in this study.

Trust, anxiety, and personal innovativeness are additional variables because they were not included in the original UTAUT model. However, anxiety had a negative association, while personal innovativeness positively impacted behavioral intentions. Anxiety involves the fear of workers when collaborating with Cobots, while personal innovativeness is the willingness to try new things. In addition, trust was examined as a positive impact on behavioral intentions, along with performance expectancy, effort expectancy, social influence, and facilitating conditions.

Overall, all three additional variables of the proposed model fit well in the context of this study. The results indicated positive employees' intentions toward Cobot applications to adopt Cobots in the core manufacturing processes of factories. Meanwhile, Vietnam has been left behind in updating new technology compared to other developing countries in the world (Nguyen et al., 2019). Therefore, there is a need for the Vietnam apparel industry to push the integration of Cobots in the factories, which might be an excellent opportunity to attract many fashion brands globally to outsource to Vietnam.

Implications

This study provided valuable insights into robotics development, especially Cobots, and contributed to the academic literature. First, the fashion industry changes daily, depending on trends, styles, and customer demands. These factors limit the advantages of Cobot practices in production because there are few repeatable tasks. Therefore, there is a need to develop and customize Cobot practices to be more flexible per the requirements of apparel production, based on company size. Facilitating conditions were found in this study to affect garment employees' intentions to use Cobots positively. This related to resources, opportunities, and knowledge that garment factories could bring to employees, while collaborating with Cobots. For example, garment manufacturers could allow employees to participate in Cobot training with additional benefits like bonus awards or allow employees to have a trial time at the beginning stage of working with Cobots to understand the Cobot operation clearly. Thus, each factory has different facilitating conditions for Cobots to fit well with the workers. Moreover, performance expectancy and effort expectancy were essential to the respondents' intentions in this study. Hence, through the level of Cobots acceptance in this study, if the Cobot companies, application partners, technology programmers, and manufacturers can discuss maximizing the advantage of

Cobots in every situation in factories. The spreading of Cobot implementation in the Vietnamese garment factories will increase significantly. This point will help the industry grow, not only economically, but also sustainably.

As mentioned, workers in the garment factories had concerns about losing jobs in terms of anxiety, if Cobots were employed. Therefore, garment manufacturers should pay attention to this crucial point to provide proper strategies for Cobot implementation, regarding personal innovativeness, updating Cobot performance, and modernizing applications, is the main responsibility of Cobot companies, technology programmers, and application partners. For example, all these parties can continue to improve the payload capacity as much as possible or design new applications to complete more complicated tasks. If there are various new things about Cobots coming, this can be a good method to allow Cobots attract more workers' intentions and manufacturers' investments because the personal innovativeness determinant in this study positively impacted workers' intentions to use Cobots.

This research also offered some significant contributions to academic literature. It proposed a conceptual model to predict garment employees' intentions to use Cobots, based on the theory of UTAUT. This added three variables—trust, anxiety, and personal innovativeness—to explore the relationships between those variables and behavioral intention, proposing the extended UTAUT. There was a positive effect of trust and personal innovativeness, while a negative effect of anxiety on the respondents' intention towards Cobot implementation.

To the best knowledge of this researcher, this study is the first extended UTAUT model for the prediction of using Cobots in the context of the garment industry. Findings from this study also added to the predictive power of the UTAUT theory of Venkatesh et al. (2003)

because these additional variables improved understanding and predicting user intentions toward new technology, specifically Cobots.

Limitations and Recommendations for Future Research

Garment manufacturing is the focus of this study. All respondents are currently working in garment factories. Therefore, the results are reflected only in the context of garment manufacturing in Vietnam. Meanwhile, garment manufacturing is the final process of the garment and textile industry. Complete textile manufacturing also includes fiber, yarn, and fabric manufacturing (Uddin, 2019). The context of textile factories for fiber, yarn, and fabrics is different from garment factories in many areas, such as processes, operations, and infrastructures. Textile manufacturing products directly affect garment manufacturing as a raw material resource (Uddin, 2019). Hence, the context of fiber, yarn, and fabric factories should be researched using this model to compare the results between manufacturing processes. It is interesting to build innovative strategies that fit the exclusive apparel and textile industry from fiber to garment products.

Moreover, acceptance of Cobots in garment factories in each developing country might be different because of specific current situations of the garment industry caused by different cultures, economics, infrastructures, politics, and government policies. Therefore, future researchers can use this proposed model or extend this model to apply in the context of garment factories in other countries to provide better conclusions about the feasibility of Cobots beyond Vietnam. Comparisons of the results towards the acceptance level of Cobots in different countries could provide meaningful insights into the apparel manufacturing industry globally.

Another recommendation is to use other additional variables in various models, such as workers' age and experience, factory location, and costs to determine whether they support evaluating the acceptance levels of Cobot practices. Finally, the scenarios in this study can cover the comparison of Cobots and automatic industrial machine practices. The strengths and weaknesses of both Cobots and automatic industrial machines might be an extensive discussion for manufacturers in the investment of factories. Thus, this point helps respondents better understand Cobot implementation.

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APPENDIX A: IRB APPROVAL FORM: PRELIMINARY STUDY

Nguyen, Phung

From:	do-not-reply@cayuse.com
Sent:	Wednesday, December 15, 2021 4:10 PM
To:	Nguyen, Phung; Ma, Yoon
Subject:	IRB-2021-540 - Initial: Exempt Determination

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ILLINOIS STATE UNIVERSITY
Illinois' first public university.

Dec 15, 2021 4:09:31 PM CST

Yoon Jin Ma
Family & Consumer Sciences

Re: Exempt - Initial - IRB-2021-540 Collaborative robots in garment factories

Dear Dr. Yoon Jin Ma:

Illinois State University Institutional Review Board has rendered the decision that your study meets the criteria for an exempt determination and you can begin the study covered under this protocol.

Your study qualified for: Category 2.(i). Research that only includes interactions involving educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior (including visual or auditory recording).
The information obtained is recorded by the investigator in such a manner that the identity of the human subjects cannot readily be ascertained, directly or through identifiers linked to the subjects.

The Exempt Status does not relieve the investigator of any responsibilities relating to the research participants or university policy. Research should be conducted in accordance with the ethical principles, (1) Respect for Persons, (ii) Beneficence, and (iii) Justice, as outlined in the Belmont Report. Any change to the protocol or study materials that might affect the Exempt Status must be submitted in Cayuse Human Ethics. Depending on the changes, you may be required to apply for either Expedited or Full Review.

Please contact the Human Subjects Research Specialist to determine if your modifications meet these criteria at 309-438-5527 or irb@ilstu.edu.

Additional Notes:
Please ensure that any COVID related guidelines provided by the university are followed. Please note that masks are required in all University buildings. Researchers are encouraged to continue remotely and/or use technology to avoid face-to-face interactions. Researchers should also determine requirements for off-site data collection. For the most up-to-date information and guidance regarding research and how it has been impacted by COVID-19, please review the following links:

1

- Redbirds Keep Researching: https://research.illinoisstate.edu/coronavirus/.
- IRB Guidance: https://research.illinoisstate.edu/ethics/human/coronavirus/.

Sincerely,

Illinois State University Institutional Review Board

APPENDIX B: IRB APPROVAL FORM: THE ACCEPTANCE MODEL TESTING

Nguyen, Phung

From:	do-not-reply@cayuse.com
Sent:	Wednesday, February 9, 2022 3:26 PM
To:	Nguyen, Phung; Ma, Yoon
Subject:	IRB-2022-44 - Initial: Exempt Determination - Comments

[This message came from an external source. If suspicious, report to abuse@ilstu.edu]

ILLINOIS STATE UNIVERSITY
Illinois' first public university.

Feb 9, 2022 3:26:25 PM CST

Yoon Jin Ma
Family & Consumer Sciences

Re: Exempt - Initial - IRB-2022-44 The application of collaborative robots in garment factories

Dear Dr. Yoon Jin Ma:

Thank you for submitting your protocol for review. The Illinois State University Institutional Review Board has decided that your study met the criteria for an exempt determination. However, issues were found that **must be addressed** before the research begins. Once they are addressed, the study can begin.

How to find the identified issues:
These issues can be seen as comments in the submission form and are found in the sections showing a grey bubble instead of green checkmarks on the left side panel. Since these issues were determined to not impact the exempt status, **the revisions to these specific comments do not need to be resubmitted for review nor do they need to be revised in Cayuse Human Ethics**.

- To view the revisions that need to be made to your study, please go into the submission and find the comments in the "Consent" section.

Selected Exempt Categories:

- Category 2.(i). Research that only includes interactions involving educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior (including visual or auditory recording).
  The information obtained is recorded by the investigator in such a manner that the identity of the human subjects cannot readily be ascertained, directly or through identifiers linked to the subjects.

Additional Notes:
The Exempt Status does not relieve the investigator of any responsibilities relating to the research participants or institutional policy. Research should be conducted in accordance with the ethical principles, (1) Respect for Persons, (ii) Beneficence, and (iii) Justice, as outlined in the Belmont Report. Any further changes to the protocol or study materials that might affect the Exempt Status must be submitted in Cayuse Human Ethics. Depending on the changes, you may be required to apply for either Expedited or Full Review.

1

Please ensure that any COVID related guidelines provided by the university are followed. For the most up-to-date information and guidance regarding research and how it has been impacted by COVID-19, please review the following links:

- Redbirds Keep Researching: https://research.illinoisstate.edu/coronavirus/.
- IRB Guidance: https://research.illinoisstate.edu/ethics/human/coronavirus/.

Please contact the Human Subjects Research Specialist to determine if your modifications meet these criteria or if you have any other questions at 309-438-5527 or irb@ilstu.edu.

Sincerely,

Illinois State University Institutional Review Board

APPENDIX C: INFORMED CONSENT: PRELIMINARY STUDY

You are being asked to participate in a research study conducted by Kim Phung Nguyen, a graduate student under the direction of Dr. Yoon Jin Ma in the Department of Family and Consumer Sciences at Illinois State University. I am conducting a research study for my master's thesis to evaluate the collaborative robot's feasibility in the garment factories in Vietnam. The purpose of this study is to explore how collaborative robots (Cobots) can be applied in production and identify any challenges in adopting Cobots as new technology.

Why are you being asked?

You have been asked to participate because you are currently working or used to work in the garment factories in Vietnam with management responsibilities. I am particularly interested in your views because of your experience with new technology adoption to improve the performance of factories. Your participation in this study is voluntary. You will not be penalized if you choose to skip parts of the study, not participate, or withdraw from the study at any time.

What would you do?

If you choose to participate in this study, your participation will involve completing multiple choices and open-ended questions. Specifically, there are four main sections including working experience, Cobots experience, Cobots applications, and potential challenges that might affect when adopting Cobots in your garment factory, such as technical concerns, cost, labor-related concerns, etc. There are no wrong or right answers. I appreciate a variety of your thoughtful responses to each question. Please feel free to share them in a comfortable way. In total, your involvement in this study will last approximately 20 to 30 minutes with 5-7 minutes for each section.

Are any risks expected?

We do not anticipate any risks beyond those that would occur in everyday life

Will your information be protected?

Your responses will be anonymous; nothing that will identify you will be linked to your responses. The findings from this study may be presented in the preliminary study and will contribute to my thesis in the next steps to understand concerns in deploying new technology, particularly Cobots in the garment factories.

Who will benefit from this study?

These will in turn help Cobots companies when developing related technologies to meet manufacturers' demands in a better way for producers.

Whom do you contact if you have any questions?

If you have any questions about the research or wish to withdraw from the study, contact Kim Phung Nguyen at pknguy1@ilstu.edu or Dr. Yoon Jin Ma at yjma@ilstu.

If you have any questions about your rights as a participant, or if you feel you have been placed at risk, contact the Illinois State University Research Ethics & Compliance Office at (309) 438-5527 or IRB@ilstu.edu.

Documentation of Consent

This consent form is included at the beginning of the survey. Before starting the survey, please check one of the two below boxes. If you click Yes, it will automatically move to the next part of the survey. If No, it will move to the end of the survey

- Yes, I am willing to participate in this study
- NO, I am not willing to participate in this study

You can print this form for your records after submitting the survey. Thank you so much for your participation.

Sincerely,

Kim Phung Nguyen

APPENDIX D: INFORMED CONSENT: THE ACCEPTANCE MODEL TESTING

You are being asked to participate in a research study conducted by Kim Phung Nguyen, a graduate student under the direction of Dr. Yoon Jin Ma in the Department of Family and Consumer Sciences at Illinois State University. I am conducting a research study for my master's thesis to evaluate the collaborative robot's feasibility in the garment factories in Vietnam. The purpose of this study is to explore the acceptance level of collaborative robot's applications based on employees' intentions.

Why are you being asked?

You have been asked to participate because you are currently working in the garment factories in Vietnam. I am particularly interested in your views because of your experience with new technology adoption to improve the performance of factories. Your participation in this study is voluntary. You will not be penalized if you choose to skip parts of the study, not participate, or withdraw from the study at any time.

What would you do?

If you choose to participate in this study, your participation will involve completing multiple choices and open-ended questions. Specifically, there are eleven main sections including demographic, I4.0 practices, collaborative robots (Cobots) practices, and eight constructs to measure the acceptance level of Cobots. There are no wrong or right answers. I appreciate a variety of your thoughtful responses to each question. Please feel free to share them comfortably. In total, your involvement in this study will last approximately 20 to 30 minutes with 5-7 minutes for each section.

Are any risks expected?

We do not anticipate any risks beyond those that would occur in everyday life

Will your information be protected?

Your responses will be anonymous; nothing that will identify you will be linked to your responses. The findings from this study may be published and will contribute to my thesis to understand the acceptance level in deploying new technology, particularly Cobots in the garment factories.

Who will benefit from this study?

These will in turn help Cobots companies when developing related technologies to meet manufacturers' demands in a better way for producers.

Whom do you contact if you have any questions?

If you have any questions about the research or wish to withdraw from the study, contact Kim Phung Nguyen at pknguy1@ilstu.edu or Dr. Yoon Jin Ma at yjma@ilstu.

If you have any questions about your rights as a participant, or if you feel you have been placed at risk, contact the Illinois State University Research Ethics & Compliance Office at (309) 438-5527 or IRB@ilstu.edu.

Documentation of Consent

This consent form is included at the beginning of the survey. Before starting the survey, please check one of the two below boxes. If you click Yes, it will automatically move to the next part of the survey. If No, it will move to the end of the survey

- Yes, I am willing to participate in this study
- NO, I am not willing to participate in this study

You can print this form for your records after submitting the survey. Thank you so much for your participation.

Sincerely,

Kim Phung Nguyen

APPENDIX E: QUESTIONAIRE SURVEY

English

Default Question Block

Dear Prospective Participant,

You are being asked to participate in a research study conducted by Kim Phung Nguyen, a graduate student under the direction of Dr. Yoon Jin Ma in the Department of Family and Consumer Sciences at Illinois State University. I am conducting a research study for my master's thesis to evaluate the collaborative robot's feasibility in the garment factories in Vietnam. The purpose of this study is to explore the acceptance level of collaborative robot's applications based on employees' intention

You are selected because you are currently working in the garment factories in Vietnam. I am particularly interested in your views because of your experience with new technology adoption to improve the performance of factories. Your participation in this study is voluntary. You will not be penalized if you choose to skip parts of the study, not participate, or withdraw from the study at any time. If you choose to participate in this study, your participation will involve completing multiple choices and open-ended questions. Specifically, there are eleven main sections including demographic, I4.0 practices, collaborative robots (Cobots) practices, eight constructs to measure the acceptance level of Cobots. There are no wrong or right answers. I appreciate a variety of your thoughtful responses in each question. Please feel free to share them in your comfortable way. In total, your involvement in this study will last approximately 20 to 30 minutes.

We do not anticipate any risks beyond those that would occur in everyday life. Your responses will be anonymous; nothing that will identify you will be linked to your responses. The findings from this study may be published and will contribute to my thesis to understand the acceptance level in deploying new technology, particularly Cobots in the garment factories..

If you have any questions concerning this research study, please contact me at pknguy1@ilstu.edu or Dr. Yoon Jin Ma at yjma@ilstu. If you have concerns or questions about your rights as a research participant, or if you feel you have been placed at risk, you can contact the Illinois State University Research Ethics & Compliance Office at (309) 438-5527 or IRB@ilstu.edu.

Thank you so much for your participation.

Sincerely,
Kim Phung Nguyen

Please choose one in two below options

- ○ Yes, I am willing to participate in this study
- ○ No, I am NOT willing to participate in this study

You can print this form for your records after you submit the survey

Block 1

Section A: Demographic

1. Position in your company

- ○ Garment worker

- ○ Line leader
- ○ Technician
- ○ Engineer
- ○ Junior manager
- ○ Senior manager
- ○ Director
- ○ [ ] Other. Please specify

2. What is your gender?

- ○ Female
- ○ Male

3. How long have you worked in the apparel industry?

Please choose the number of working year in below box [▾]

4. How many average production lines are there in your current company's factory?

Please choose the number of production lines in below box [▾]

5. What is the average monthly capacity of your current company's factory?

- ○ 0 - 1,000 (pieces/ month)
- ○ 1,001 - 10,000 (pieces/ month)
- ○ 10,001 - 50,000 (pieces/month)
- ○ 50,001 - 100,000 (pieces/ month)
- ○ 100,001 - 500,000 (pieces/month)
- ○ 500,001 - 1,000,000 (pieces/ month)
- ○ Over 1,000,000 (pieces/month)

6. How many workers in your current company's factory?

- ◯ 0 - 100 workers
- ◯ 101 - 500 workers
- ◯ 501 - 1,000 workers
- ◯ 1,001 - 5,000 workers
- ◯ 5,001 - 10,000 workers
- ◯ 10,001 - 50,000 workers
- ◯ Over 50,000 workers

Section B: The Industrial Revolution 4.0 (I4.0) Practices:

7. Have you ever heard about the "Industrial Revolution 4.0", shortly named as "I4.0" prior to participating in this study?

- ◯ Yes
- ◯ No

8. Where have you heard about "I4.0"? Please check all that apply

- ☐ a. Never heard of I4.0 before
- ☐ b. Co-workers
- ☐ c. Facebook
- ☐ d. Family and relatives
- ☐ e. Friends
- ☐ f. Groups related to innovation and new technology adoption
- ☐ g. Instagram
- ☐ h. Industrial exhibitions
- ☐ i. LinkedIn

- ☐ k. Neighbors
- ☐ l. Newspaper or magazine articles
- ☐ m. News on television
- ☐ n. Technology events
- ☐ o. Twitter
- ☐ p. Youtube
- ☐ q. Websites
- ☐ ____________ r. Others, please specify

9. When you hear the word "I4.0", what ideas come to your mind? What do the words mean to you?

____

Regardless of your knowledge about I4.0, please read the below I4.0 definition and applications, which is important for completing the questionnaire

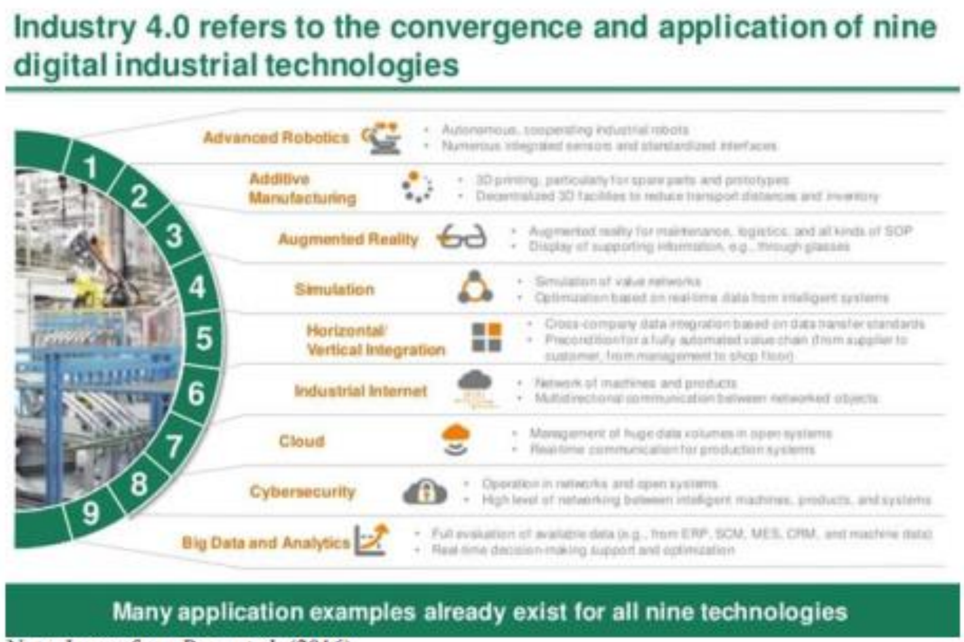
Definition

Industrial Revolution 4.0 (I4.0): New technologies which are reshaping and transforming many business models and manufacturing versions to bring the latest breakthrough in the development and competition of many areas such as Internet of things (ioT), robotics, digitalization, artificial intelligence, additive manufacturing, augmented reality, simulation, big data and analytics, cloud, cybersecurity, and horizontal/vertical integration. Please refer to below picture to understand the effect and application of nine typical digital industrial technologies in I4.0. Each technology shows its definition and advantages to help you answer next questions

• Advanced robotics is autonomous integrated sensors and standardized interfaces, cooperating industrial robots

• Additive manufacturing including 3D printing for decentralized 3D facilities to reduce transport distances and inventory

• Augmented reality is the display of supporting information through glasses and used for maintenance, logistics, and all kinds of SOP
• Simulation includes simulation of value networks and optimization based on real time data from intelligent systems
• Horizontal/ Vertical integration is cross-company data integration based on data transfer standards and the precondition for a fully automated value chain
• Industrial internet is a network between machines and products
• Cloud manages huge data volumes in open systems
• Cybersecurity is a high level of networking between intelligent machines, products, and systems
• Bid data and analytics is the full evaluation of available data (ERP, SCM, MES, etc)



Note. Image from Rose et al. (2016)

10. Which process has your current company's factory been applying I4.0 practices? If your company did not apply any I4.0 practices or you did not know, please check the option in the two last columns. Please refer to above picture to

understand the effect and application of nine typical digital industrial technologies in I4.0 to answer this question. Please check all that apply

	Advanced Robotics	Additive Manufacturing	Augmented Reality	Simulation	Horizontal/ Vertical Integration	Industria Internet
Manufacturing operations	☐	☐	☐	☐	☐	☐
Warehouse operations	☐	☐	☐	☐	☐	☐
Inventory tracking	☐	☐	☐	☐	☐	☐
Product quality	☐	☐	☐	☐	☐	☐
Maintenance	☐	☐	☐	☐	☐	☐
Environmental, health, and safety	☐	☐	☐	☐	☐	☐

11. Do you have other I4.0 applications in any processes in your current company's factory, except above options in question 10?

- ○ ________ Yes. Please specify
- ○ No

12. Have you ever worked with any automatic industrial machines in your current company's factory, such as automatic cutting machine, automatic assembling machine, automatic spreading fabric machine, etc ?

Yes. Please indicate the number of years that you have worked with those machines in the box	⌄
No. Please choose "0" in the box	⌄

Section C: Collaborative robots (Cobots) background

13. Have you ever heard about the word "Collaborative robots", shortly named as "Cobots" prior to participating in this study?

- ○ Yes
- ○ No

14. Where have you heard about "Cobots"? Please check all that apply

- ☐ a. Never heard of Cobots before
- ☐ b. Co-workers
- ☐ c. Facebook
- ☐ d. Family and relatives
- ☐ e. Friends
- ☐ f. Groups related to innovation and new technology adoption
- ☐ g. Instagram
- ☐ h. Industrial exhibitions
- ☐ i. LinkedIn
- ☐ k. Neighbors
- ☐ l. Newspaper or magazine articles
- ☐ m. News on television
- ☐ n. Technology events
- ☐ o. Twitter
- ☐ p. Youtube
- ☐ q. Websites
- ☐ ________ r. Others, please specify

15. When you hear the word "Cobots", what ideas come to your mind? What do the words mean to you?

16. Do you know any Cobots companies around the world?

- ◯ Yes. Please indicate the name of companies that you may know
- ◯ No

Regardless of your knowledge about Cobots, please read the description about Cobots below, which is important for completing the questionnaire.

Definition:
Cobot, a robot model, which can function together with humans in an uncaged environment to improve safety and productivity (Dobra & Dhir, 2016; Perez et al., 2019)

General applications:
Regarding the application of Cobots in many industries, Universal Robots, one of the biggest robotics companies globally, noticed that their Cobots could be activated in multi-disciplinary tasks. They cover assembly, dispensing, finishing, machine tending, material handling and removal, quality inspection, welding, and other processing tasks. They attach flexible automation to manufacturers of all sizes. First, Cobots can pick up and put objects in the correct positions. Thus, factories can apply them in packaging and palletizing with repetitive processes. Second, they can load-unload machines such as computer numerical control (CNC), injection molding, press brakes, and stamping presses to mitigate accidental injuries while working with heavy, dirty, dangerous machinery. Third, in the finishing processes such as polishing or deburring, Cobots attach to the internal force sensors to control the amount of force running across the surface of materials. Finally, Cobots are equipped with a

UR+ certified vision camera to capture and analyze images that do not meet product requirements (Universal Robots, n.d)

For further understanding about Cobots applications, you can click below link to watch videos. Or you can copy below links to watch on another browser not to exit the survey

Watch a robot sew a shirt from start to finish (1:02 mins), published on Youtube by CNN Business
https://www.youtube.com/watch?v=oeSu9Vcu0DU

Robotics applications by Universal Robots – Easy Automation with Collaborative Robots [2020] (10:33 mins), published on Youtube by Universal Robots
https://www.youtube.com/watch?v=plcxOGo7ieU

Image: Universal Robots Launches UR16e Cobot For Collaborative Automation

17. Have you ever worked with Cobots?

Yes. Please indicate the number of years that you have worked with those machines in the box	
No. Please choose "0" in the box	

Below scenarios are separated into five main sections in the garment factory's process: fabric warehouse, cutting, assembling, finishing, and packaging. Each scenario lists the tasks in that section based on the typical procedure flow of the garment factory. Those scenarios also show which tasks Cobots CAN do. You can read all scenarios in the whole factory's process or read the scenario in the section that you are currently working on.

		Tasks *(Nhiệm vụ)*	How Cobots work *(Cách hoạt động của Cobots)*
Fabric warehouse *(Kho vải)*		Arrange fabrics between the racks for checking and inventory *(Sắp xếp vải giữa các giá để kiểm tra và tồn kho)*	• Cobots are designed with moving parts at the bottom can move materials in and out in certain area in the same route. *(Cobots được thiết kế với bộ phận chuyển động ở phía dưới có thể di chuyển nguyên phụ liệu ra vào kho trong khu vực nhất định theo cùng một lộ trình.)* • Cobots can be adjust the heights to put the materials in high positions where human cannot touch. Its loading is up to 20 kg *(Cobots có thể được điều chỉnh độ cao để đưa các nguyên phụ liệu ở những vị trí cao mà con người không thể chạm vào. Tải trọng của nó lên đến 20kg)*
Cutting (Bộ phận *Cắt*)		1. Move fabrics from fabric warehouse to cutting section *(Di chuyển vải từ kho vải sang bộ phận cắt)* 2. Spread and smoothen fabrics *(Trải và làm phẳng vải)* 3. Cut fabrics based on the marker *(Cắt vải dựa sơ đồ cắt)* 4. Bundle fabric after cutting *(Bó vải sau khi cắt)* 5. Numbering *(Đánh số)* 6. Move cut panels to assembling section *(Di chuyển các bán thành phẩm đến bộ phận lắp ráp)*	• Cobot's arms are designed with moving parts at the bottom to move on the cutting table to spread and cut fabric based on the marker is set in the program. *(Cobots có các cánh tay được thiết kế với các bộ phận chuyển động ở phía dưới có thể di chuyển trên bàn cắt để trải và cắt vải dựa trên các sơ đồ cắt được được nhập vào trong chương trình.)* • Also, Cobots are attached to vision camera to recognize the barcode sticker on the fabric for bundling and numbering correctly *(Ngoài ra, Cobots được gắn vào camera quan sát để nhận dạng nhãn dán mã vạch trên vải để bó vải và đánh số một cách chính xác)*
Assembling (3 popular garments with complex level increased: T-shirt < Legging < Hoodie jacket) ***(Lắp ráp (3 loại hàng may mặc được liệt kê này phổ biến với mức độ phức tạp tăng dần: Áo thun < quần ôm legging< áo khoác)***	T-shirt or Tank top *(Áo thun hoặc áo sát nách)*	1. Join shoulder lines *(Ráp vai)* 2. Attach neck and armhole binding with folder *(Viền cổ áo và nách áo sử dụng cữ)* 3. Close side seam with side label *(Ráp sườn với nhãn bên)* 4. Mark and set label to back neckline *(Đánh dấu và gắn nhãn vào đường viền cổ áo sau)* 5. Set sleeve to body if it has *(Ráp tay với thân nếu có)* 6. Invert hem *(Lộn lai áo)* 7. Tack neck tape ends (*Chốt 2 đầu viền cổ)*	• Cobot's arms work with industrial machines, such as sewing machines, overlock machines, tacking machines, etc to complete tasks. *(Các cánh tay của Cobots được gắn để làm việc với các máy công nghiệp, chẳng hạn như máy may, máy vắt sổ, máy đính, v.v. để hoàn thành nhiệm vụ.)* • Cobots pick up garment pieces, put them in the industrial machines and run based on the set up program, and take them out from machines. *(Cobots lấy các bán thành phẩm, đưa chúng vào các máy công nghiệp và vận hành dựa trên chương trình đã thiết lập, sau đó Cobots sẽ lấy chúng ra khỏi máy.)* • Workers have to arrange garment pieces in the right position on the table to let Cobots pick up easily. *(Công nhân phải đưa các bán thành phẩm vào đúng vị trí trên bàn để Cobots lấy dễ dàng.)* ➔ As a result, the percentage of tasks that Cobots can handle depends on the complication of styles. It decreses if there are more difficult tasks. *(Do đó, tỷ lệ công đoạn mà Cobots có thể xử lý phụ thuộc vào sự phức tạp của các mẫu quần áo. Nó sẽ giảm nếu có nhiều công đoạn khó hơn.)* ➔ Cobots handle less tasks for jacket than T-shirt and legging because the jacket has more difficult tasks than T-shirt and legging *(Vì vậy, Cobots xử lýcác công đoạn của áo khoác ít hơn áo thun và quần ôm vì áo khoác có nhiều công đoạn khó khăn hơn áo thun và quần ôm)*
	Legging *(Quần ôm)*	1. Measure and cut elastic *(Đo và cắt thun)* 2. Join elastic ends *(Nối các đầu thun)* 3. Join waistband ends *(Nối bo lưng)* 4. Join front rise and back rise *(Ráp đáy trước và đáy sau)* 5. Close inseam continuously *(Đóng sườn trong liên tục)* 6. Attach care label *(Gắn nhãn)* 7. Tack crotch *(Chốt bọ đáy)* 8. Heat transfer label *(Ép nhãn)*	
	Jacket *(Áo khoác)*	1. Tack excess thread on center hood *(Chốt chỉ thừa ở giữa nón)* 2. Buttonhole hood *(Thùa khuy nón)* 3. Trim left and right interlining *(Cắt keo trái, phải)* 4. Mark placement on Kangaroo pocket before set (*Làm dấu túi Kangaroo trước khi tra)* 5. Mark Kangaroo pocket placement on front body (*Đánh dấu vị trí túi Kangaroo trên thân trước)* 6. Bartack Kangaroo pocket 4 times *(Đính bọ túi Kangaroo 4 lần)* 7. Mark front center and cut *(Đánh dấu giữa thân trước và cắt làm đôi)*	

	8. Join 3 pieces waistband *(Ráp 3 miếng bo lai)* 9. Overlock waistband edge with notch *(Lược 2 đầu mép lai có dấu bấm)* 10. Measure and cut drawstring *(Đo và cắt dây luồn)* 11. Join shoulder *(Nối vai)* 12. Set sleeve *(Tra tay)* 13. Close side seam *(Ráp sườn)* 14. Set waistband open *(Tra bo lai áo mở)* 15. Overlock front and waistband edge *(Lược mép thân trước với bo lai)* 16. Tack hood to neckline 3 times with mark *(Đính nón vào đường cổ 3 lần với vị trí dấu)* 17. Set hood to body *(Tra nón vào thân)*	
Finishing (Bộ phận hoàn tất)	1. Move garment pieces from cutting to finishing section *(Di chuyển các bán thành phẩm từ giai đoạn cắt tới giai đoạn hoàn tất)* 2. Ironing *(Ủi)* 3. Hand tag attaching *(Gắn thẻ bài)* 4. Folding (*Gấp xếp*) 5. Put garments in poly bag *(Đặt sản phẩm vào túi bóng)* 6. Close poly bags *(Khóa túi)* 7. Put poly bags into the boxes *(Đặt túi bóng vào thùng)*	• Cobot's arms are designed with moving parts at the bottom and work with iron machines to move and iron garments. *(Các cánh tay của Cobot được thiết kế với các bộ phận chuyển động ở phía dưới và hoạt động với máy ủi để di chuyển và ủi quần áo.)* • Also, Cobots are attached to vision camera to recognize the barcode on the garments for folding, tag attaching correctly, and put garments or boxes in the right position *(Ngoài ra, Cobots có camera quan sát để nhận dạng mã vạch trên quần áo để gấp xếp, gắn thẻ một cách chính xác, và đặt sản phẩm hoặc thùng vào đúng vị trí)* • Each Cobot's loading under 20kgs per round *(Sức tải của mỗi Cobot dưới 20kgs cho một vòng đi*
Packaging (Bộ phận đóng gói)	1. Move boxes from finishing to packaging section *(Di chuyển thùng từ giai đoạn hoàn tất tới giai đoạn đóng gói)* 2. Close the boxes *(Đóng thùng)* 3. Move the boxes to shipping area *(Di chuyển thùng tới khu vực giao hàng)*	

Please choose one in two below options

○ Yes, I read the above scenarios

○ No, I did not read the above scenarios

Section D: Performance expectancy

	Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
I would find Cobots are useful in my factory	○	○	○	○	○	○	○

	Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
Using Cobots enables me to accomplish tasks more quickly	○	○	○	○	○	○	○
Using Cobots would increase the productivity	○	○	○	○	○	○	○
If I use Cobots, I will spend less time on routine job tasks	○	○	○	○	○	○	○
Cobots should replace human labor if this is more effective/ productive	○	○	○	○	○	○	○

Section E: Effort expectancy

	Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
I expect my interaction with Cobots would be clear and understandable	○	○	○	○	○	○	○
Learning to operate Cobots is easy for me	○	○	○	○	○	○	○

	Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
It would be easy for me to become skillful at using Cobots	○	○	○	○	○	○	○
I believe Cobots are easy to use in my factory	○	○	○	○	○	○	○

Section F: Social influence

	Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
People who influence my behavior think that I should collaborate with Cobots	○	○	○	○	○	○	○
People who are important to me think that I should collaborate with Cobots	○	○	○	○	○	○	○
The senior management of my factory has been helpful in the use of Cobots	○	○	○	○	○	○	○

	Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
In general, my factory supports the use of Cobots	O	O	O	O	O	O	O

Section G: Behavioral intention

	Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
I predict that my factory will implement Cobots in the near future	O	O	O	O	O	O	O
I intend to use Cobots in the near future	O	O	O	O	O	O	O
I plan to use Cobots in my factory in the near future	O	O	O	O	O	O	O

Section H: Anxiety

	Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree

	Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
It scares me to think that I could lose my jobs by Cobots application	○	○	○	○	○	○	○
I hesitate to work with Cobots for fear of making mistakes I cannot correct.	○	○	○	○	○	○	○
I feel apprehensive that Cobots take over many things in my job	○	○	○	○	○	○	○
Cobots are intimidating to me.	○	○	○	○	○	○	○

Section I: Trust to Cobots

	Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
I find products made by Cobots reliable	○	○	○	○	○	○	○
Cobots are reliable	○	○	○	○	○	○	○

	Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
I would trust the work completed by Cobots	○	○	○	○	○	○	○
Cobots will keep human interests in mind	○	○	○	○	○	○	○

Section J: Personal innovativeness

	Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
Among my co-workers, I am usually the first to try out new technologies	○	○	○	○	○	○	○
If I heard about Cobots, I would look for ways to experiment with it	○	○	○	○	○	○	○
In general, I am hesitant to try out Cobots.	○	○	○	○	○	○	○
I like to experiment with Cobots	○	○	○	○	○	○	○

Section K: Facilitating conditions

	Strongly disagree	Disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Agree	Strongly agree
I have the resources necessary to use Cobots	○	○	○	○	○	○	○
I have the knowledge necessary to use Cobots	○	○	○	○	○	○	○
Cobots is not compatible with other automatic industrial machines I use	○	○	○	○	○	○	○
Given the resources, opportunities, knowledge it takes to use Cobots, it would be easy for me to use Cobots	○	○	○	○	○	○	○
I think that using Cobots fit well with the way I like to work	○	○	○	○	○	○	○
Using Cobots is compatible with all aspects of my work	○	○	○	○	○	○	○

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APPENDIX F: E-MAIL INVITATION LETTER

TITLE: Questions about the application of collaborative robots in garment factories.

Dear Prospective Participant,

I am Kim Phung Nguyen, a graduate student under the direction of Dr. Yoon Jin Ma in the Department of Family and Consumer Sciences at Illinois State University. I am conducting a research study for my master's thesis to evaluate the collaborative robot's feasibility in the garment factories in Vietnam. Therefore, this survey aims to explore the acceptance level of collaborative robot's applications based on employees' intentions.

You are selected because you are currently working in the garment factories in Vietnam. I am particularly interested in your views because of your experience with new technology adoption to improve the performance of factories. Your participation in this study is voluntary. You will not be penalized if you choose to skip parts of the study, not participate, or withdraw from the study at any time. If you choose to participate in this study, your participation will involve completing multiple choices and open-ended questions within approximately 20 to 30 minutes. There are no wrong or right answers. I appreciate a variety of your thoughtful responses to each question. Please feel free to share them in a comfortable way.

Thank you so much for your help in this important undertaking.

Please click the below link to take the survey

English version

https://illinoisstate.az1.qualtrics.com/jfe/form/SV_0VDxZg5RO4wmf8q

Vietnamese version

https://illinoisstate.az1.qualtrics.com/jfe/form/SV_0VDxZg5RO4wmf8q?Q_Language=VI

If you know anyone who might be interested in this topic and qualified, please feel free to send this invitation email to them. They can complete the survey directly or be free to contact me through this invitation email.

If you have any questions concerning this research study, please contact me at pknguy1@ilstu.edu.

Sincerely,

Kim Phung Nguyen

APPENDIX G: E-MAIL FOLLOW UP LETTER

TITLE: Follow-up letter: Questions about the application of collaborative robots in garment factories.

Dear Participants,

Five days ago, I sent you an online survey via email seeking your opinion about collaborative robots. If you already responded to the survey, please accept my sincere thanks. If you do not, I hope you can do it as soon as possible, as I value your opinions on sustainable new technology in the garment industry.

This study is conducted at Illinois State University as my Master's thesis. I want to know what you think about the collaborative robots and their applications whether are feasible in garment factories.

As I mentioned before, all responses are voluntary and will be kept confidential. There is no penalty or loss to you for not completing the survey or if you begin the survey but wish to withdraw and discontinue. I appreciate a variety of your thoughtful responses to each question.

The online survey is available for you at

English version

https://illinoisstate.az1.qualtrics.com/jfe/form/SV_0VDxZg5RO4wmf8q

Vietnamese version

https://illinoisstate.az1.qualtrics.com/jfe/form/SV_0VDxZg5RO4wmf8q?Q_Language=VI

If you have any questions concerning this research study, please contact me at pknguy1@ilstu.edu. Thank you so much for your participation.

Sincerely,

Kim Phung Nguyen