

**EXPLORING THE ROLE OF DEPLOYER IN TRUST
MODELS FOR HUMAN ROBOT COLLABORATION: A
CASE STUDY AT TURKEY FMCG INDUSTRY**

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**by
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To my family for their unwavering support through this study and all of life's chaos.



DECLARATION OF ORIGINALITY

I hereby declare that I am the sole author of this thesis and that this is the true copy of my thesis, including the final revisions, approved by my thesis committee. All data and information have been obtained, produced, and presented in accordance with the rules of research ethics and principles of academic honesty. As required by these rules, to the best of my knowledge I have acknowledged ideas, thoughts, and any copyrighted material in accordance with the standard referencing rules. I certify that any part of this thesis has not been submitted for a degree or diploma in another educational institution.

Şirin Aktaş

ABSTRACT

Thanks to technology, robots are now widely used in many industries and can perform an increasing number of tasks. While the use of robots can improve product development and delivery speed, the biggest concern lies in trust and safety in human-robot interaction. Human-Robot Interaction (HRI) is a new field focused on designing, mastering, and evaluating collaboration between humans and robots. Despite a broad and rigorous literature in this field, trust in human-robot collaboration can be below expectations due to a lack of focus on creating effective and collaborative environments. The purpose of this research is to gain a deeper understanding of the dynamics of trust in human-robot collaboration and to demonstrate that it is possible to add new actors and factors to the trust model identified through literature reviews. Ensuring the validity and applicability of the trust model is crucial for its successful implementation across different contexts and industries. Using the "Trust Model Adjusted with Actors and Factors" proposed in this research, it is possible to analyze different environmental conditions and develop recommendations. The approach used in a case study in the Fast-Moving Consumer Goods (FMCG) sector, which defines and determines the roles of a previously non-existent actor named "Deployer/Developer" in the trust chain, is believed to encourage collaboration and technological innovation in many industries by adapting to different environments. Validating and applying this trust model across various scenarios ensures that it remains robust and effective, fostering trust and enhancing human-robot collaboration.

Keywords: Human robot interaction, human robot trust, trust models, trust in robots, Fast Moving Consumer Goods (FMCG)

ÖZET

Teknoloji sayesinde robotlar artık birçok endüstride yaygın olarak kullanılmakta ve giderek daha fazla görevi yerine getirebilmektedir. Robotların kullanımı ürün geliştirme ve teslimat hızını artırabilse de en büyük endişe insan-robot etkileşiminde güven ve güvenlik konularında yatmaktadır. İnsan-Robot Etkileşimi (HRI), insanlar ve robotlar arasındaki işbirliğini tasarlamaya, yönetmeye ve değerlendirmeye odaklanan yeni bir alandır. Bu alandaki geniş ve titiz literatüre rağmen, insan-robot işbirliğinde güven, etkili ve işbirlikçi ortamlar yaratmaya odaklanılmadığı için beklentilerin altında kalabilir. Bu araştırmanın amacı, insan-robot işbirliğinde güven dinamiklerini daha derinlemesine anlamak ve literatür taraması yoluyla belirlenen güven modeline yeni aktörler ve faktörler eklemenin mümkün olup olmadığını keşfetmektir. Güven modelinin geçerliliği ve uygulanabilirliğinin sağlanması, farklı bağlamlar ve endüstrilerde başarılı bir şekilde uygulanması için çok önemlidir. Bu çalışmada önerilen "Aktörler ve Faktörlerle Ayarlanmış Güven Modeli" kullanılarak farklı çevresel koşullar analiz edilebilir ve öneriler geliştirilebilir. Hızlı Tüketim Malları (FMCG) sektöründe yapılan bir vaka çalışmasında kullanılan yaklaşım, güven zincirinde daha önce var olmayan "Deployer/Developer" adlı bir aktörün rollerini tanımlamakta ve belirlemektedir. Bu yaklaşımın, farklı ortamlara uyum sağlayarak birçok endüstride işbirliğini ve teknolojik yeniliği teşvik edeceğine inanılmaktadır. Bu güven modelinin çeşitli senaryolarda doğrulanması ve uygulanması, modelin sağlam ve etkili kalmasını sağlayarak insan-robot işbirliğini geliştirmektedir.

Anahtar Kelimeler: İnsan robot etkileşimi, insan robot güveni, güven modelleri, robotlarda güven, Hızlı Tüketim Malları

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LIST OF ACRONYMS AND ABBREVIATIONS

FMCG:	Fast Moving Consumer Goods
HRI:	Human Robot Interaction
cHRI:	Cognitive Human Robot Interaction
pHRI:	Physical Human Robot Interaction
IFR:	International Federation of Robotics
ISO:	International Organization for Standardization
ANT:	Actor-Network Theory
Cobot:	Collaborative Robot
FDM:	Fuzzy Delphi Method
IT/OT:	Information Technology/Operation Technology Engineer
OPP:	Obligatory Passage Point
TCC:	Trust Calibration Cues
KPI:	Key Performance Indicators
IEN:	Industrial Engineering News
HR:	Human Resources
OLS:	Ordinary Least Squares regression
HLM:	Hierarchical Linear Modeling

1. INTRODUCTION

Historically, robots have been perceived as tools designed to replace humans in dangerous but necessary roles, such as search and rescue in disaster situations, military operations, and hostage situations. However, with technological advancements in recent years, the application areas and capabilities of robots have significantly expanded (Choudhury et al., 2024).

Similar to the evolution of computers, modern robots have become economically more accessible, offering higher quality work. Over time, the tasks of robots have shifted from being used as independent "tools" to collaborative "team members" in many industries, increasing the importance of working with and alongside robots. Robots now assist professionals in various fields such as healthcare, law enforcement, manufacturing, and agriculture. Despite the increase in the number and potential of environments where humans and robots collaborate, millions of people are unprepared or untrained for such interactions (Fallett & Jonathon, 2014).

Human-Robot Interaction (HRI) is a rapidly developing field that aims to enhance human capabilities and ensure safe, effective interactions by examining how humans and robots communicate and share tasks in shared environments (Murphy et al., 2010; Yanco & Drury, 2002). Collaborative robots, or COBOTs, are specifically designed to work alongside humans, combining the precision, speed, and consistency of robots with the adaptability and decision-making ability of humans (Odważny et al., 2018). Despite being designed so competently, humans and Cobots must learn to interact in ways that complement each other's abilities. Without this, building trust and collaboration is difficult. Studies on trust in automation emphasize the importance of

reliability and transparency in increasing human trust in robots (Maurtua et al., 2017). Many models have been developed to measure and enhance the interaction between human expectations, robot behavior, and the context in which these interactions occur (Hancock et al., 2019; Lewis et al., 2018). These models emphasize adjusting trust levels to prevent over-trust or under-trust (Khavas et al., 2021).

Despite all these studies, trust - both in terms of safety and reliability - remains a significant challenge in situations where humans and robots collaborate. While existing trust models provide valuable insights, they often focus on closed-loop interactions between humans and robots, with limited consideration of external factors or actors that affect collaboration. This research aims to expand traditional trust models by exploring new actors that configure and sustain robotic systems. The fear of automation replacing existing roles and tasks continues, leading to concerns about employment; however, according to the International Federation of Robotics (IFR, 2017), the biggest threat to employment is not automation itself but the lack of competitiveness. This definition fits the Fast-Moving Consumer Goods (FMCG) industry, which includes packaged foods, beverages, convenience foods, toiletries, candies, cosmetics, over-the-counter drugs, dry goods, and other consumables sold quickly and at relatively low cost. According to the IFR 2022 Report, robots have reached a position where they can increase competitiveness by speeding up product development and delivery. Through a Case Study in the FMCG sector, this research aims to address the complexity of trust dynamics in human-robot collaboration environments and demonstrate how trust can be adjusted. The findings from this study will support businesses in maintaining competitiveness, modernizing supply chains, and creating new collaboration opportunities between humans and machines when robots are effectively integrated.

1.1 Literature Review

In this section, we present a comprehensive review of the existing literature in three distinct areas relevant to our study: Human-Robot Interaction (HRI), Safety and Trust in HRI, and Methodology for an HRI research. Each area has been thoroughly examined to provide a solid foundation for understanding the dynamics of trust in human-robot collaboration and to identify key factors that influence this interaction.

1.1.1 Literature Review for HRI

Human-robot interaction (HRI) is an extensive and diverse research topic that has been gaining importance in last years. Different fields of study have used HRI approaches for solving complicated problems, where humans and robots interact in some way to obtain advantages from their collaboration (Vasconeza et al., 2017). Human-robot interaction (HRI) is an emerging research field focused on the study of physical (pHRI) and cognitive (cHRI) interaction among people and robots, which can extend and improve human capabilities and skills. It is focused on designing, understanding, and evaluating the interaction between humans and robots that can communicate and/or share physical space (Murphy et al., 2010; Yanco & Drury, 2002). The design of human-robot interaction strategies has been a challenging problem, partly because of the human complexity and the large number of different interactions that can be presented. Many approaches have been studied for different applications, such as: humanoids (Kanda et al., 2008), vehicle navigation (Mead & Mataric, 2017), rescue robots (Murphy, 2004), assistant robots (Robins et al., 2005), and collaborative task robots (Kosuge & Hirata, 2004). HRI is a relatively new field that is still under development, and many of its guidelines and design considerations might depend on the context (Cavallaro et al., 2013).

HRI can be classified into human-robot coexistence, human-robot cooperation, and human-robot collaboration. If there is a common workspace for both entities and they act at the same time, the HRI can be labeled as a human-robot coexistence. In addition, humans and robots are working on the same goal in a human-robot cooperation. Should direct contact occur, the interaction can be labeled as a human-robot collaboration (Schmidtler et al., 2015). HRI design frameworks should help optimizing working conditions by adapting collaborative robotics solutions in terms of human acceptance and well-being.

Robots are starting to work side by side with people and present profound new challenges for **interaction, emotion, culture, and technology frameworks**. In the dictionary, collaboration is defined as “the action of working with someone to produce or create something.” Robots can only collaborate with us if they are designed for that purpose with safety, communication and social skills in mind. Previously, highly trained technicians and programmers were the only ones allowed to interact with robots that cost hundreds of thousands of dollars. Even technically savvy people were not allowed near the robots when they were running, and safety regulations required the robots to be caged off. New technology is enabling robots to be safer, cheaper, and to work in a wider variety of environments performing new tasks. They are helping doctors, police, fireman, farmers, factory workers, disabled patients, soldiers, cleaners, and warehouse employees. The huge increase in deployed robots means they will interact with millions of untrained and unprepared people (Fallett & Jonathon, 2014).

1.1.2 Literature Review for Safety and Trust in HRI

Robots are having an important growing role in human social life, which requires them to be able to behave appropriately to the context of interaction so as to create a successful long-term human-robot relationship.

A major challenge in developing intelligent systems, which could enhance the interactive abilities of robots, is defining a robust model for “health and safety”. From the literature review, we recognized that safety was considered the key requirement for succeeding in the introduction of the human–robot collaborative paradigm, followed by usability, flexibility and efficiency (Maurtua et al., 2017). We believe that a closer look at safety properties for a typical HRI process has been modeled and worth to understand due to the reason that an attack on or a failure of a robot may affect negatively the human companion or co-worker (Giuseppe & Lamprecht, 2017).

In terms of physicals human-robot interaction (pHRI), we found out that awareness, fault tolerance, and explicit communication are the three areas of the robotic safety framework that will replace the need for cages. Despite the high performance demonstrated in research-oriented environments, few of these technical methods and scientific results have been transferred so far to real manufacturing applications. The foremost reason of the difficulty of transferring solutions that work in the lab to industrial settings is the need to comply with strict safety requirements, notably the robot standards.

According to International Organization for Standardization (aka ISO), there are four key standards that apply to Robots and Cobots and it is important to check that suppliers are complying to these standards:

- ISO 10218-1 Robots and robotic devices — Safety requirements for industrial robots Part 1: Robots: This applies to the partially complete machines so compliance to this standard alone is not enough.
- ISO 10218-2 Robots and robotic devices — Safety requirements for industrial robots Part 2: Robot systems and integration: The system integrator must be asked to comply with this standard.
- ISO/TS 15066:2016 – Safety of Collaborative Robots: This is a technical specification which specifies safety requirements for collaborative industrial robot systems and the work environment and supplements the requirements and guidance on collaborative industrial robot operation given in ISO 10218-1 and ISO 10218-2.
- ISO 13849 -1 – Safety of machinery — Safety-related parts of control systems Part 1: General principles for design: Performance level ‘‘d’’, Category 3

In terms of cognitive Human-Robot Interaction (cHRI), the cognitive process is a list of tasks which human, robot and their joint actions are considered end to end to accomplish a task or goal. Core research activities in this area include the development of representations and actions that allow robots to participate in joint activities with people; a deeper understanding of human expectations and cognitive responses to robot actions; and, models of joint activity for human–robot interaction (Mutlu et al., 2016). The key research activity in cHRI field is the development of frameworks to represent human (Trafton et al., 2006; Fong et al., 2006; Bueno et al., 2008).

From the cognitive side, it is very important to consider the primary role of users’ trust during HRI. In the automation literature, cognitive (rather than affective) processes

may play a dominant role in the determination of trustworthiness, i.e., the extent to which automation is expected to do the task that it was designed to do.

In the trust in automation literature, it has been argued that trust is best conceptualized as an attitude and a relatively well accepted definition of trust is: “...an attitude which includes the belief that the collaborator will perform as expected, and can, within the limits of the designer’s intentions, be relied on to achieve the design goals” (Lewis et al., 2018).

Most of the research in trust in automation has focused on the relation between automation reliability and operator usage, often without measuring the intervening variable, trust. The utility of introducing an intervening variable between automation performance and operator usage, however, lies in the ability to make more precise or accurate predictions with the intervening variable than without it. This requires that trust in automation be influenced by factors in addition to automation reliability/performance.

In human interaction with automation, it has been observed that the human may fail to use the system when it would be advantageous to do so. This has been called disuse (underutilization or under-reliance) of the automation (Parasuraman & Riley, 1997). As a result, misuse, disuse or abuse can decrease automation benefits and lead to accidents. As robots have been gaining importance in last years at FMCG industry, trust in these robots becomes a crucial issue, and work area to understand current status, and challenges.

To measure and assess how humans exercise trust, mistrust, distrust, and skepticism in nascent autonomy, we have seen a series of research studies specifically concerning human–robot interaction (HRI). Under the overall zeitgeist of moving robots

from “tools to team-mates,” many factors affect implicitly and explicitly the forms of trust (Hancock et al., 2019).

Trust is a fundamental characteristic of any work relationship and one of the most frequently studied constructs in organizational research today (de Jong et al., 2017; Fulmer & Gelfand, 2012). It is imperative to gain an understanding on what trust means in general and how trust in robots can be conceptualized for different industries, how it influences operator reliance and use of automation, and overall human-robot interaction efficiency.

Trust is a concept that received attention from several of the social sciences – psychology, sociology, political science, economics, anthropology, history and sociobiology (Gambetta, 1988). As can be expected each field has approached the problem with different lens and filters.

In the article “The Meanings of Trust”, authors McKnight and Chervany (1996) managed to facilitate cumulative research, and that turned on the lights on the concern regarding researchers collective lack of consensus about trust’s meaning and conceptualization. In this article, we see different views on the trust meaning:

- "confusing potpourri," (Shapiro, 1987a, p. 625),
- "conceptual confusion" (Lewis & Weigert, 1985a, p. 975),
- “conceptual morass” (Barber, 1983; Carnevale & Wechsler, 1992, p. 473)
- “elusive” concept” (Gambetta, 1988, p. ix; Yamagishi & Yamagishi, 1994, p. 130).

The authors examine the conceptual propagation of trust and detect the similar confusion by individual researchers: “while sociologists tend to see trust as structural in nature (e.g., Garfinkel, 1967; Lewis & Weigert, 1985b; Shapiro, 1987a), some

psychologists have viewed trust as a personal attribute (e.g., Erikson, 1968; Rotter, 1967). Social psychologists are more likely to view trust as an interpersonal phenomenon (e.g., Deutsch, 1973; Holmes, 1991). Economists are more inclined to view trust as a rational choice mechanism (see Williamson, 1993).”

These kind of narrow definitions and individual commentaries raise the need of the broader research: “working the theoretical part but supporting them with empirical results of Trust Definitions & Conceptualization” That is why, in this research study, we would like to start with understanding the nature of trust and trust models. To broaden the area of our interest, we will focus on social concept of the trust. Our scholarly interest will be about “intra-team trust”, since our empirical design in this research will be applied to a corporate organization where human and robots will build up the “team” and work in “collaboration”.

A multilevel study by Kassa and Abere (2018) shows us intra-team trust enhances employee satisfaction, overall performance, and work engagement and collaboration. Working with a data set from a major bank Kassa realized that intrateam trust is positively related to:

1. team members’ individual job performance, job satisfaction, and collaboration.
2. overall team performance, team satisfaction, and team collaboration
3. unit-level performance

In the corporate life, humans learned to cooperate and collaborate in many ways and on different tasks to achieve the shared goals. This teamwork includes communication, conflict resolution, rapport-building and listening, problem-solving, planning, delegating, helping, relying on each other etc. Although those are the foundational aspects of human-to-human teamwork, we started to see the evolution of

cooperative models' diverse constructs of various kinds (e.g., purely interactional, technical-legal, organizational, socio-cognitive, etc.), have been opportunely introduced or spontaneously emerged to support decision making in collaborative situations (Falcone et al., 2001).

Hence, we need to disrupt the traditional trust constructs and consider the new socio-cognitive construct in the general frame of human-robot teamwork. As trust building is the key factor for collaboration and teamwork, it will be necessary to understand the nature of trust in automation and examine the relationship between aggregate expressions of trust and Cobots. If we can find a model regarding trust in automation this will contribute into many industries where HRI is applicable.

1.1.3 Literature Review for Trust Models

Our goal is to **explore and synthesize existing theoretical frameworks, models, and conceptual discussions** on trust. We aim to understand the **breadth and evolution** of trust models across contexts.

As robots become increasingly integrated into domains such as domestic life (Salem et al., 2015), industrial operations (Graetz & Michaels, 2018), and military contexts (De Visser & Parasuraman, 2011; Hancock et al., 2011), trust in Human-Robot Interaction (HRI) has emerged as a critical factor influencing system effectiveness, safety, and user acceptance.

The degree of the usage is tightly related with the trust modelling and calibration. (Lewis et al., 2018; Parasuraman & Riley, 1997). If trust level is excessive, then it results with apathy, insufficient trust leads to carelessness (Kessler et al., 2017; Lee & See, 2004; Ososky et al., 2013). In order to increase working conditions, Trust modeling and calibration are essential to ensure appropriate reliance on robotic systems—avoiding both

overtrust, which can lead to complacency, and undertrust, which can result in disuse (Lee & See, 2004; Kessler et al., 2017).

Other computational models have also contributed to the field. For instance, Xu and Dudek's OPTIMo (Online Probabilistic Trust Inference Model) integrates causal reasoning and evidential data to infer trust in real-time (Xu & Dudek, 2015), while the trust-POMDP model by Chen et al. (2018) enables robots to systematically infer and influence human trust for fluid collaboration. These models highlight the growing sophistication in trust modeling, particularly in supervisory and collaborative HRI contexts.

Trust models help us to understand the trust level and the performance of the work, and the interaction quality as there is a strong correlation between these factors. As we have seen in many domains, the interaction is no longer a co-existence or cooperation but collaboration. Xu and Dudek (2012) worked on a generic model that allows a robot under human supervision to infer the human's level of trust in it, based on their interactions. According to this computational study high levels of trust among human-robot teammates often demonstrate great collaboration so human can take better decisions and the great level of control of the robotic agent. On the contrary, a low level of trust can cause inefficient use of robotic agent: no delegation or disable. On such a supervisor-worker team model, there is a "trust module" designed by Xu and Dudek to adjust the human's reactive commands by altering the behaviors of the robot. These kinds of reactive interventions calibrate the robot's task performance together with reducing the human's task load. This model formulates "trust" as a function of the robot's success and failure in performing the defined task.

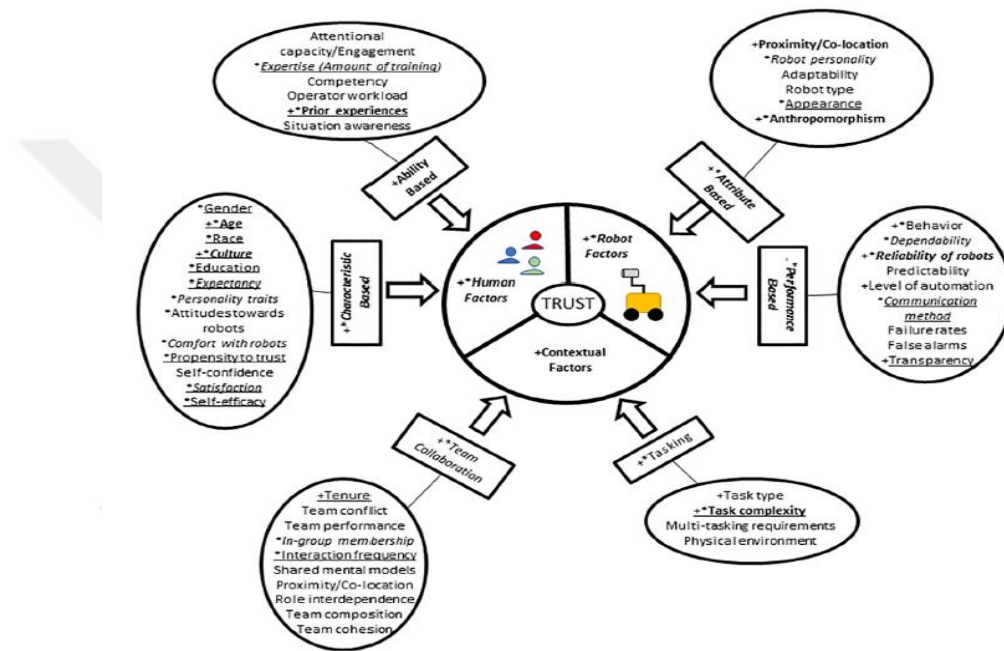
Xu and Dudek kept working on this area, and improved this model with more factors affecting trust in supervisory collaboration such as failure rate in the autonomous agent and the rate of supervisor intervention were involved in designing the trust model: Online Probabilistic Trust Inference Model (OPTIMo) for asymmetric human-robot teams (Xu & Dudek 2015). OPTIMo combines the two well-known modeling approaches: causal reasoning of the robot's trustworthiness as a result of a task performance, and evidential data to underpinning beliefs regarding the human's latent trust level. When compared with the previous models Auto-Regressive Moving Average Value (ARMAV) (Lee & Moray, 1994), dTrust (Xu & Dudek, 2013) and Area Under Trust Curve (AUTC) (Desai, 2012), OPTIMo can predict real-time trust assessments with better accuracies and at much better time spans.

Another computational study and real-time model of trust in human-robot collaboration is the trust-POMDP (partially observable Markov decision process) (Chen et al., 2018). When compared to OPTIMo, this model closes the loop between trust models and robot decision making. It enables the robot to infer and influence human trust systematically and to leverage trust for fluid collaboration. The trust-POMDP model provides a rule-making process for human-robot trust calibration.

Among the foundational works in this field, the meta-analytic framework developed by Hancock and colleagues (2020) stands out for its empirical depth and conceptual clarity (Figure 1.1). This meta-analysis examined all qualifying articles related with trust in robots from 2010 to 2019. With an extensive search on numerous databases, research team identified 1,113 identified articles in the first run. 48 articles remained for detailed review. Synthesizing findings from over a decade of research, the Hancock model categorizes trust antecedents into three primary domains: human-related, robot-

related, and context-related factors. The revised model builds upon the earlier 2011 version by incorporating dynamic and temporal dimensions of trust, as well as emphasizing the importance of team collaboration and environmental context in shaping trust perceptions.

Figure 1.1 *Revised Human-Robot Trust Model (Hancock et. al., 2020)*



Elaborating on Hancock study (Hancock et al., 2020), Khavas et al. (2021) reviewed and classified reviewed and classified the recent academic studies about the factors regarding trust the similar classifications. They came up with some updates in categories and subcategories. They excluded some factors as they were paid less attention on the recent studies. They also added new factors which were highlighted more in the recent studies. In their own study, a few factors are also classified under different categories when compared with Hancock (Figure 1.2).

Figure 1.2 *Factors Affecting Trust in HRI: Trust Model by Khavas et al. (2021)*

Category	Subcategory	
Robot-Related	Performance-Related	Dependability, reliability and error
Robot-Related	Performance-Related	Situation awareness, feedback and transparency
Robot-Related	Behavior-Related	Dialogues, Proximity
Robot-Related	Behavior-Related	Likeability and friendliness with humans
Robot-Related	Behavior-Related	Personality (harmony with task)
Robot-Related	Behavior-Related	Confess to reliability
Robot-Related	Behavior-Related	Apology for failure
Robot-Related	Behavior-Related	Engagement
Robot-Related	Appearance-Related	Similarity with operator
Robot-Related	Appearance-Related	Gender
Robot-Related	Appearance-Related	Harmony of appearance with task
Robot-Related	Appearance-Related	Anthropomorphism
Human-Related	Personality	
Human-Related	Culture	
Human-Related	Demographics	
Human-Related	Experience with robots	
Human-Related	Subjective feeling	
Task & Environment-Related	Nature of task	
Task & Environment-Related	Physical presence of robot in task site	
Task & Environment-Related	In-group membership	
Task & Environment-Related	Task site	
Task & Environment-Related	revocability	
Task & Environment-Related	rationality	
Task & Environment-Related	workload complexity and required level of multi-tasking	

Regardless of the performance issue in human-robot interaction, the trust calibration should be effectively applied to adjust trust levels and estimate the future trust level. According to Khavas et al. (2021) Trust Calibration Cues (TCCs) can be used to shift trust in the right direction they are designed. TCCs can be verbal, visual, audible, physical or a combination of any of these factors. TCC experiments proved that the feedback that the robot provided corresponded with the desired change in trust level. Despite the good performance with the robot, we can diminish the trust with TCCs. Besides, when we repair trust, then there is an increase in the trust level even with low performance with the robot.

During a typical team collaboration scenario with human and robot, human have more advanced capabilities to take decisions on a shared task to increase the effectiveness of the automation. When we have more advanced decision support systems with complex algorithms, it gets difficult for operators to do adjustments by providing trust cues so that the perceived trustworthiness of a system matches its actual trustworthiness, so the the shared goal with human and robot will be achieved at the maximum performance level. **Trust Module, OPTIMO, tPOMDP, TCCs** are the course enablers to calibrate the trust, but also, we need to have a model to identify information that can lead to specific design of trust cues. With this in mind, de Visser et al. (2014) worked on a taxonomy of **Trust Calibration Cues (TCCs)**. They show-cased that providing more contextual information to the human operator about the automation can lead to calibrated trust. For example, visual cues to diagnose the actual trustworthiness of the system by showing the risk and uncertainty of the associated information can support increased understanding of the automation. Therefore, the system can provide trustworthiness cues to the operator directly so that operator can calibrate the trust almost real-time.

Starting from the Hancock study (Hancock et. al., 2020), most of the recent academic studies consider the contextual, task and environment related factors to assess and calibrate trust (Lee & See, 2004). Even though this was emphasized by Lee and See and many more, it was limited with the training of the human about the deployed system and the trust calibration in a closed loop between human and robot. However, there are some external agents like developer, designer or vendor of the specific for HRI might effect on the relation (Cameron & Collins, 2021).

Cameron and Collins (2021) proposed a triadic model of trust that includes the deployer—such as designers, developers, or vendors—as a third actor in the trust

relationship. This model outlines a network of interactions between the human (U), the robot (R), and the deployer (D), emphasizing the role of external agents in shaping trust through design, training, and feedback mechanisms.

In the social triad of trust relation by Cameron and Collins, there are interactions between human, robot and deployer:

- interaction from Deployer (D) to Robot (R) includes the production of robot behavior, specifying goals for the robot, or developing architectures to generate behavior, programing, setting and monitoring KPIs (Key Performance Indicators),
- interaction from Deployer (D) to Human (U) includes the designing the context of the relation, providing the HRI, training, continuous improvement of the design
- interaction from Human (U) to Deployer (D) includes the feedback, the questions, the issues,
- interaction from Robot (R) to Deployer (D) includes the alerts and notifications about the failures, the data regarding the KPIs, the logs regarding trust calibrations
- interaction from Human (U) to Deployer (D) includes the operations, the trust calibration cue design, real-time calibrations

1.1.4 Literature Review for Methodology

This research aims to explore and develop approaches to HRI strategies and Trust Models and apply them to the FMCG industry. The goal of this research is to identify the elements or conditions that lead to interaction and collaboration within the framework of FMCG and to seek explanations for the observed phenomena of "trust."

Human-robot interaction encompasses not only robot technology but also the social factors involved in building trust in humans. Therefore, different approaches within the framework of socio-technical theories have been examined.

The main contributors to socio-technical theories are Bruno Latour, Madeleine Akrich, and Michel Callon (Akrich et al., 1988). Actor-Network Theory (ANT) was introduced us by Centre de Sociologie de l'Innovation (CSI) of the École nationale supérieure des mines de Paris in the early 1980s. Michel Callon and Bruno Latour and visitors John Law were the first to share their theories within STS (Science and Technology Studies) community (Muniesa, 2015).

To start with, it was thought as a good method to understand large technological system, the innovation and knowledge-production process regarding these systems by building on the existing STS studies. ANT might be called as social theory focusing on techno-science, rather than only a theory for techno-science. On the other hand, the actors included in the networks where ANT applied might be both human and non-human without a difference applying the methodology. ANT behaves the same both human and non-human to understand their interest that make them to act, and bound with each other in the same network accommodating, managing, and using all in the same manner.

In the modern world, technology reshapes our social and physical world, ecosystems we are living in, and our business models. While ANT (Latour, 1993) explaining the idea of modernity, he stated that technology is integral to understand the society. Human “nature” is not very dependent to technology. People developed and shaped the technology, but now technologies are reshaping the field of agency, controls our “nature”, because we are delegating the agency to technology artifacts. We are now inter-connected, living in a complex and heterogeneous network. Science and technology implicitly and explicitly create more situations in which humans and non-humans impact each other. Therefore, the real focus of Actor-Network Theory is describing the development of a network of allied interests come together and act as a whole. Either

human or non-human actors work in coherence, and all agree that the network should be built and defended.

ANT is easy to use theory to make analysis, to comprehend the dynamics of a network with its flexible heuristic nature which makes it possible to use for extensive number cases. ANT focuses on the entities included in the material realm, and research for the issues within the materiality of relations with its linkages. Even though it is called as a "theory", ANT does not usually explain the reasons why that network takes the form. It is also a methodology or like a “how-to book” as Latour explains. ANT has many useful concepts like actor, network, enrolment, translation, mobility, black box for the researcher use to explore a network deeply. Hence, a researcher can perform an empirical study using ANT by documenting all actors, translation process, mobilization, and the black-box creation to understand how that network operates:

- **Problematization:** The focal actor defines the problem and identifies itself as essential to the solution. It establishes the Obligatory Passage Point (OPP)—a critical path that all other actors must pass through to achieve their goals.
- **Interessement:** The focal actor attempts to stabilize the identities and roles of other actors by aligning their interests with the network’s goals, reinforcing the OPP.
- **Enrollment:** Other actors accept the roles defined for them and agree to the proposed network structure, committing to pass through the OPP.
- **Mobilization:** The network is consolidated as spokespersons represent the interests of broader groups, ensuring that the network functions cohesively through the established OPP.

A review of the literature revealed limited or no research focusing on HRC from a socio-technical perspective. This study aims to adapt Akrich's approach to examine how

the design of robots and their usage scenarios affect trust and collaboration among team members. Additionally, following Callon's perspective on ANT, it was also aimed to understand how different stakeholders (e.g., robot designers, users, and managers) align their goals and expectations to build trust. During background studies, we could not find specific articles on human-robot interaction from a socio-technical perspective.

During this research, past studies on "Trust" and "Safety" and the research methods used to understand the phenomenon of "Trust in Automation" were examined. It was observed that factors such as the nature of the study (qualitative or quantitative), the expertise of the researcher, and the applicability of the chosen method to the research field influenced the selection of the research method. For example, Kassa and Abere (2018) used quantitative methods to analyze how intra-team and inter-team trust affects organizational performance, satisfaction, and commitment. Khavas et al. (2020) conducted a qualitative survey and meta-analysis to propose a trust model for HRI and identify future challenges and research directions. Xu and Khavas (2015) introduced OPTIMo, a quantitative trust model that combines causal reasoning and evidential factor analysis to evaluate reliability and user trust levels in asymmetric human-robot collaboration. Xu and Dudek (2013) and Chen et al. (2018) presented quantitative experiments on trust-focused interactive visual navigation and planning for human-robot collaboration. Khavas et al. (2021), Okamura and Yamada (2020), and Visser et al. (2014) used quantitative methods to investigate Trust Calibration and Cue design (TCC) for cognitive agents such as robots and unmanned aerial vehicles and their impact on human perception and team cohesion. When considering the FMCG industry as the research area, the complexity of human-Cobot interaction encompasses not only technical aspects but also psychological and social dimensions due to the complex and multifaceted nature of

trust in such environments. The literature suggests that "qualitative methods" are suitable for capturing nuanced concepts, diverse perspectives, individual experiences, and subjective judgments involved in the development and functioning of trust. Qualitative research provides in-depth exploration of these elements through methods such as interviews, focus groups, and ethnographic studies, offering rich, contextual insights that quantitative data often cannot provide (Rauch 2020; Rauch et al., 201). Additionally, qualitative research is flexible and sensitive to the context in which it is conducted, making it ideal for uncovering the fundamental mechanisms of trust, including tacit knowledge, emotional components, and the development of trust over time in the FMCG workshop environment.

1.2 Primary Concept/Theory

1.2.1 Research Questions

The subject of this study focuses on the possibilities to expand HRI strategies and Trust Models to be applied in industry by understanding the role of deployer from Actor Network Theory viewpoint.

Therefore, the research questions are:

- From a socio-technical perspective, is it possible to expand trust models in human-robot collaboration for FMCG with new actors and factors?
- How can we explore new actors and factors in HRI for FMCG in production area of factories in the frame of Actor Network Theory?
- If the results of exploration and validation give satisfactory results, will it be possible to say, Case Study method can improve trust and safety issues for varying industrial sectors?

1.2.2 The Hypothesis

As robots have been gaining importance in last years at FMCG industry (Odważny et al., 2018), trust in these robots becomes a crucial issue, and work area to understand current status, and challenges. Like every machine, collaborative robots are most effective when you use their potential to work with the actors onto a few certain topics to be a team, however misuse, disuse or abuse can decrease automation benefits and lead to accidents. Furthermore, we have seen with the preliminary study and background research that there are limitations of trust in robotics for FMCG.

In parallel with the research questions indicated above, this study claims to expand traditional trust models by exploring new actors that configure and sustain robotic systems) by applying Trust Models to FMCG industry (in terms of Human Robot collaboration in production area of factories in the frame of Actor Network Theory.

On a much more general level, the outcomes of this research can encourage similar researches to be applied to varying industries to investigate their production models to yield sustainable processes. With the outcomes, benefits for production processes for the FMCG companies can be improved and meet industry demands, so the companies may remain competitive.

1.2 Aims and Objectives

The subject of this research is to understand the dynamics of trust in human-robot collaboration from a sociological point of view and to develop the reference trust model by adding new actors and factors to create effective and collaborative production environments in factories. This research explores the possibility of Trust Models to be expanded /improved/ adapted for FMCG industry concerning robot human collaboration in the light of Actor Network Theory.

On a methodological level, this research aims to address the need for broader research on definitions and conceptualizations of trust in automation and to support this goal with empirical results using a "Multi-Method Strategy". Due to research area being complex and broad, some limitations are placed in the research as given below:

- a. We started the research by building a preliminary study to explore the potential of this topic as a research subject. Within the preliminary study, we have seen that many actors involved into the network creates the knowledge around Cobots to increase its accuracy level, speed, repeatability, safety and level of collaboration. While this network is advancing on what their actors want to achieve, the Cobots are still in the fences, and also the number and utilization of those Cobots are still low because of Trust issues. Because of this among 3 aspects of HRI (coexistence cooperation collaboration), we limited this research to exploring strategies regarding human robot collaboration.
- b. After the preliminary study and accomplishing background information regarding trust in robots, we have seen that the further study can be developed to understand and investigate the different trust factors that represent team collaboration between the Cobot and the human. So, in order to limit the area of interest more, the focus was on the social concept of trust. Since the empirical design in this research is applied to an organizational setting where humans and robots form a "team" and work in "collaboration," the academic interest is on "intra-team trust".
- c. While all industrial areas with factories make use of COBOTs, this study considered FMCG industry as the application area, due to its product size, importance in competing in the market and availability of robots. Therefore, this study is limited as

research on FMCG industry shop floor area, mainly for Unilever factory, to understand the possibility of expanding the literature on trust and safety in CObots,

- d. Last but not least, the obligatory passage point for this network on the preliminary study was “to work together to increase the operational effectiveness while working with Cobots”. With this ANT analysis, we have also seen designer and/or developer (deployer) are part of the entities, and the role of deployer should not be underestimated. We have seen that there are very limited studies regarding trust in robots for FMCG and the role of deployer in the trust model where human & robot involved, especially from the lens of science technology and society theories. Deployer was introduced as the new actor and the factors related with deployer were examined, which created the third limitation for this research.

2. METHOD

2.1 Research Phases

Within the scope and purpose of this research, the possibilities of expanding and thus strengthening the framework of trust and safety in human-robot collaboration (Cobot) with different actors and factors have been explored. As indicated in the previous chapter, socio-technical perspective was benefited in this research.

Using the Multi-Method Data collection approach, it was desired to obtain more comprehensive and in-depth information, and the "Qualitative research method," which has long been used in social sciences to produce knowledge and to better understand the behaviors, motivations, and interactions of individuals and groups, was preferred.

To support the qualitative method, a socio-technical perspective was used in this research. Socio-technical theory suggests that the design and performance of organizational systems can be comprehensively understood and optimized when the 'social' and 'technical' dimensions are integrated and considered as interdependent components. This socio-technical research was designed with a qualitative method, and a Case Study was planned to examine a specific industry in depth. Throughout the research, different methods were used at different stages, and the Multi-Method Data Collection approach was preferred.

As the range of industries that use Cobots is large, this research employs Case Study methodology to explore how trust models can be adapted within the context of a leading FMCG company. The case study enables an in-depth examination of trust dynamics across internal and external stakeholders (Baxter & Jack, 2008). A case study is particularly well-suited for exploring trust models due to its ability to provide contextual depth, capturing how trust is built, maintained, or eroded within specific

organizational settings. This method is especially relevant in fast-moving consumer goods (FMCG) environments, where real-world dynamics and operational nuances significantly influence trust. Given the exploratory nature of our research—such as adapting trust models—a case study approach is ideal for uncovering insights and generating hypotheses. It allows us for a detailed investigation of contributing factors behind events or outcomes, offering both depth and practical relevance.

A typical case study follows these structured steps (Hassan, 2024):

1. **Define the Case and Objectives:** Identify the subject of the case study and clarify the research questions or hypotheses.
2. **Design the Research Framework:** Choose the type of case study (exploratory, explanatory, descriptive, etc.) and determine the data collection methods (qualitative, quantitative, or mixed).
3. **Collect Data:** Use interviews, observations, documents, and surveys to gather rich, contextual data.
4. **Analyze the Data:** Apply thematic, content, or statistical analysis depending on the nature of the data.
5. **Develop Findings and Interpretations:** Identify patterns, relationships, and insights that answer the research questions.
6. **Report the Results:** Present the case, analysis, and conclusions in a structured format, often including recommendations.
7. **Validate and Review:** Ensure reliability and validity through triangulation, peer review, or participant feedback.

Below you can see the steps of the research and the methods used at each stage (Table 2.1):

Table 2.1 *Research Steps*

0. Idea Stage	Define the Case and Objectives: Researching the Concepts of Trust and Safety through Literature Review	Literature Review
1. Preliminary Research	Define the Case and Objectives: Preliminary Research and Theory Development	ANT - Actor-Network Theory
	Define the Case and Objectives: Determining the Possibility of Introducing New Factors with Preliminary Research & ANT	ANT - Actor-Network Theory
	Design the Research Framework: Determining the Measurement System with Preliminary Research & ANT	ANT - Actor-Network Theory
	Design the Research Framework: Selecting the Reference Model	Literature Review
2. Conducting	Collect Data and Analyze the Data: Data Collection and Classification Based on the Determined Case	Cyclical Data Analysis
	Develop Findings and Interpretations & Report the Results: Analysis of Data Collected and Classified at Different Time Intervals and Reporting Based on Findings	Cyclical Data Analysis
4. Testing the Results	Validate and Review: Testing the Reliability and Validity of the Results	Fuzzy Delphi Method

During “*the idea and preliminary stages*” of our research, ANT (Actor Network Theory) used to “Define the Case and Objectives”, and avoid predefining categories, allowing the network to emerge from the data. ANT supported iterative refinement of our research focus as new actors and relationships are discovered.

This study employed a **cyclical data analysis** strategy on for Case Study “Conducting” i.e. “Collect Data”, “Analyze the Data”, and “Develop Findings and Interpretations”. Rather than following a linear path, the analysis was structured as a

series of feedback loops, allowing for continuous refinement of both the trust model and the actor-network map.

During “*Conducting Stage*”, data will be collected through semi-structured interviews, internal documentation, and observational insights. Thematic coding will be applied to identify emerging actor roles, trust factors, and mediating influences. Each cycle of analysis informed the next round of data collection, enabling:

- Refinement of actor definitions (e.g., emergence of the “Deployer” role)
- Adjustment of trust dimensions based on observed interactions
- Recalibration of survey instruments to reflect new insights

The findings will be analyzed using established trust frameworks, with the goal of refining these models to better suit the fast-paced, consumer-driven environment of FMCG firms.

In “Conducting Stage”, cyclical analysis will support:

- **Model validation** through repeated stakeholder feedback
- **Network expansion** as new actors and mediators to be introduced
- **Trust model adaptation** to reflect operational realities in the FMCG context

Each cycle involves revisiting earlier assumptions, re-mapping actor relationships, and updating the qualitative trust model accordingly. This approach culminates in the development of the “Actors and Factors Adjusted Trust Model,” which will be validated through multiple rounds of field testing and expert review.

Researchers should ensure the empirical basis, generalizability, and minimization of bias by mimicking the scientific method in the research design (Franklin et al., 2010). In research areas with a social nature, such as trust, researchers are advised to apply all

research steps and include the "validation" step to ensure the quality of qualitative research (Gilbert & Churchill, 1979).

In this research, the results were tested using the Churchill model in “*the Testing the Results stage*” (Churchill, 1979). This model is a methodological guide used to ensure that the research design, method, and results are clear and rigorous. By referencing the "Reliability and Validity" in this model, the **Fuzzy Delphi Method (FDM)** was used for the Evaluation of Existence, and the Likert Scale was used for the Evaluation of Importance to ensure that the research made a meaningful contribution to the field. FDM is a modified and improved version of the classical Delphi technique. Improvements were made to correct the flaws of the Traditional Delphi Method (DM) such as low convergence in obtaining results, loss of important information, and long research process. FDM is mostly used in the screening process by using fuzzy sets to represent the opinions of experts. However, this approach has been used in various application areas such as social sciences, management, business, physical sciences, and engineering (Amira et al., 2016).

As the first sub-step of validation, the "significance" of the findings in building the existing knowledge base was tried to be understood, and it was aimed to make a meaningful contribution to the field using the Likert scale. **The Likert scale** is a measurement method used in research to evaluate attitudes, opinions, and perceptions (Bhandari et al., 2023). Considering daily work routines, the factors that operators really consider important to feel trust and confidence while working with Cobot were examined.

As qualitative studies often struggle with the applicability of their findings to real-world scenarios, FDM provides a systematic approach to validate the content by quantifying expert agreement. This enhances the **reliability and applicability** of the

study, making it more robust and applicable to practical situation. In order to ensure that the models or frameworks proposed in the study are they are robust and applicable to practical situations, the factors were verified by FDM for the second time with a different company using Cobots.

All procedures involving human participants in this study were conducted in accordance with the ethical standards of the institutional research committee. According to the institutional procedure, ethical approval was obtained from the Ozyegin University Ethics Committee (Approval No: 2025/08/03). Participants were informed about the purpose of the study, their rights, and the voluntary nature of their involvement. Informed consent was obtained from all individual participants included in the study. The study design, including the use of surveys and interviews to assess trust dynamics in Human-Robot Interaction (HRI), was reviewed to ensure that it posed minimal risk to participants and maintained confidentiality and data protection standards.

2.2 Theory

2.2.1 Theoretical Framework

On the broader area of study regarding Trust in Robots, we have seen that there are different research methods used depending on the desired outcome (Table 2.2):

Table 2.2 *Research Regarding Trust in Automation and the Methods Used*

The Research	The Research Method
“The Effects of Intrateam and Interteam Trust on Organizational Outcomes: A Multilevel Study” (Kassa, Abere, 2018)	Quantitative: Used OLS regression analysis and hierarchical linear modeling (HLM) techniques
“Modeling Trust in Human-Robot Interaction: A Survey” (Khavas, Zahra Rezaei; Ahmadzadeh, S. Reza; Robinette, Paul, 2020)	Qualitative: Survey & Meta-analysis to find a model and present a list of potential directions for further research and some challenges that need to be addressed in future work on human-robot trust modeling
“Trust-driven interactive visual navigation for autonomous robots” (Xu, A., Dudek, G., 2012)	Quantitative: A quantitative measure that infers the human’s degree of trust in the robot’s autonomy, as well as an adaptation strategy for adjusting the robot’s autonomous behaviors to be in line with the human’s actions
“Optimo: Online probabilistic trust inference model for asymmetric human-robot collaborations” (Xu, A., Dudek, G, 2015)	Quantitative: OPTIMo combines the two main approaches used by existing trust models, namely through causal reasoning on updates to the robot’s trustworthiness given its task performance, and evidential factor analyses of each user’s actual degree of trust.
“Planning with trust for human-robot collaboration” (Chen, M., Nikolaidis, S., Soh, H., Hsu, D., Srinivasa, S, 2018)	Quantitative: A computational model for integrating human trust into robot decision making
“Trust-driven interactive visual navigation for autonomous robots” (Xu, A., Dudek, G, 2013)	Quantitative: Experimental set-up with “trust module” which reacts to the human’s intervening commands by changing the behaviors of “the robot’s planner module”.
“Trust Calibration and Trust Respect: A Method for Building Team Cohesion in Human Robot Teams” (Khavas, Zahra Rezaei; Perkins, Russell; Robinette, Paul, 2021)	Quantitative: An experiment set up for an online game conducted with participants from Mechanical Turk. Trust Calibration cues are used to change trust level in the set up.
“Calibrating Trust in Human-Drone Cooperative Navigation” (Okamura, K.; and Yamada, S., 2020)	Quantitative: Experimental model used Trust Calibration cues and measured the probabilities regarding the perception of reliability.
“A Design Methodology for Trust Cue Calibration in Cognitive Agents.” (de Visser, E.; Cohen, M.; Freedy, A.; and Parasuraman, R. 2014)	Quantitative: Experiment with visual cues to diagnose the actual trustworthiness of the system by showing the risk and uncertainty of the associated information can support increased understanding of the automation.
“Trust and Team Performance: A Meta-Analysis of Main Effects, Moderators, and Covariates” (Jong, Bart & Dirks, Kurt & Gillespie, Nicole., 2016)	Qualitative: Meta analytical method for the fundamental questions of whether intrateam trust is positively related to team performance

As we have seen on this table, depending on the type of study (either qualitative or quantitative), the discipline of the researcher, applicability of the method on the area of research, researchers chose very different type of methods to understand the Trust phenomenon in Automation. (Table 2.2)

Trust is deeply influenced by **context**, such as culture, environment, and personal experiences. Qualitative methods (like interviews or focus groups) allow researchers to explore these nuances in depth. Through thematic or content analysis, qualitative research can identify **emerging themes**—such as skepticism, reliance, or adaptation strategies—that may not be anticipated in advance. As we are developing or refining a trust model, qualitative insights can help **build or adapt theoretical frameworks** by grounding them in real-world experiences. Qualitative methods are well-suited for **exploratory research**, especially when the goal is to understand **how trust models evolve** in response to new technologies, policies, or social dynamics. Therefore, we would like to employ a qualitative study on our research topic.

Case Study is a qualitative research method for an in-depth investigation of a problem in one or more real-life settings (case sites) over an extended period of time. (Baxter, P., Jack, S.,2008) Data is collected using a combination of surveys, interviews, personal observations, and internal or external documents. Case Study undertakes the exploration through variety of lenses in order to reveal multiple facets of the phenomenon i.e. human related, robot related and contextual (Priya, 2020). Therefore, we can use Case Study for interpretive research at Unilever to be able to discover a wide variety of human related, robot related and contextual factors potentially related to the phenomenon of our interest that may not be known in advance, and also, we can explore and describe the new construct “deployer” in the frame of the other factors for FMCG.

Unilever was purposefully selected as the focal company for this Case Study due to its strategic alignment with the research objectives and its contextual richness in trust-related dynamics. The researchers selected Unilever as the case study subject based on a few considerations that aligned with their research goals. First, Unilever's active engagement in digital transformation—spanning automation, data-driven decision-making, and supply chain innovation—offered a highly relevant context for examining trust in Human-Robot Interaction (HRI), especially in evolving collaborative environments. Second, the researchers had privileged access and approval to internal stakeholders and operational data, enabling rich qualitative inquiry through interviews, document analysis, and observation. Lastly, while Unilever's global scale and unique organizational traits made it distinctive, its operations also reflected broader trends in the fast-moving consumer goods (FMCG) sector, making it both a unique and representative case. These factors collectively made Unilever the preferred choice for the researchers. In summary, Unilever selected for our Case Study to provide a rich, accessible, and strategically relevant environment for exploring the complexities of trust in digitally transforming FMCG settings.

2.2.2 Determining the Reference Model

The most important study on trust in robots is the model created by P. A. Hancock and his team, first in 2011 and then in 2020, using the meta-analysis method. In the 2011 meta-analysis, 29 studies were reviewed to identify and analyze the key factors affecting trust in human-robot interaction (HRI), and 10 studies that met the inclusion criteria for meta-analysis were selected. In the 2020 meta-analysis, Hancock and his team reviewed 132 studies, focusing on a wide range of human-machine interactions to develop a comprehensive model of trust in human-machine systems, including both automated

systems and robots. During this research, both Hancock's studies and various articles investigated during the literature review were reviewed using the meta-analysis method. As a result, the 2020 "Hancock Trust Model" was selected as a reference. This model addresses the concept of trust in a multidimensional way and includes different types of trust (cognitive, emotional, physical, etc.). Since this model itself is formed by combining the strengths of models obtained from different studies through meta-analysis, it offers more generalizable results. This increases the applicability of the model in different contexts. The model is designed for practical applications and is easy to implement in the FMCG case study.

On the other hand, in the early stages of our research, we conducted a Preliminary Study (2019) to explore the evolving dynamics of trust in Human-Robot Interaction (HRI), particularly focusing on the role of external agents—what Cameron and Collins (2021) later conceptualized as the “deployer.” This actor, often overlooked in traditional dyadic models of trust, includes designers, developers, and vendors who shape the context and behavior of robotic systems. Notably, both our study and that of Cameron and Collins independently identified this third actor, underscoring its critical role in shaping trust dynamics. Our earlier work in 2019 predates their formalization of the concept, demonstrating the originality and foresight of our approach. While the Collins Model is particularly useful for understanding how trust is shaped not only by direct human-robot interaction but also by the broader ecosystem of design and deployment, it remains in the early stages of empirical validation. However, while conceptually rich, the Collins model is still in its early stages of empirical validation and lacks the structured categorization and statistical grounding found in the Hancock model (Table 2.3).

Table 2.3 *Hancock Trust Model for HRI*

Robot Related			Human Related		Contextual Factors	
Performance Related	Attribute Based	Appearance Related	Ability Based	Characterize Based	Team Collaboration	Tasking
Dependability	Proximity/ Co-location	Appearance	Attentional Capacity/ Engagement	Gender	Tenure	Task Type
Reliability of Robots	Robot Personality	Anthropomorp hism	Expertise / Amount of Training	Age	Team Conflict	Task Complexity
Behavior	Adaptability		Competency	Race	In-group membership	Multi-tasking Requirements
Predictability	Robot Type		Operator Workload	Culture	Interaction Frequency	Physical Environment
Level of automation			Prior Experience	Education	Shared mental models	
Communication Method			Situation Awareness	Expectancy	Proximity/ co-location	
Failure Rates				Personality Traits	Role interdependence	
False Alarms				Attitude Towards Robots	Team Composition	
Transparency				Comfort with Robots	Team cohesion	
				Propensity to Trust		
				Self-confidence		
				Satisfaction		
				Self-Efficacy		

While we acknowledge the theoretical contributions of the Collins model—especially its emphasis on Trust Cue Design and the influence of external agents—we chose the Hancock model as the primary framework due to its empirical robustness, adaptability to our research context, and alignment with our methodological approach. The selected model demonstrates strong empirical rigor, as it is grounded in a comprehensive meta-analysis of 132 studies, providing a robust foundation of evidence. Its conceptual breadth is notable, integrating both static and dynamic factors, which makes it particularly suitable for our real-world Case Study, evolving Human-Robot Interaction (HRI) environments. Additionally, the model is highly relevant to team-based HRI contexts, as it explicitly addresses trust within multi-agent and collaborative team settings. These qualities align closely with our focus on intra-team trust and collaboration, making it a fitting choice for our research study.

3. CASE STUDY

In this socio-technical research that Case Study method used with within a three-step process of research was followed to test the hypothesis Idea & Preliminary, Conducting, and Testing the Results. Throughout these steps, multi-method was used to obtain more comprehensive and in-depth data about the "trust" phenomenon in human-robot collaboration, and the Reference Model was adapted to the case study. The steps taken to develop the Adjusted Trust Model are shown in the diagram below (Figure 3.1).

3.1 Idea & Preliminary

This stage involves organizing the research to be conducted and identifying the guiding steps. It consists of the following steps:

3.1.1 *Actors & Heterogeneity*

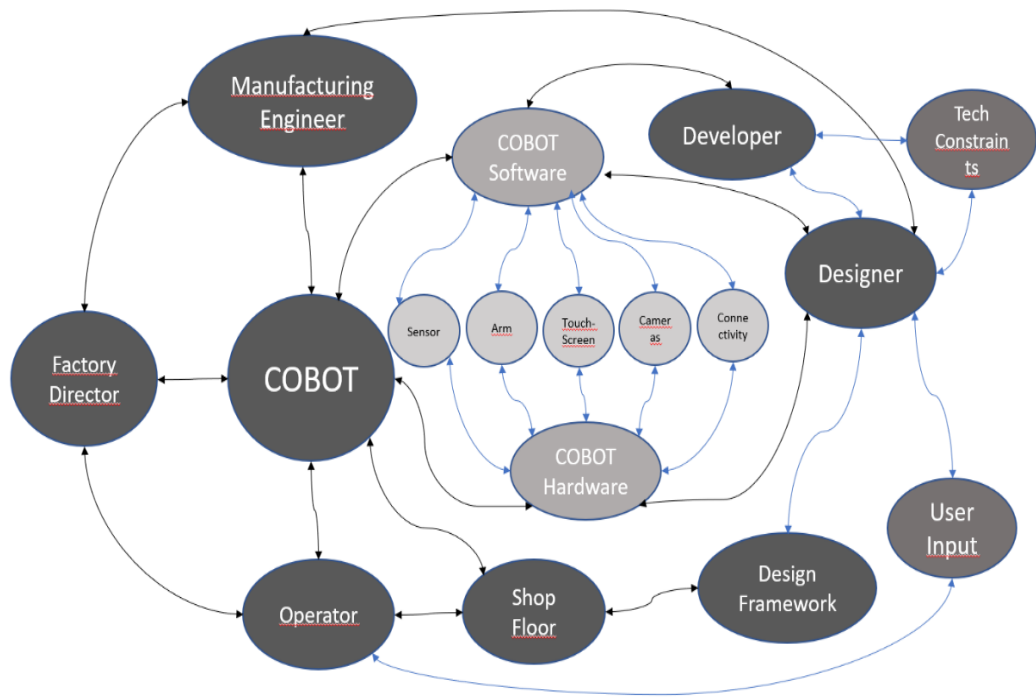
In principle, ANT is agnostic about the social and technological but the inherent characteristics of the actor of a network to build. There is always an equal way to understand both human and non-human actors. The theory has two aspects as being materialist and relationalist. Materialist aspect is useful while understanding the success and the failures of the facts and artifacts which is the result of the translation of actions, and interests for the alliance. Relational aspect refers to the results of analysis on how humans and non-humans are connected, and the features of the connections their own including goals, interest, obstacles.

Figure 3.1 *Model Development Stages*

Case Study Method											
Model Development Stages	Idea & Preliminary (Define the Case and Objectives)		Idea & Preliminary (Design the Research Framework)		Conducting (Data Collection, Analysis, Findings)				Conducting (Report the Results)	Testing The Results (Validate and Review)	
Purpose	Selection of actors to be evaluated	Identification of new factors	Determination of the analysis system	Data collection analysis to test the hypothesis	Data collection and analysis to test the hypothesis	Data collection and analysis to test the hypothesis	Data collection and analysis to test the hypothesis	Data collection and analysis to test the hypothesis	Development of the model based on all Coding & Thematic Analysis results	Testing the reliability and validity of the results	Testing the reliability and validity of the results
Data Collection Method	Survey	Survey	Qualitative/Quantitative Data Collection Methods	Observation	Document Analysis	Initial Interview	Survey	Second Interview	Reporting	Evaluation of Existence	Evaluation of Importance
Data Analysis Method	Actor-Network Theory	Actor-Network Theory	Cyclic Data Analysis is	Cyclic Data Analysis (Coding & Thematic Analysis)	Cyclic Data Analysis (Coding & Thematic Analysis)	Cyclic Data Analysis (Coding & Thematic Analysis)	Cyclic Data Analysis (Coding & Thematic Analysis)	Cyclic Data Analysis (Coding & Thematic Analysis)	Cyclic Data Analysis (Coding & Thematic Analysis)	Survey and FDM	Survey and Likert Scale
Conclusion	Addition of a new actor "Deployer" to the Reference Model	Identification that new factors can be added to the Reference Model	Selection of Cyclic Data Analysis to understand and analyze the dynamic and constantly changing nature of the data	New Adjustments on the Reference Data Model	New Adjustments on the Reference Data Model	New Adjustments on the Reference Data Model	New Adjustments on the Reference Data Model	New Adjustments on the Reference Data Model	New Adjustments on the Reference Data Model	Validation of the New Adjustments on the Reference Data Model	Validation of the New Adjustments on the Reference Data Model

Using the analytical power of Actor-Network Theory, we worked on Unilever as the focal company to explore an FMCG production area, i.e. the factory shop floor, with different actors aiming to use the power of automation by using a collaborative robot. Primarily, there is a two-way interaction between the cobot and the other actors related with their goals that puts the cobot in the center of the alliance. Actors are affected by the actions of each other in every phase of the interaction from idea creation to the usage. (Figure 3.2)

Figure 3.2 *The Heterogeneous Network on The Case Study*



As for this case study, we have focused on the cobots at the center of the network which are used in Unilever Besan Factory, Tuzla Istanbul. This factory is one of the seven Unilever factories in Turkey and specialized in food and beverage for two big Unilever brands Lipton and Knorr. During the Case Study, an Information Technology/Operation Technology Engineer (IT/OT) working for Unilever Turkey helped to collect the data,

and observe the actors related with my target Actor-network. we conducted an online survey (Table 3.2) with 11 different human actors: 1 factory director, 5 manufacturing engineers, 3 operators, 1 designer, and 1 developer. The survey was about 4 different kinds of Cobots working in this factory: Fanuc, Universal Robots, Kuka, and ABB. Those Cobots are working together with their operators to do packaging, parceling, palletizing, and feeding the production line.

3.1.2 Selection of Actors to be Evaluated

Using ANT, actors were identified through a preliminary study conducted at the Unilever Besan factory selected for the case study. In addition to Human, Robot, and Context in Hancock's Reference Trust model, Deployer/Developer was added. The new model's framework was built on four actors (Table 3.1).

Table 3.1 Actor Analysis Survey

Tarih	DD/ MM/ YYYY
Ülke	Türkiye
Şirket	Unilever
Şehir	İstanbul / Tekirdag / Kocaeli / Rize
Fabrika	Ev ve Kişisel Bakım / Gıda / Dondurma
Kullanıcının Rolü	Operator/Mühendis/Tasarımcı/Developer/ Fabrika Direktörü
Kullanılan Cobot Marka/Model	Fanuc/Universal Robots/Kuka
Cobot'un İşlevi	paketleme/ kolileme/ paletleme/ hat ürün besleme
Cobot'la çalışırken en çok etkileşime geçilen kişiler	Operator/Mühendis/Tasarımcı/Developer/Fabrika Direktörü
Cobot'un sağladığı fayda	üretkenlik/ maliyet azalması / doğruluk / hız / kalite
Cobot'un konfigürasyon/ customizasyon kolaylığı	az / orta / yüksek
Cobot'un konfigürasyon değişiklik sayısı / ay	1 / 12ay
Cobot'la beraber çalışırken meydana gelen kaza sayısı / ay	Kaza sayısı / Ay
Cobot'un ortalama arıza sayısı / ay	Arıza sayısı / Ay
Cobot'la çalışma ile ilgili engeller	güvenlik / yüksek fiyat / tasarım sorunları / donanım sorunları / yazılım sorunları / operator eğitim eksikliği

The fundamental distinction of ANT is to embrace both human and non-humans in the same network and no methodological difference between them. Therefore, the network is heterogeneous in that all entities form alliance, all have interests that make them act., succeed, and overcome the obstacles. (Table 3.2)

Table 3.2 *Actor Analysis*

	Factory Director	Increase productivity and competitiveness	Productivity measurement Safety concerns Cost Realization
HUMAN	Manufacturing Engineer	increase level of accuracy increase speed increase repeatability increase agility	Productivity measurement, Safety concerns, Better Human-Robot Experience
	Designer	Collaborative design with great user experience Fast, Cheap, Safe solution	Safety constraints Cost Technology constraints
	Developer	Modular programming of the cobot software with desired functionalities to satisfy the demand from the designer	Inflexible software platforms Constraints with the change management Error handling
	Operator	Collaboratively working on the same task Transferring non-value added and insecure activities Easy to configure	Design issues Shop Floor workplace constraints Safety risk
NON-HUMAN	Cobot Hardware	Physical part of the robot with sensors, cameras, visual processing Technologies, arm, touch-screen tablet, handling grippers, processor etc.	Better Human-Robot Experience, Cost, Safety
	Cobot Software	Software programs on the robot to program your robot offline to perform a specific manufacturing activity	Better Human-Robot Experience, Safety, Being open to be configured by operator
	Design Framework	optimizing working conditions by adapting collaborative robotics solutions in terms of human acceptance and well-being	Safety, Collaboration, Interaction, Shop Floor Constraints
	Shop Floor	a common workspace for both human and robot and they act at the same time	Safety, Physical constraints

3.1.3 Four Moments of Translation

In addition to the surveys as a data gathering methodology for this Case Study, we have interviewed IT/OT Engineer to understand his observations about this actor-network, and how the allies of this network translate each other's' interests into their own. (Appendix A IT/OT Engineer Interview). As Callon introduced the idea of translation, he said the “translation is the collection of all interactions among codified information, technical devices, and tacit knowledge and skills that result to the production of claims and statements; and when brought to interact with human actors, translation leads to translation networks“(Callon M., 1995). Hence, we would like to understand the design of a collaborative working environment by analyzing the translation of the existing actors in this case study.

According to Callon (1986) there are four steps of translation process: “problematization, interessment, enrolment and mobilization” to successfully bind up the actors to a network. In order to have a clarity on the translation process, we would like to start with “the Cobot” amongst all the actors in this network as a focal actor and examine the process of translation.

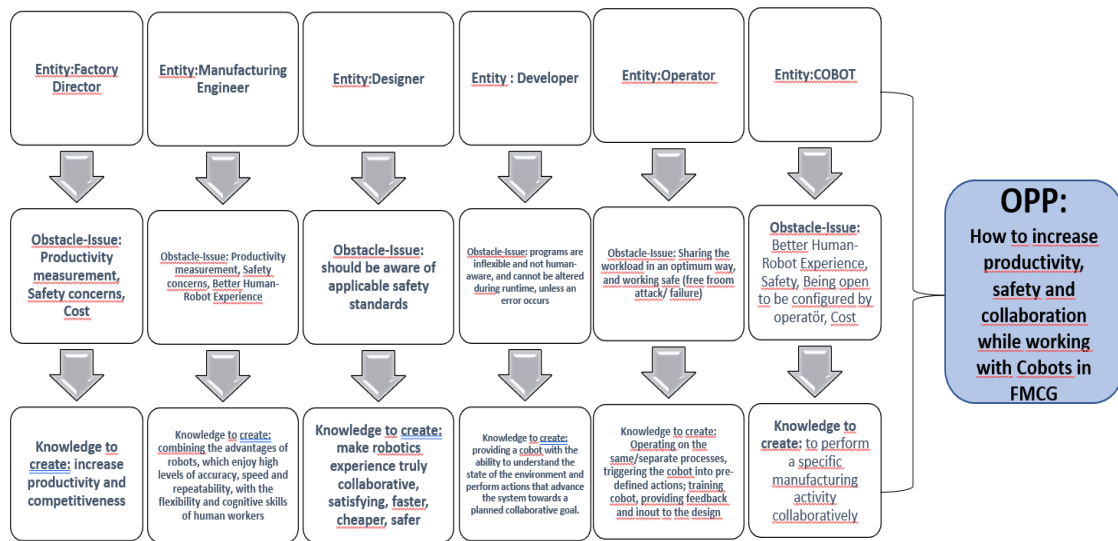
3.1.3.1 Problematization

The initial phase of the translation process is the problematization which is a definition of actors with interests, and defining an obligatory passage point (OPP), to understand the coherence of the alliance to satisfy the interests and to address the obstacles. (Callon, 1986)

In our case study, there is a Cobot entity as a focal actor and a group of people working with different roles but with a strong OPP to join the forces of the whole actors onto a few certain topics to be a team. The latent need of those actors is to increase the

productivity, safety and collaboration by designing the best human-robot interaction framework applicable to Cobots working for Unilever Besan Food Factory. Figure 3.3 shows a detailed analysis of each entity, obstacle and the knowledge to create, as well as the OPP in a schematic way.

Figure 3.3 *Obligatory Passage Point for the Case Study*



3.1.3.2 Interesement

The second phase of the translation process is the interesement which is creating relations between the actors to strengthen the engagement with each other and accept the roles and responsibilities within the same network. (Callon, 1986).

By thinking of “a day in Unilever Besan Factory”, all actors have specific roles and interests to work with the Cobots in the workplace. While the full list of interests is defined at Figure 3.2, we can give some examples like increasing level of accuracy, increasing the speed, cost saving, collaboration, eliminating non-value-added activities.

3.1.3.3 Enrolment

The third phase of the translation process is enrolment, where all actors aligned on the same interest defined by the focal actor (Callon, 1986). As intersement is not enough to have a successful translation, entities should negotiate and accept the new roles and definitions to support the network.

In this case study, we can see the ultimate aim is increasing the Cobot usage in an effective way to create a competitive advantage for Unilever Besan Food Factory, and produce the knowledge to have better, cheaper, faster Cobot solutions.

3.1.3.4 Mobilization

The last phase of the translation process is mobilization. Till this phase, the temporary actor-network would evolve and eventually transform to its final form by the help of the few individual actors, spokespersons, who control and mobilize the others. But the question here is “Will the masses ... follow their representatives?” (Callon 1986, p. 214). If they follow the aim of the controlling actors, then the translation process is successful.

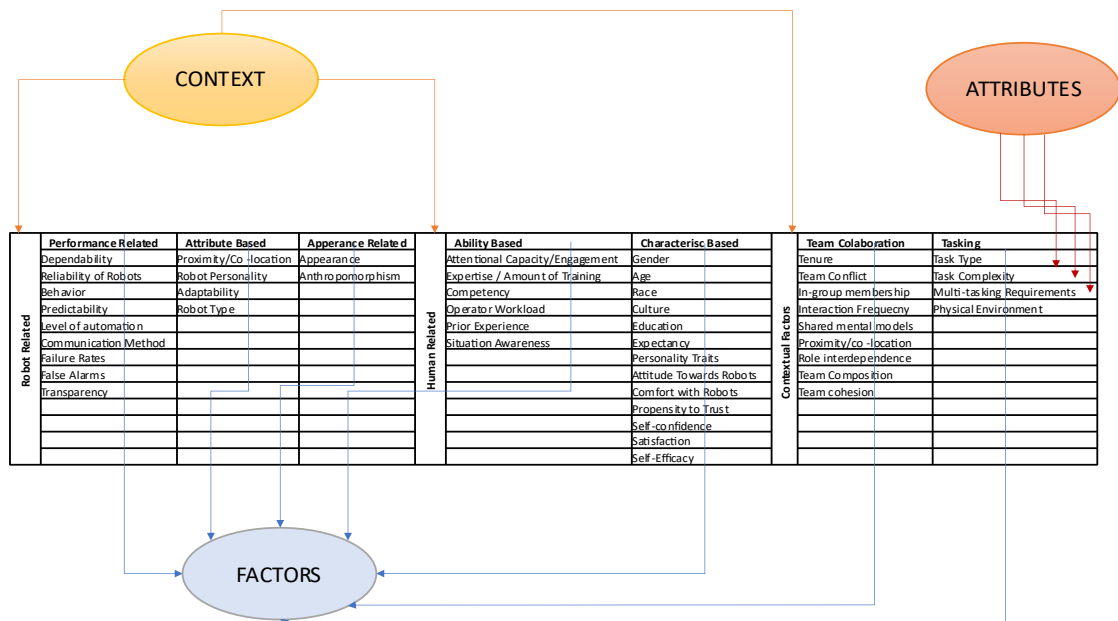
In this case study, we can bring manufacturing engineers as a controlling group in the foreground to drive the mobilization. Thinking of the hierarchy in such a factory environment between the employees, those group are the one working as a mediator between the decision maker who is factory director working on top-floor, and the operator who works actively collaborating with Cobots on the shop-floor. The manufacturing group has also the ownership of the Cobots, and should control all Cobot success criteria (accuracy, safety, reliability) to work smoothly. With their engineering knowledge, this group is also capable of given the requirements to designer and the developer.

3.1.4 Introduction of New Factors

By means of the methods for data collection applied in this study, we have a variety of choices when operationalizing “Trust in Cobot” concept to measure the constructs. “Context” is the main pillars of the model with special characteristics: “Factors” and “Attributes”. We have defined “Factors” and “Attributes” as the indicators to be observed and measured to calibrate “Trust in Cobot”. “Factors” are the functional “Attribute” groups within the “Context” of the model.

We would like to define the fuzzy concept of “Trust” clearly distinguishable, measurable, and understandable. As we have a theoretical construct with Hancock study (Hancock et. al., 2020; Khavas et al., 2021; we have a list of factors regarding trust in the similar classifications (Figure 3.4).

Figure 3.4 Context & Factors & Attributes Affecting Trust in Cobots: Reference Trust Model by Hancock



Using ANT, an analysis was conducted to determine if there were any new factors that could be associated with the actors. By examining the relationships, transitions, and requirements among the actors, it was observed that new factors were necessary. The framework of the model was established as shown in the table below, considering new actors and factors to be added in the subsequent stages (Figure 3.3).

Table 3.3 *Adjusted Trust Model Framework*

Robot Related			Human Related	
Performance Related	Attribute Based	Apperance Related	Ability Based	Character Based
Attribute 1	Attribute 1	Attribute 1	Attribute 1	Attribute 1
Attribute 2	Attribute 2	Attribute 2	Attribute 2	Attribute 2
Attribute 3	Attribute 3	New Attribute	Attribute 3	Attribute 3
Attribute 4	Attribute 4		Attribute 4	New Attribute
Attribute 5	New Attribute		New Attribute	New Attribute
Attribute 6	Attribute		New Attribute	
Attribute 7				
New Attribute				
New Attribute				

Contextual Factors		New Dimension		
Team Colaboration	Tasking	New Attribute Group	New Attribute Group	New Attribute Group
Attribute 1	Attribute 1	New Attribute	New Attribute	New Attribute
Attribute 2	Attribute 2	New Attribute	New Attribute	
Attribute 3	Attribute 3	New Attribute	New Attribute	
Attribute 4	New Attribute		New Attribute	
New Attribute	New Attribute			
New Attribute	Attribute			

3.1.5 Determining the Analysis System

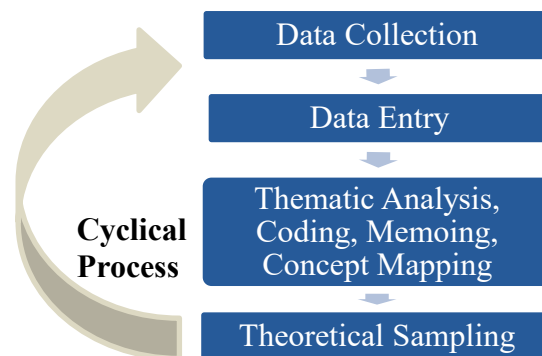
In this Case Study, Thematic Analysis was used to identify the fundamental mechanisms of trust and determine how these mechanisms operate and which factors influence them.

Although the research is qualitative, both **qualitative and quantitative data collection methods** were used. **Qualitative data** were collected through in-depth interviews and focus group discussions. **Quantitative data** were collected through surveys and documents.

Throughout the research process, the hypothesis validation and model development process progressed with a cyclical approach. At all stages of the research, new dimensions and factors were added from the data collected in the case study, applying the **Cyclical Data Analysis** method (Figure 3.5).

Cyclical data analysis is the process of continuously collecting, analyzing, and feeding back the results of this analysis into the data collection process. This method is effective for understanding and analyzing the dynamic and constantly changing nature of data.

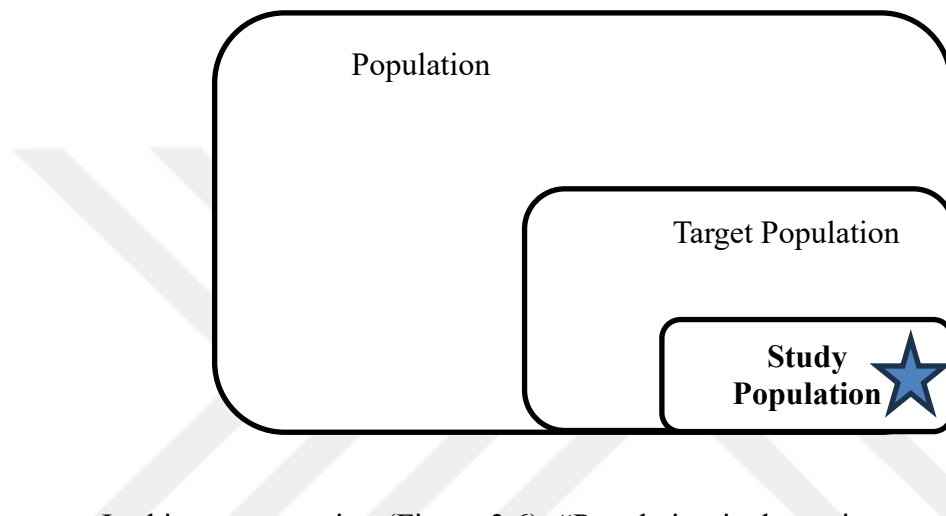
Figure 3.5 *Cyclical Data Analysis*



3.1.6 Population and Sampling Strategy

We selected a study population very carefully to represent with the right sample. On this selection, we will use the sample selection methodology used by Martínez-Mesa et al. (2014) (Figure 3.6).

Figure 3.6 *Sample Selection*



In this representation (Figure 3.6), “Population is the main group of individuals within a geographical region (city, country, continent etc.), or institutions (industries, communities etc.) where individuals have at least one characteristic in common. The *target population* is a portion of the population whose characteristics are the real interest of the investigator to draw a conclusion. *Study population* is the representative sample for the research to collect data, evaluate and help conclusions to be drawn about the target population.

We would like to apply purposive sampling as we have prior knowledge about the eligible participants according to our preliminary study. Our purposive sample was selected non-randomly as a typical smaller subset of FMCG population we intended to represent logically. While selecting, we obtained the knowledge from individuals with particular expertise. Those individuals are not ordinary members of FMCG, but the ones

who will have a role on our research problem area. We believe that some respondents in our area of study are more knowledgeable than others since working with robots requires expertise and experience, and our ANT analysis already defined the actors can be participated into our research.

In this research our Population is FMCG industry, our target population is Turkey FMCG Industry, and our study population for our case study will be Unilever Turkey. According to International Federation of Robotics (IFR 2022 Report), there are about 1300 operational robots in Turkey. There are 20 robots for every 10.000 workers in the last few years whereas this increased to 80 worldwide. This is average of all sectors, but automotive has a different place with average around 200. The automotive sector is followed by Food in Turkey. According to Statista 2023 there are 230.000 people work for FMCG in Turkey. Unilever Turkey holds 5000 people in 4 factories in Turkey. Considering IFR report mentioning 20 robots for every 10.000 employee, we had better accommodate at least minimum 10 robots and their corresponding operators per 5000 employees for Unilever. This research's sample is limited to 3 factories in Turkey where they have active Cobot usage. In the design of surveys, we selected only 11 specialists as respondents, but also we have 2 factory directors, 1 engineer, and 2 deployers were the participants of different data collection stages such as interviews, secondary analysis of survey data or field research observer.

3.2 Conducting

This stage involves data collection, classification, and analysis based on the determined case. The purpose of the conducting stage is to better understand the fundamental mechanisms of trust in human-robot interaction and how these mechanisms operate.

3.2.1 Use of Cyclical Data Analysis

Cyclical data analysis was used in the hypothesis testing process as follows:

- **Data Collection:** First, the necessary data to test the hypothesis were collected. These data were continuously collected and analyzed over a specific period. Data collection methods included observations, surveys, interviews, and document analysis.
- **Observations:** The non-participant observation method was applied in the factory to see how humans and robots work together. In the daily production routine of the factory, the human operator and the robot were observed without intervention. Human-Cobot interactions were observed in real work environments; behaviors such as hesitation, participation, or bypassing the Cobots were noted.
- **Surveys:** Structured surveys were applied to stakeholders in the factory using Cobots. The survey was organized online about the actors involved in working with the Cobot and what was done in the areas of improving cooperation in network groups. Fourteen questions were answered by different human actors selected as factory managers, production engineers, operators, designers, and developers.
- **Interviews:** In-depth interviews were conducted with managers such as factory managers and production engineers to obtain expert opinions and qualitative insights. Their observations about trust in Cobots and their feedback on the applied Trust models were received.
- **Document Analysis:** Case studies, work guides, safety reports, and company policies related to Cobot integration were examined.

- **Data Analysis:** The collected data were analyzed at regular intervals. These analyses were used to determine whether the hypothesis was validated. Meaningful patterns or themes in the data were identified, analyzed, and reported using the thematic analysis method.
- **Feedback:** The analysis results were fed back into the data collection process to improve the data collection process and help test the hypothesis more accurately.
- **Model Development and Testing:** Based on the analysis results, theories or models were developed. While developing new measurements for the Hancock Trust Model, the development continued with cyclical data analysis and thematic coding to deeply examine the "Trust" phenomenon.

3.2.2 The Strategies Used to Collect and Analyze Data

Non-Participant Observation: Initial observations were made at the Unilever Besan Factory, focusing on the interaction between Cobots and operators. Due to factory rules, the data was limited, and initial themes were identified and refined through thematic mapping.

Document Analysis: Two main documents were analyzed: a briefing for factory directors and a Cobot operating manual. Themes such as Cobot usage, safety, and the role of the Deployer/Developer were identified and refined.

Initial Interview: A semi-structured interview with a Senior Director at Unilever Turkey provided insights into human-Cobot interaction, trust calibration, and safety. New actors were added to the Trust Model.

Survey Data: Surveys were conducted with operators using Cobots across three different cities to explore the depth of human-Cobot interaction and the influence of third parties in the process. Prior to distribution, all survey instruments received formal

approval from company authorities. To uphold ethical standards, the surveys were designed to be anonymous—collecting no personal data—and structured to minimize bias in both question framing and interpretation.

Final Interview: Survey data was reviewed with the new Supply Chain Director, and findings were validated, emphasizing the importance of the deployer's role in trust calibration.

“Mapped/Not Mapped”. If there is a reference to the variable on the first or last interview, then the mapping will be explained in detail.

On each of the data collection method “Other Findings” will be used in 2 ways:

1. to make up a new context, attribute, or factor These factors will be explained in detail as new construct to adjust Reference Trust Model.
2. to highlight very specific knowledge addressed in FMCG environment.

Depending on the data collection method, we have used different measures for attributes:

Nominal measures: Variables whose attributes have the characteristics of robot, operator and the environment. Examples: the role, education, the robot type, location of the factory are amongst those variables used in data collection on the surveys to identify “Operators” or “Cobots”.

Ordinal measures: Data collected by consisting of two possible values. Examples: Response data on the surveys such as “yes” or “no”. Predetermined variables as a multiple choice: “productivity / cost efficiency / accuracy / speed / quality” as the response to the survey question “What is the benefit using Cobots?”

To support the interpretive Case Study at Unilever, three types of surveys will be employed at different stages of the research process:

1. Exploratory Survey (Preliminary/Planning Phase): This survey will be distributed early in the study to gather broad insights into human, robot, and contextual factors potentially influencing the deployment process. It will help identify unknown variables and refine the interview and observation protocols. (Table 3.4)

2. Diagnostic Survey (Execution Phase): Conducted midway through the fieldwork, this survey will validate emerging themes and patterns. It will also serve to triangulate findings from interviews and observations, ensuring consistency and depth in interpretation. (Figure 3.7)

Validation Survey (Testing The Results Phase): After initial analysis, this final survey will be used to test the existence and importance (Table 3.5) of the results in FMCG context.

Table 3.4 *Surveys Used in the Research – Data Collection Survey*

Sorular	Cevaplar	Yorumlar
Tarih	Gün/Ay/Yıl	
Ülke	Türkiye	
Şirket	Unilever	
Şehir	İstanbul / Tekirdag/ Kocaeli / Rize	
Fabrika	Ev ve Kişisel Bakım / Gıda / Dondurma	
Kullanıcının Rolü	Operator/Mühendis/Tasarımcı/ Developer/Fabrika Direktörü	
Kullanıcının Eğitim Durumu	Lise/Üniversite/Diğer	
Kullanıcının Sektör Tecrübesi (kaç yıl)		
Kullanıcının Cobotlarla Çalışma Deneyim Süresi (kaç yıl)		
Kullanılan Cobot Marka/Model	Fanuc/ Universal Robots/ Kuka	
Cobot'un İşlevi	Paketleme/ kolileme/ paletleme/ hat ürün besleme	
Sorular	Cevaplar	Yorumlar

Cobot'la çalışırken en çok etkileşime geçilen kişiler	Operatör/Mühendis/Tasarımcı/ Developer/Fabrika Direktörü	
Cobot'un sağladığı fayda	Üretkenlik/ maliyet azalması / doğruluk / hız / kalite	
Cobot-Operatör birlikte çalışma modelinizde sistemi configure eden/yöneten operatör dışında biri var mı?	Evet / Hayır	Evet ise kim olduğunu tanımlar mısınız?
Operatör sistemi tasarlayan/uygulayan uzmana geri bildirimde bulunuyor mu?	Evet / Hayır	Evet ise nasıl geri bildirimde bulunduğunu açıklar mısınız?
Sistemden otomatik olarak ya da operatörden sistemi tasarlayan/uygulayan uzmana alarm ya da bildirim gidiyor mu?	Evet / Hayır	Evet ise ne tür alarmlar/bildirimler olduğunu örnekler misiniz?
Sistemi tasarlayan/uygulayan uzman sistemin durumunu, operatör ile ilgili kriterleri izliyor ve raporluyor mu?	Evet / Hayır	Evet ise hangi kriterleri izleyip raporladığını örnekler misiniz?
Operatör sistemde performans iyileştirmesi yapmak, daha verimli-etkin çalışmak için Cobot'un konfigürasyonunu değiştiriyor mu?	Evet / Hayır	Evet ise hangi sıklıkta/hangi durumlarda yaptığını açıklar mısınız?
Hata ya da kaza durumunda sistemi tasarlayan/uygulayan uzman sisteme uzaktan müdahale edebiliyor mu?	Evet / Hayır	Evet ise hangi sıklıkta ve ne tür müdahaleler olduğunu örnekler misiniz?
Cobot hatalarından öğrenip, önleyici önlemler alıyor ya da öğrendiği öngörülerini sistemi tasarlayan/uygulayan uzmana gönderiyor mu?	Evet / Hayır	Evet ise örnek verebilir misiniz?
Cobotların robotlara göre avantaj /dezavantajları nelerdir?		
Cobotların kullanım ömürleri asıl? Çok fazla parça değiştiriyor musunuz?		
Cobotları yan ekipmanlar ile kullanıyor musunuz? (Kamera sistemi, data sistemleri)		
Bir den fazla cobot koordineli çalışıyor mu?		
Cobotların kullanımı kolay mı? Operatörler olarak arızaların % kaçını yapabiliyorsunuz?		
Cobotlar gelen ambalaj malzemelerindeki hataları tolere edebiliyor mu? Yoksa küçük duruşlar mı yaşıyorsunuz?		

Figure 3.7 Survey Form Used in the Research - Existence Survey

Tanımlayıcı Bilgiler	
Tarih (Lütfen Gün/Ay/Yıl şeklinde tarihi giriniz)	.../12/2023
Ülke	Türkiye
Şirket	Unilever
Şehir	İstanbul
Fabrika	Besan
Kullanıcının Rolü	Operator
Kullanıcının Eğitim Durumu (Lise/Üniversite/Diğer birini yazınız)	
Kullanıcının Sektör Tecrübesi (kaç yıl)	
Kullanıcının Cobotlarla Çalışma Deneyim Süresi(kaç yıl)	
Kullanılan Cobot Marka/Model (Fanuc/Universal Robots/Kuka vb. birini veya birkaçını yazabilirsiniz)	
Cobot'un İşlevi (paketleme/kolileme/paletleme/hat ürün besleme vb. birini veya birkaçını yazabilirsiniz)	
Lütfen aşağıdaki soruları cevaplarırken sağ taraftaki Cevaplar sütununu doldurunuz. Herbir soru için Cobotlarla günlük çalışma rutininizi düşünerek 7 cevap seçeneğinden size en uygun olanı seçiniz.	
Sorular	Cevaplar
Cobot ile beraber çalışırken, parça alıp verme, bir işi devam ettirme, sözlü-yazılı komut verme, geri bildirim alma gibi iletişim ihtiyaçları oluyor mu?	
Cobot gerektiğinde hata mesajı veriyor mu?	
Sistemden otomatik olarak ya da operatörden sistemi tasarlayan/uygulayan uzmana alarm ya da bildirim gidiyor mu?	
Sistemi tasarlayan/uygulayan uzman sistemin durumunu, operator ile ilgili kriterleri izliyor ve raporluyor mu?	
Cobotun programlanması kolay mı?	
Cobotun hata yapma oranı yüksek mi?	
Cobotun geliştirilmesi için bir uzman desteği gerekiyor mu?	
Sorular	Cevaplar
Cobot ile çalışırken verimlilik, süreklilik ve doğru kullanım gibi konularda kaynak yönetimini etkileyen öneriler çıkabiliyor mu?	
Cobot durma, hatalı aksiyon gibi üretimi, lojistiği ya da operasyonu etkileyen durumlar yaratıyor mu?	
Operatör sistemi tasarlayan/uygulayan uzmana geri bildirimde bulunuyor mu?	
Operatör Cobot'ta yeni bir görev için programlama yapmak istese hangi sıklıkta firma yetkilisinden yardım alıyor?	
Hata ya da kaza durumunda sistemi tasarlayan/uygulayan uzman sisteme uzaktan müdahale edebiliyor mu?	
Herhangi bir konuda sistemi tasarlayan firma sorumlusuna alarm ya da bildirim gidiyor mu?	
Sistemi tasarlayan firma sorumlusu herhangi bir izleme ve kontrol aracı kullanıyor mu?	

Otomasyonun herkes için erişilebilir olmasını sağlıyor mu?	
Cobot ile iletişim yöntemleri yeterli mi?	
Cobot bir sorun durumunda operatöre ya da ilgili sorumluya sesli ya da yazılı bir uyarıda bulunuyor mu?	
Cobot beraber çalışırken hiç hata yapıyor mu?	
Cobot ile beraber çalışırken, parça alıp verme, bir işi devam ettirme, sözlü-yazılı komut verme, geri bildirim alma gibi etkileşim ihtiyaçları oluyor mu?	
Cobot operatörlerinin eğitim, farkındalık ve doğru kullanımı için sistemden geri bildirim ya da rapor alınıyor mu?	
Cobotlarla çalışırken daha güvenli hissetmesi için operatöre önerilerde bulunuluyor mu?	
Operator Cobot'u eğitirken görev türünü hızlı bir şekilde değiştirebilecek sisteme sahip mi?	
Cobot sesli ya da yazılı sorun bildiriyor mu?	
Firma yetkilisi sorun olduğunda yerinde müdahale mi etmek zorunda?	
Gün içinde bir sorun olduğunda sistemi tasarlayan firma sorumlusuna herhangi bir alarm ya da bildirim gidiyor mu?	
Sistemi tasarlayan firma operator ya da yönetim ekibi ile durjım ya da performansa dair bir rapor paylaşıyor mu?	
Cobotun otomasyon seviyesini arttırmak ne kadar mümkün?	
Cobot firma yetkilisine Cobot ile etkileşim açısından önerilerde bulunmak gerekiyor mu?	
Cobot firma yetkilisine Cobot ile etkileşim açısından önerilerde bulunmak gerekiyor mu?	
Cobot ile çalışan operatörün verimliliği, bilgisi, kullanımını iyileştirecek tavsiyeler alınıyor mu?	
Cobot operatörlerinin Cobotlarla çalışırken sisteme güveninin artması için üretici firma ya da uygulayıcısı tarafından bir analiz yapılıyor mu?	
Operatör firma yetkilisi olmadan yeni bir görev tanımlayabiliyor mu?	
Firma yetkilisi sorun olduğunda hangi sıklıkta sisteme uzaktan müdahale ediyor?	

Table 3.5 *Surveys Used in the Research - Significance Survey*

Cobot'lar operatörlerin iş yükünü azaltmak için geliştirildi. Bu bağlamda, operatörler veCobot'lar görevleri ve çalışma alanını paylaşıyorlar.

1. “Cobot ile beraber çalışırken kendinizi güvende hissediyor musunuz? Cobot’un size fiziksel zarar vermesi, beraber yaptığınız işe zarar vermesi, sizin iş tatmin ve motivasyonunuzu azaltması gibi sorunlara neden olacağını düşünüyor musunuz? Cobot ile işbirliğiniz açısından güven seviyenizi işaretlemenizi rica ederiz:

(1: Çok düşük, 2: Düşük 3: Orta, 4: Yüksek, 5: Çok yüksek)

2. Lütfen günlük çalışma rutininizi düşünerek aşağıdaki faktörlerin Cobot ile çalışırken kendinizi güvende hissetmeniz için ne kadar önemli olduğunu işaretleyiniz:

(1: Çok önemsiz, 2:Önemsiz, 3:Kararsız, 4:Önemli, 5:Çok önemli)

	Faktör	1	2	3	4	5
Geribildirim Döngüsü:	Kontrolör ya da tasarımcıya geri bildirim döngüsü olması kendinizi güvende hissetmeniz için ne kadar önemlidir? Cobot'ların belirli hareketi ayarlamak, aktiviteleri izlemek ve “zaman aşımı, robot etiketi okuyamıyor, acil durum durdurması” vb. hataları gidermek için kontrolleri vardır. Geri besleme döngüsü bir mekanizmadır. Cobot’la ilgili kontrollerin gerçek çıktısını beklenen çıktıyla karşılaştıran, bu durumlarla ilgili raporları tasarımcısına gönderen mekanizmadır.	Size fiziksel zarar vermesi açısından				
		Size psikolojik zarar vermesi açısından				
		Beraber yaptığınız işe zarar vermesi açısından				
İzleme	İzleme sisteminin olması kendinizi güvende hissetmeniz için ne kadar önemlidir? İzleme sistemi, Cobot'un fiziksel koşullarını ve beraber çalışma süreçlerini inceler. Bir cobot uygunsuz veya kararsız davranış gösterdiğinde bir insan operatörü veya tasarımcıyı uyarır.	Size fiziksel zarar vermesi açısından				
		Size psikolojik zarar vermesi açısından				
		Beraber yaptığınız işe zarar vermesi açısından				

Faktör		1	2	3	4	5
Otomasyon Seviyesi	Otomasyon seviyesinin iş isterlerine uygun olacak şekilde geliştirilmiş olması kendinizi güvende hissetmeniz için ne kadar önemlidir? Cobot otomasyonu, robotlar alanında yeni bir teknolojidir ve geleneksel otomasyon seçeneklerinden farklıdır. Bir cobot, cobot'un çevreye ve dokunmaya duyarlı olmasını sağlayan sensörlerle donatılmıştır. En yeni cobot'lar hiçbir programlama kullanmaz. Görevlerini tasarlayıcılardan öğrenirler. Tasarlayıcı cobot'u işin adımları boyunca hareket ettirir ve cobot öğrenir.	Size fiziksel zarar vermesi açısından				
İletişim Metodu	İnsan ve Cobot ekip olarak çalışırken birbirleri ile etkin iletişimde olması güveni ne kadar etkiler? Ekip olarak eylemler, dokunma, güçlü etkileşim, biyometrik sinyaller, sözlü ipuçları ve daha fazlası yoluyla çok modlu bir bilgi alışverişi olan somutlaştırılmış iletişime güvenir. Mevcut haliyle iletişim genellikle tasarımcı tarafından tasarlanır, zaman içinde tek yönlü ve statiktir.	Size fiziksel zarar vermesi açısından				
		Size psikolojik zarar vermesi açısından				
Arıza Oranları	Cobot'un normal çalışma düzenini bozacak ya da verimliliği düşürecek arızalarının oranının fazla olması güveni ne kadar etkiler? Cobot'lar da bozulmaya maruz kalıyor ve fonksiyonel arızalar operasyonlarını etkileyerek anormal yörüngelere yol açabilmektedir. Bu bağlamda Cobot'lar, beklenen performanslarını sağlamak için arıza oranları kontrol edilebilir ve programlanabilir.	Beraber yaptığınız işe zarar vermesi açısından				
		Size fiziksel zarar vermesi açısından				
		Size psikolojik zarar vermesi açısından				
		Beraber yaptığınız işe zarar vermesi açısından				

Faktör		1	2	3	4	5
Yanlış Alarm	Cobot'un normal çalışma düzeni bozulmadığı halde oluşan hatalı alarmlar nedeniyle işin durması ya da verimin azalması güveni ne kadar etkiler? Zaman aşımı hataları, acil durum durdurma gibi Cobotların arıza tespiti ve teşhisi, farklı alarm türlerinin ayarlanmasıyla iyileştirilebilir.	Size fiziksel zarar vermesi açısından Size psikolojik zarar vermesi açısından Beraber yaptığınız işe zarar vermesi açısından				
Etkileşim Dizaynı	Cobot ile etkileşimde bulunmak için kullanılan fiziksel nesnelerin tasarımı ya da operatörün Cobotla beraber çalışma deneyiminin tasarımı güveni ne derece etkiler? Geleneksel olarak Cobotların tasarımında işlevsellik ve güvenliğe odaklanmıştır. Ancak bunun yeterli olmadığını görmüştür. Deneyim odaklı tasarım hedeflerine ihtiyacımız vardır. İşlev kadar operatörün ve Cobotun o işlevi yerine getirirken nasıl davranacağını, zorluk, tepki süresi, iletişim organı (ses, göz, el vs) açısından da tasarlamaktır.	Size fiziksel zarar vermesi açısından Size psikolojik zarar vermesi açısından Beraber yaptığınız işe zarar vermesi açısından				

Faktör		1	2	3	4	5
İK için Talimatlar	Cobot ile beraber çalışırken oluşan deneyimden oluşan insan kaynağı talimatlarının yerine getirilmesi güveni ne kadar etkiler? Cobot denetleyicisi, yanlış kullanım (eğitim ihtiyacı), kullanılmama (direnç gösterme) veya kötüye kullanım (yetersiz kullanım veya hasar) olup olmadığını anlamak için İK departmanlarının faaliyetlerini izleyebilir ve günlük olarak kaydedebilir.	Size fiziksel zarar vermesi açısından				
Kalibrasyon İpuçlarına Güven	Cobot'a, operatöre ya da ortama dair alınan geribildirim ve ipuçlarının kullanılması ile güven modelini ne kadar kalibre edilebilir? Cobot üreticileri, programcıları veya dağıtıcıları, İnsan Cobot Güven Yapısında Cobot'u veya Bağlamsal Faktörleri geliştirmek ve iyileştirmek için sahadan bazı geri bildirimler alabilirler ve Cobota güven modelini kalibre edebilirler.	Size fiziksel zarar vermesi açısından Size psikolojik zarar vermesi açısından Beraber yaptığınız işe zarar vermesi açısından				
Görev Tipi	Cobot ile beraber çalışılan görev tiplerinin yeni, zor, karmaşık, çoklu ve tekrarlı olması gibi durumlar güveni ne kadar etkiler? Cobot'un operatörü ile işbirliğindeki birçok görev önceden tanımlanmıştır ya da görev tipi değişikçe tekrar ayarlanabilir. Görev tiplerinin yeni, zor, karmaşık, çoklu ve tekrarlı olması gibi değişik durumlar olabilir.	Size fiziksel zarar vermesi açısından Size psikolojik zarar vermesi açısından Beraber yaptığınız işe zarar vermesi açısından				

Faktör		1	2	3	4	5
Uzaktan Müdahale	Cobotla ilgili bir uygunsuz ya da şüpheli durum olduğunda Cobot'a ya da ortama uzaktan müdahale edilebilir olması güveni ne derece etkiler? Cobot'un konuşlandırıcısı fiziksel koşulları izleyebilir ve uygunsuz veya kararsız bir davranış durumunda kurulumu durdurabilir/değiştirebilir.	Size fiziksel zarar vermesi açısından Size psikolojik zarar vermesi açısından Beraber yaptığınız işe zarar vermesi açısından				

While conducting in-depth research on the trust phenomenon under the Case Study method framework, the Cyclical Data Analysis approach helped to develop the Adjusted Trust Model. The study progressed step by step over a two-year period. At each data collection and analysis step, findings related to the factors of trust affecting the interaction between humans and Cobots were gathered and added to the model

During the conducting stage, the role of the new actor within the case study was also revealed. It was observed that the Deployer/Developer played a critical role in contexts such as feedback loops, monitoring, and remote intervention in human-Cobot interaction.

3.2.3 Data Collect

We will use data sheet as a systematic tool for collecting and analyzing data. Our data sheet will be based on Hancock reference model. We will use 4 tables to collect the data in different contexts: 1. Robot Related (Table 3.6), 2. Human Related (Table 3.7), 3. Contextual Factors (Table 3.8), and 4. Other Findings (Table 3.9).

Typical data sheet table will have 2 columns. The first column will contain different set of data variables while the second column is used for data findings.

Table 3.6 *Robot Related Data Sheet*

Robot Related					
Performance Related	Findings	Attribute Based	Findings	Appearance Related	Findings
Dependability		Proximity/ Co-location		Appearance	
Reliability of Robots		Robot Personality		Anthropo-morphism	
Behavior		Adaptability			
Predictability		Robot Type			
Level of automation					
Communication Method					
Failure Rates					
False Alarms					
Transparency					

Table 3.7 *Human Related Data Sheet*

Human Related			
Ability Based	Findings	Characteristic Based	Findings
Attentional Capacity/ Engagement		Gender	
Expertise / Amount of Training		Age	
Competency		Race	
Operator Workload		Culture	
Prior Experience		Education	
Situation Awareness		Expectancy	
		Personality Traits	
		Attitude Towards Robots	
		Comfort with Robots	
		Propensity to Trust	
		Self-confidence	
		Satisfaction	
		Self-Efficacy	

Table 3.8 *Contextual Factors Data Sheet*

Contextual Factors			
Team Collaboration	Findings	Tasking	Findings
Tenure		Task Type	
Team Conflict		Task Complexity	
In-group membership		Multi-tasking Requirements	
Interaction Frequency		Physical Environment	
Shared mental models			
Proximity/co-location			
Role interdependence			
Team Composition			
Team cohesion			

Table 3.9 *Other Findings*

Other Findings	

Data findings will be done on different ways for each collection method:

1. **Non-Participant Observation and investigation on site & photography:**
Observations are recorded text based and photography used as evidence. Findings will be entered on the corresponding columns as “Observed/Not Observed”. If there is a valid observation, then the observation will be explained in detail.
2. **Document Analysis:** Documents are shared by Factory directors as digital copies. Findings will be entered on the corresponding columns as “Mapped/Not Mapped”. If there is a reference to the variable on the document, then the page number and the mapping will be explained in detail.
3. **Survey:** Surveys are designed as excel sheets, and distributed and collected via e-mails. Survey results will be mapped with Reference Model. All survey questions

shared with company authorities first to be approved to be inquired. Findings will be entered on the corresponding columns as “Mapped/Not Mapped”. If there is a question and answer to the variable on the survey, then mapping will be shown.

4. **Interview:** Interviews are done over virtual conferencing system, recorded as video and hand-written scripts. Findings will be entered on the corresponding columns as “Mapped/Not Mapped”. If there is a reference to the variable on the first or last interview, then the mapping will be explained in detail.

On each of the data collection method “Other Findings” will be used in 2 ways:

- i. to make up a new context, attribute, or factor These factors will be explained in detail as new construct to adjust Reference Trust Model.
- ii. to highlight very specific knowledge addressed in FMCG environment.

3.2.4 Classification of Findings

After the cyclical analysis and thematic analysis for trust models in human-robot interaction, the findings were classified under specific themes and categories in the Reference Trust Model. Themes were conceptualized as shared meaning codes among data elements and grouped as "human-related, Cobot-related, contextual, or Deployer-related factors." The classification was made as follows to better understand trust dynamics and create effective collaboration environments:

1. **Human-Related:** This category covers the psychological and physical foundations of humans' trust in robots. Factors such as how much humans trust the decision-making processes of robots, the predictability and reliability of robots are included in this classification. Additionally, the trust and comfort humans feel when interacting with robots are also included in this category.

2. **Cobot-Related:** This category is related to the technical features and performance of Cobots (collaborative robots). Factors such as the movement speeds, strengths, responses in emergencies, and overall reliability of the robots fall into this classification. Additionally, how Cobots interact with humans and how safe these interactions are also included in this category.
3. **Contextual:** This category is related to the environment and conditions in which human-robot interaction takes place. Factors such as the layout of the work environment, the areas where robots are placed, and the safety of these areas are included in this classification. Additionally, how work processes are organized and the role of robots in these processes are also included in this category.
4. **Deployer-Related:** This category is related to the people who manage and implement the integration of robots into work processes. Measures, training, and procedures taken by developers to ensure the safe and effective use of robots are included in this classification. Additionally, the methods used by deployers to monitor and evaluate the performance of robots are also included in this category.

3.2.5 Coding of Findings with Thematic Analysis

After collecting the necessary data to validate the hypothesis, a "Actors and Factors Adjusted Trust Model" specialized for FMCG was developed with the new actors and factors resulting from the **Thematic Analysis**. The model development process continued with a cyclical approach. At all stages of the research, new dimensions and factors were added from the data collected in the case study, applying Cyclical Data Analysis. In general, qualitative analysis involves a continual interplay between theory and analysis. In analyzing qualitative data, we seek to discover patterns such as possible causal links between variables. The processing of qualitative data is as much art as

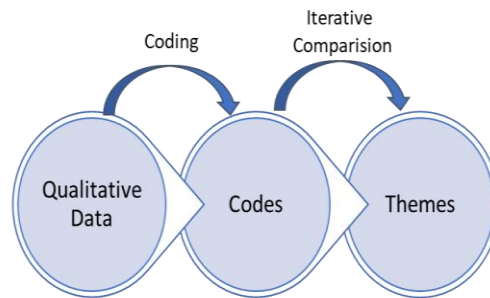
science. Three key tools for preparing data for analysis are coding, memoing, and concept mapping. In contrast to the standardized units used in coding for statistical analyses, the units to be coded in qualitative analyses may vary within a document. Although codes may be derived from the theory being explored, more often researchers use open coding, in which codes are suggested by the researchers' examination and questioning of the data.

Memoing is appropriate at several stages of data processing and serves to capture code meanings, theoretical ideas, preliminary conclusions, and other thoughts that will be useful during analysis. Concept mapping uses diagrams to explore relationships in the data graphically.

Thematic analysis is a qualitative research method used to identify, analyze, and report meaningful patterns or themes in the data (Naeem et al., 2023). In this research, it was aimed to identify, analyze, and interpret the meaning patterns of Trust Models in HRI with the collected qualitative data. Therefore, qualitative data analysis methods such as "thematic analysis" and "coding" (Braun & Clarke, 2006) were used. This allowed understanding the main themes in the data and how these themes emerged.

The analysis began by examining the Reference Trust Models in HRI based on Hancock's study. Themes were conceptualized as shared meaning codes among data elements supported by the central concept of "human-related, robot-related, and contextual factors in Hancock's study" and were used to understand the phenomenon and the related research question (Figure 3.8).

Figure 3.8 *Thematic Analysis and Coding*



The themes derived from the data actively construct the patterns of meaning to answer a research question. In short, themes are ‘a patterned response or meaning’ derived from coded data that represent overarching ideas embedded within the larger data set.

Our Reference Trust Model has different constructs affecting Trust in Cobots can be classified under different categories: Context, Factors, Attributes (Table 3.10).

Table 3.10 *Abstraction of Trust Model Based on Hancock Study*

Robot Related			Human Related		Contextual Factors	
Performance Related	Attribute Based	Appearance Related	Ability Based	Characterise Based	Team Collaboration	Tasking
Attribute 1	Attribute 1	Attribute 1	Attribute 1	Attribute 1	Attribute 1	Attribute 1
Attribute 2	Attribute 2	Attribute 2	Attribute 2	Attribute 2	Attribute 2	Attribute 2
Attribute 3	Attribute 3	New Attribute	Attribute 3	Attribute 3	Attribute 3	Attribute 3

In order to process our qualitative data we used “Coding” and “Thematic mapping”. Codes were derived from data explored by sexamination of the reference Trust Model by Hancock and questioning of the data in the referred data analysis steps (Table 3.11).

Table 3.11 *Thematic Data Analysis Steps*

Data Analysis Steps	
Initial Coding	Getting to know the data in hand Coding sentences and word groups as initial meanings/themes
Generating Themes	Collating codes into potential themes
Thematic Mapping	Identifying patterns Mapping with Themes
Refining Themes	Generating clear definitions and relations between themes
Report	Findings

We followed the cyclic approach to define and refine codes to end up developing some general conclusions regarding a new/adjusted Trust Model. We added a new dimensions and new attributes to be derived from the data collected from Case Study. With the new additions, the model was supposed to adjust to a new model which is customized for FMCG Turkey (Table 3.5).

3.3 Testing the Results

As we progressed through the data collection and analysis steps in the case study, we provided a concise summary of our key research findings and highlighted the main themes among the significant results. During the final phase, we analyzed the findings to understand their practical implications for the case study. By the end of the evaluation, it became evident that the Reference Trust model could be adjusted to include new factors

4.ANALYSIS

4.1 Data Collect

4.1.1 Data Collect Non-Participant Observation

As a researcher, we had limited access to Cobots and Operators on the field because of the very strict safety and access rules on the factory production area. And also, we didn't want to interfere the relation and the team work. Therefore, we have chosen non-participant observation as an unobstructive qualitative research strategy for gathering the data about the constructs of "Trust Models in HRI" without directly interacting.

We visited Besan Factory, and observed the different types of Cobots working with Operator on packing activity. There were very strict rules on the production area: wearing protection wares such as helmets, goggles, and shoes irrespective of working or not, maintaining the safety distance indicated by the accompanying person, observing all prohibition, warning, mandatory and guideline signs, not distracting the focus of the workers. We spent more than an hour there and observed Cobot, Operator and the environment: the type of the work, frequency of the joint tasks, safety cautions, and other parties involved. We jotted down my field notes, and took photos like Cobots, fences, signs, and materials (Appendix B).

4.1.2 Data Collect for Document Analysis

Document analysis was used as a qualitative research technique. The process involved evaluating electronic documents to interpret them, gain an understanding of their meaning and derive some points to build up the constructs related with "Trust Models in HRI". We studied the content and structure of the documents to identify the content, and understand the themes related with our research area.

Document analysis was used as a qualitative research technique in this Case Study of Unilever Turkey. The process involved evaluating electronic documents to interpret them, gain an understanding of their meaning and derive some points to build up the constructs related with “Trust in Cobots”. The documents provided by Factory Director were the presentation named as “*Collaborative robotics Briefing for Factory Directors*” and a training document named as “*Cobot Operating Manual*”. We studied the the content and structure of the documents to identify the content, and understand the themes related with our research area (Appendix C).

4.1.3 Data Collect for the First Interview

We planned a semi-structured interview with a mixture of prepared questions and prompt questions. Prepared questions:

1. How are Cobots in ... positioned?
2. What is the latent need for Human Robot interaction in?
3. How do you think about Cobots & Trust?
4. Do you think Cobots are effective in?
5. What and how to measure their performance?

Interview was done with Unilever Turkey Supply Chain Director responsible from Cobot Operations. We used Microsoft Teams as a conference tool, and the interview session was recorded for half an hour. It was semi-structured interview with a mixture of prepared questions and prompt questions. The questions prepared in advance were aimed to check the validity of the findings from the previous steps of Data Collection and Analysis. Additionally, I asked prompt questions to understand his expert point of view on Human Cobot Interaction and the importance of Trust Calibration for Unilever. The

answers to these questions in turn generated a new set of data to analyze for Unilever Turkey (Appendix D).

4.1.4 Data Collect for Survey

The survey was designed to apply to Cobot Operators, and there are 26 questions on the survey. There were categorical questions which were simple, specific and direct to get neutral answers. Survey answers were combined with Comments (Yorumlar) column to add details, examples, and thoughts if required (Table 4.1).

Table 4.1 *Survey Questions*

Sorular	Cevaplar	Yorumlar
Tarih	Gün/ Ay/ Yıl	
Ülke	Türkiye	
Şirket	Unilever	
Şehir	İstanbul/ Tekirdağ / Kocaeli/ Rize	
Fabrika	Ev ve Kişisel Bakım/ Gıda / Dondurma	
Kullanıcının Rolü	Operatör/Mühendis/Tasarımcı/Developer/Fabrika Direktörü	
Kullanıcının Eğitim Durumu	Lise/Üniversite/Diğer	
Kullanıcının Sektör Tecrübesi (kaç yıl)		
Kullanıcının Cobotlarla Çalışma Deneyim Süresi (kaç yıl)		
Kullanılan Cobot Marka/Model	Fanuc/ Universal/ Robots/ Kuka	
Cobot'un İşlevi	Paketleme/ kolileme/ paletleme/ hat ürün besleme	
Cobot'la çalışırken en çok etkileşime geçilen kişiler	Operatör/Mühendis/Tasarımcı/Developer/Fabrika Direktörü	
Cobot'un sağladığı fayda	Üretkenlik/ maliyet azalması / doğruluk / hız / kalite	
Cobot-Operatör birlikte çalışma modelinizde sistemi configure eden/ yöneten operator dışında biri var mı?	Evet / Hayır	Evet ise kim olduğunu tanımlar mısınız?
Operatör sistemi tasarlayan/ uygulayan uzmana geri bildirimde bulunuyor mu?	Evet / Hayır	Evet ise nasıl geri bildirimde bulunduğunu açıklar mısınız?

Sistemden otomatik olarak ya da operatörden sistemi tasarlayan/ uygulayan uzmana alarm ya da bildirim gidiyor mu?	Evet / Hayır	Evet ise ne tür alarmlar/bildirimler olduğunu örnekler misiniz?
Sistemi tasarlayan/ uygulayan uzman sistemin durumunu, operatör ile ilgili kriterleri izliyor ve raporluyor mu?	Evet / Hayır	Evet ise hangi kriterleri izleyip raporladığını örnekler misiniz?
Operatör sistemde performans iyileştirmesi yapmak, daha verimli-etkin çalışmak için Cobot'un konfigürasyonunu değiştiriyor mu?	Evet / Hayır	Evet ise hangi sıklıkta/hangi durumlarda yaptığını açıklar mısınız?
Hata ya da kaza durumunda sistemi tasarlayan/ uygulayan uzman sisteme uzaktan müdahale edebiliyor mu?	Evet / Hayır	Evet ise hangi sıklıkta ve ne tür müdahaleler olduğunu örnekler misiniz?
Cobot hatalarından öğrenip, önleyici önlemler alıyor ya da öğrendiği öngörülerini sistemi tasarlayan/ uygulayan uzmana gönderiyor mu?	Evet / Hayır	Evet ise örnek verebilir misiniz?

While designing the survey, we elaborated on the attributes of Reference Trust Models. We mapped each survey question with a correspondent attribute to understand if the survey covers the key elements of my research (Table 4.2).

Table 4.2 *Survey Questions Mapped with Trust Models*

Sorular	Cevaplar	Yorumlar	Type of The Question	Factors	Attributes	Potential/ Existing
Tarih	Gün/ Ay/ Yıl		General Demographic	Not applicable	Not applicable	Existing
Ülke	Türkiye		General Demographic	Not applicable	Not applicable	Existing
Şirket	Unilever		General Demographic	Not applicable	Not applicable	Existing
Şehir	İstanbul/ Tekirdağ/ Kocaeli/ Rize		General Demographic	Not applicable	Not applicable	Existing
Fabrika	Ev ve Kişisel Bakım / Gıda / Dondurma		General Demographic	Not applicable	Not applicable	Existing
Kullanıcının Rolü	Operatör/Mühendis/Tasarımcı/Developer/Fabrika Direktörü		Human Related	Team Colaboration	Team Composition	Existing
Kullanıcının Eğitim Durumu	Lise/ Üniversite/ Diğer		Human Related	Character Based	Education	Existing
Kullanıcının Sektör Tecrübesi (kaç yıl)			Human Related	Ability Based	Expertise / Amount of Training	Existing

Sorular	Cevaplar	Yorumlar	Type of The Question	Factors	Attributes	Potential/ Existing
Kullanıcının Cobotlarla Çalışma Deneyim Süresi (kaç yıl)			Human Related	Ability Based	Prior Experience	Existing
Kullanılan Cobot Marka/Model	Fanuc/ Universal Robots/ Kuka		Robot Related	Attribute Based	Robot Type	Existing
Cobot'un İşlevi	Paketleme/ kolileme/ paletleme/ hat ürün besleme		Robot Related	Attribute Based	Robot Type	Existing
Cobot'la çalışırken en çok etkileşime geçilen kişiler	Operatör/M ühendis/Ta sarımcı/De veloper/Fab rika Direktörü		Contextual	Team Collaboration	Team Composition	Existing
Cobot'un sağladığı fayda	Üretkenlik/ maliyet azalması/ doğruluk/ hız/ kalite		Robot Related	Performance Related	Added Value	Potential
Cobot-Operatör birlikte çalışma modelinizde sistemi konfigüre eden/yöneten operatör dışında biri var mı?	Evet/ Hayır	Evet ise kim olduğunu tanımlar mısınız?	Contextual	Team Collaboration	In-group membership	Existing

Sorular	Cevaplar	Yorumlar	Type of The Question	Factors	Attributes	Potential/ Existing
Operatör sistemi tasarlayan/uygulayan uzmana geri bildirimde bulunuyor mu?	Evet / Hayır	Evet ise nasıl geri bildirimde bulunduğunu açıklar mısınız?	Deployer Related	Tasking	Trust Calibration Cues	Potential
Sistemden otomatik olarak ya da operatörden sistemi tasarlayan/uygulayan uzmana alarm ya da bildirim gidiyor mu?	Evet / Hayır	Evet ise ne tür alarmlar/bildirimler olduğunu örnekler misiniz?	Deployer Related	Performance Related	Feedback Loop	Potential
Sistemi tasarlayan/uygulayan uzman sistemin durumunu, operator ile ilgili kriterleri izliyor ve raporluyor mu?	Evet / Hayır	Evet ise hangi kriterleri izleyip raporladığını örnekler misiniz?	Deployer Related	Performance Related	Monitoring	Potential
Operatör sistemde performans iyileştirmesi yapmak, daha verimli-etkin çalışmak için Cobot'un konfigürasyonunu değiştiriyor mu?	Evet / Hayır	Evet ise hangi sıklıkta/hangi durumlarda yaptığını açıklar mısınız?	Human Related	Ability Based	Competency	Existing

Sorular	Cevaplar	Yorumlar	Type of The Question	Factors	Attributes	Potential/ Existing
Hata ya da kaza durumunda sistemi tasarlayan/uygulayan uzman sisteme uzaktan müdahale edebiliyor mu?	Evet / Hayır	Evet ise hangi sıklıkta ve ne tür müdahaleler olduğunu örnekler misiniz?	Deployer Related	Performance Related	Remote intervention	Potential
Cobot hatalarından öğrenip, önleyici önlemler alıyor ya da öğrendiği öngörülerini sistemi tasarlayan/uygulayan uzmana gönderiyor mu?	Evet / Hayır	Evet ise örnek verebilir misiniz?	Robot Related	Attribute Based	Feedback Loop	Existing
Cobotların robotlara göre avantaj /dezavantajları nelerdir?			Robot Related	Performance Related	Added Value	Potential
Cobotların kullanım ömürleri nasıl? Çok fazla parça değiştiriyor musunuz?			Robot Related	Performance Related	Failure Rates	Existing
Cobotları yan ekipmanlar ile kullanıyor musunuz? (kamera sistemi, data sistemleri)			Robot Related	Attribute Based	Adaptability	Existing
Bir den fazla cobot koordineli çalışıyor mu?			Contextual	Team Collaboration	In-group membership	Existing
Cobotların kullanımı kolay mı? Operatorler olarak arızaların % kaçını yapabiliyorsunuz?			Human Related	Ability Based	Competency	Existing
Cobotlar gelen ambalaj malzemelerindeki hataları tolere edebiliyor mu? Yoksa küçük duruşlar mı yaşıyorsunuz?			Robot Related	Performance Related	Predictability	Existing

The survey was on Excel Sheets and shared via e-mails with 11 different operators from 3 different factories in 3 different cities: Istanbul, Konya, Tekirdağ. The results were gathered back via e-mail between 17.05.2022 and 25.05.2022 (Appendix E).

4.1.5 Data Collect for the Last Interview

As the last data collection step of the research, the survey data was shared with the new Unilever Turkey Supply Chain Director responsible from Cobot Operations. The previous Supply Chain Director was retired; therefore, the last interview was done with his successor Director working for Unilever and Cobots for 20 years. The new director was part of the research from the very beginning as he was one of the Actors on our preliminary study. It was face-to-face semi-structured interview with a mixture of prepared questions and prompt questions. The questions prepared in advance were aimed to refine the answers of Operators already surveyed. Prepared questions:

1. Who is the 3rd party resource interacted with Operator?
2. How is the sourcing of 3rd party person done? What are the names of the outsource resource providers?
3. How is the training done by the operator or 3rd party resource?
4. Any orientation program or regular training regarding Cobots usage for operators?
5. Who is using the monitoring and reporting system? How do you interpret/action on the insights reported?
6. Can Cobot replace operator? Do they feel Cobots threatening their employment?
7. Do you ever calibrate the Cobots according to Operator needs or feedbacks?

Additionally, we asked prompt questions to understand his expert point of view on Human Cobot Interaction and the importance of Trust Calibration for Unilever. He

also reviewed the results of previous data collection steps to verify the existing and new attributes accumulated throughout the research (Appendix F).

4.2 Data Analysis

4.2.1 Processing the Outcome of Non-Participant Observation Data

This was the first step on the data collection, and we had very limited information about the circumstances on the shop floor of a FMCG company. Our initial codes were generic based on our preliminary study and background research. During non-participant observation, we observed the different types of Cobots working with Operator on packing activity at Unilever Besan Factory. As there are many strict factory rules, our observation was limited with photo taking and getting field notes from a remote location. After the visit, the photos and notes were used to identify patterns and map with the initial “Themes” (Table 4.3). We used Reference Trust Model to map the observations.

Table 4.3 *Data Analysis Steps for Non-Participant Observation*

Data Analysis Steps	
Initial Coding	Cobots
	Technology
	Operator
	Factory
	Production
	Interaction
	Safety
Generating Themes	Actors
	Reshaping FMCG Supply Chain
	Cobots Usage
	Adoption Framework
Thematic Mapping	Initial themes mapped & verified
	Many attributes were not found or recognized
Refining Themes	Existing themes validated
	A new theme/dimension discovered: Deployer

Findings:

As the observation was limited in many ways, many attributes were not found or recognized. The most important findings were (Table 4.4):

Table 4.4 *Findings for Non-Participant Observation*

A new dimension discovered	There are other parties on the shop floor like engineer and technician interfering with Cobot and/or Operator. This finding is in line with recent research (Cameron & Collins, 2021).
There is an issue with "Human Robot Interaction"	There are rules for "separation" than "collaboration".
Safety has a framework	Safety rules are very clear and applied in discipline.

4.2.2 *Processing the Outcome of Document Analysis Data*

Document analysis was used as a qualitative research technique in this Case Study of Unilever Turkey. The process involved evaluating electronic documents to interpret them, gain an understanding of their meaning and derive some points to build up the constructs related with "Trust Models in HRI". The documents provided by Factory Director were the presentation named as "Collaborative robotics Briefing for Factory Directors" and a training document named as "Cobot Operating Manual". I studied the content and structure of the documents to identify the content, and understand the themes related with my research area.

Our document analysis process considered a cautious and focused re-reading and review of the documents. We looked at the data in hand, carried out coding sentences and word groups based on the data's characteristics to disclose themes applicable to our Trust phenomenon. Predefined codes re-used the document analysis is auxiliary to non-participant observation deployed in this study (Table 4.5).

Table 4.5 *Data Analysis Steps for Document Analysis*

Document #1	Collaborative Robotics Briefing for Factory Directors
Initial Coding	Collaborative robots
	Cobots
	Technology
	Objective
	New World
	Change
	Safety
	Cost
	Market
	Fast
	Agile
	changing set of business & consumer needs
	Super-users
	Early Adopters
	Change leaders
	Safety
	Quality
	Finance support
Generating Themes	Reshaping FMCG Supply Chain
	Cobots Usage
	Adoption Framework
Refining Themes (Initial themes are validated)	Reshaping FMCG Supply Chain
	Cobots Usage
	Adoption Framework

Findings:

The first document was a Cobot implementation feasibility study prepared for 8 factories in different Unilever countries: Turkey, Israel, Russia, UAE. In this feasibility study, we have seen the problems to be solved by using Cobots and project details regarding the scope, the cost and the time (2017-2018). With the help of this study Unilever decided to reshape their Supply Chain, and start using Cobots for the locations including our Case Study area. The document verifies our initial argument that “**FMCG industry must embrace technology and robotics as a means to achieve future success.** This industry needs to consider how to get benefit of robot evolution and improve working conditions, productivity and profitability in cases where manual labor cannot be replaced by but can be cooperated with robots” (Table 4.6).

Table 4.6 *Data Analysis Steps for Document Analysis*

Document #2	Cobot Operating Manual for Operators
Initial Coding	Trainer
	Function
	Safety
	System Requirements
	Handler Unit
	Mobile Unit
	Set Up
	Workflows
	Tasks
	Program
	Calibration
	Modifying
	Troubleshooting
	Error
	Solution
Generating Themes	Emergency
	Test
	Cobot Set Up
	Cobot Calibration
	Deployer
Refining Themes (Initial themes are validated)	Cobot Technical Issues & Resolution
	Cobot Operating Model Manual for Operators
	Deployer should be added as a new theme with new attributes like Feedback Loop, Monitoring, Remote Intervention.
	Cobot Set Up
	Cobot Calibration
	Cobot Technical Issues & Resolution

Findings:

The second document was Autonomous Cobot Essay Operating Procedure prepared in 2020 as a training document and manual for deployers. The document is very useful to go beyond our experience and knowledge as researchers and help us to get partially trained about how to manage a Cobot system.

This document introduces the Cobot with all the components either hardware or software. And also it explains the interaction between Cobot and the operator such as user tasks, notification tasks, troubleshooting and emergency. This document strengthen the role of deployer in the human robot interaction design by explaining deployer's role and

responsibilities in this guide. The document supports the interpretation of themes with the support of data provided for Unilever domain.

4.2.3 Processing the Outcome of First Interview Data

Semi-structured interview was done with a Senior Director responsible from Cobot Operations at Unilever Turkey Supply Chain Function. As we planned to follow cyclical approach on Data Analysis, we would like to structure the the steps of the process thematic data analysis in the same order: Qualitative Data, Coding, Generating Themes. With this approach, we accumulate the knowledge at each phase and then feed into the original Reference Trust Model.

The questions prepared in advance were aimed to check the validity of the findings from the previous steps of Data Collection and Analysis. Additionally, I asked prompt questions to understand his expert point of view on Human Cobot Interaction and the importance of Trust Calibration for Unilever. The answers to these questions in turn generated a new set of data to analyze for Unilever Turkey (Table 4.7).

Table 4.7 *Data Analysis Steps for The First Interview*

Initial Coding	Safety
	Risk
	Interaction Design
	Deployer
	Set up
	Deployment
	Cobot
	Fence
	Robot
	AGW
	Tasking
	Operator
	Collaboration
	Interaction
	Teamwork
	Payback
	Cost Saving
	Effectiveness
	Performance
	Packaging
	Failures
	Intervention
	Adoption
	Production Loss
	Misuse
	Damage
	Job loss
Generating Themes	Interaction Design
	Instructions for HR
	Trust Calibration
	Safety
	Saving
Refining Themes: Initial Themes are validated, and a few attributes added to the Trust Model	Interaction Design
	Instructions for HR
	Trust Calibration
	Safety
	Saving

Findings:

Once again *Thematic Analysis* was used to analyze the data collected. The themes for the interview were Interaction Design, instructions for Human Resource Management, Trust Calibration, Safety and Cost Saving. The answers to the questions in turn generated a new set of attributes to be analyzed for Unilever Turkey:

- **Interaction Design:** Cobots are easy to program, fast to set up and enable flexibility within automation. Deployer should be able to understand the process and the interaction need first and then complete the deployment with the necessary hardware and software configurations.

- **Instructions for Human Resource Management:** Collaboration requires a teamwork. Human resources should define the roles and responsibilities for each part of the interaction. The instruction for Cobot should be given the deployer for Cobot design, the instructions for Operator should be given directly the Operator group as trainings, workshops, change management activities.

-**Trust Calibration Cues:** As Cobots used for a while in this company, they have started to learn how to increase the engagement by doing some adjustments on the Cobot, Operator or the environment to increase the trust level of the interaction.

4.2.4 Processing the Outcome of Survey Data

Adjusted Trust Model with new dimension and attributes was first tested by the survey applied to operators working for Unilever Turkey using Cobots on different production activities. The survey was applied to **11 different operators** at **3 factories** in **3 different cities:** Istanbul, Konya, Tekirdağ.

The outcome of this survey was used to generate an in-depth, multi-faceted understanding of Human and Cobot Trust issue in its real-life context of FMCG. In this study, we have seen **5 different types of Cobots** and Cobot Vendors active for **packaging, parceling, palletizing, feeding the production line** (Table 4.8).

Table 4.8 *Cobot Analysis*

City	Factory	Cobot Vendor	Cobot Function
İstanbul	Besan	Universal Robots/ Kuka	Paketleme
İstanbul	Besan	Universal Robots/ Kuka	Kolileme/ paetleme
İstanbul	Besan	Universal	Kolileme
İstanbul	Besan	Kibele	Hat sonu toplama
İstanbul	Besan	ABB, Universal (Kol), Kuka	Kolileme/ paetleme/ hat ürün besleme
İstanbul	Besan	ABB, Universal (Kol), Kuka	Kolileme
İstanbul	Besan	Universal	Paketleme/ kolileme
İstanbul	Besan	KİBELE	Kolileme
İstanbul	Besan	KİBELE	Kolileme
Tekirdağ	Dondurma	FANUC	Kolileme
Tekirdağ	Dondurma	FANUC	Kolileme
Konya	Dondurma	KİBELE	Kolileme
Konya	Dondurma	KİBELE	Kolileme

Users interacting with Cobots are mostly senior operators with average 14 years of experience and average 4 years working with Cobots. They are working in a collaborative environment with Cobots and other parties like technician, engineer, developer or other operators (Table 4.9).

Table 4.9 *User Analysis*

City	Factory	User Role	User Education Level	User Experience in FMCG (years)	User Experience working with Cobots (years)	Cobot Vendor	Cobot Function	3rd Parties Involved into Process
İstanbul	Besan	Operatör	Lise	14	4	Universal Robots/ Kuka	Paketleme	Operatör
İstanbul	Besan	Operatör	Üniversite	0,25	0,25	Universal Robots/ Kuka	Kolileme/ paletleme	Operatör
İstanbul	Besan	Operatör	Lise	21	2	Universal	Kolileme	Operatör
İstanbul	Besan	Operatör	Lise	21	9	Kibele	Hat sonu toplama	Elektrikçi
İstanbul	Besan	Operatör	Lise	20	5	ABB, Universal (Kol), Kuka	Paketleme/ kolileme/ paletleme/ hat ürün besleme	Servis
İstanbul	Besan	Operatör	Lise	17	5	ABB, Universal (Kol), Kuka	Kolileme	Mühendis, Developer
İstanbul	Besan	Operatör	Lise	20	3	Universal	Paketleme / kolileme	Tasarımcı
İstanbul	Besan	Operatör	Lise	20	5	KİBELE	Kolileme	Mühendis / Teknisyen
İstanbul	Besan	Operatör	Ortaokul	15	2	KİBELE	Kolileme	Developer
Tekirdağ	Dondurma	Operatör	Lise	10	4	FANUC	Kolileme	Operatör
Tekirdağ	Dondurma	Operatör	Lise	8	4	FANUC	Kolileme	Operatör
Konya	Dondurma	Operatör	Lise	8	4	KİBELE	Kolileme	Operatör
Konya	Dondurma	Operatör	Lise	10	5	KİBELE	Kolileme	Operatör

When we asked questions regarding the everyday usage of Cobots to understand if they are working smoothly by ensuring safety, interaction, and collaboration, all the operators agreed on efficient co-working on different aspects (Table 4.10).

Table 4.10 *Human Cobot Interaction/Usage Analysis*

Cobotların kullanım ömürleri asıl? Çok fazla parça değiştiriyor musunuz?	Cobotları yan ekipmanlar ile kullanıyor musunuz? (Kamera sistemi, data sistemleri)	Bir den fazla cobot koordineli çalışıyor mu?	Cobotların kullanımı kolay mı? Operatorler olarak arızaların % kaçını yapabiliyorsunuz?	Cobotlar gelen ambalaj malzemelerindeki hataları tolere edebiliyor mu? Yoksa küçük duruşlar mı yaşıyorsunuz?
Evet	Evet	Evet	Kolay	Küçük duruşlar
Uzun. Nadiren parça değişiyor	Evet	Evet	Kolay	Küçük duruşlar
Hayır	Hayır	Hayır	Kolay	Küçük duruşlar
Hayır	Hayır	Hayır	Kolay	Küçük duruşlar
Sorunsuz	Evet	Evet	Kolay	Küçük duruşlar
Uzun kullanımlı, parça değişimi nadir	Hayır	Evet	Kolay	Küçük duruşlar
	Evet	Evet	Kolay	Küçük duruşlar
Uzun vantuzlar. 3-6 ay arası değişmesi gerekiyor	Hayır	Evet	Kolay	Küçük duruşlar
Uzun, çok parça değişmiyor	Hayır	Evet	Kolay	Küçük duruşlar
Bakımı kolay	Hayır	Evet	Kolay	Küçük duruşlar
Bakımı kolay	Hayır	Evet	Kolay	Küçük duruşlar
Bakımı kolay	Hayır	Evet	Kolay	Küçük duruşlar
Bakım maliyetleri var. Belli bir periyotta parça değişimleri vs.	Hayır	Evet	Kolay	Küçük duruşlar

Finally, we asked questions to understand if any other party is involved into the closed loop of human and Cobot, we saw that **all of them** described a 3rd party on different activities. However, their relationship with this 3rd party is not strong as **half of them don't feedback** to this 3rd party, and they are **not aware that this 3rd party is responsible** monitoring the interaction loop and fixing the issues if necessary. This shows that there is a weak relationship between the two entities of the closed loop. Operator mostly thinks that there is no direct relationship between the deployer and himself/herself, it is through the Cobot (Table 4.11).

Table 4.11 *Deployer Impact Analysis*

Şehir	Fabrika	Cobot'la çalışırken en çok etkileşime geçilen kişiler	Cobot'un sağladığı fayda	Cobot-Operatör birlikte çalışma modelinizde sistemi konfigure eden/yöneten operatör dışında biri var mı?	Operatör sistemi tasarlayan/uygulayan uzmana geri bildirimde bulunuyor mu?	Sistemden otomatik olarak ya da operatörden sistemi tasarlayan/uygulayan uzmana alarm ya da bildirim gidiyor mu?
İstanbul	Besan	Operatör	Doğruluk / hız	Hayır	Evet	Hayır
İstanbul	Besan	Operatör	Üretkenlik/ maliyet azalması / doğruluk / hız / kalite	Hayır	Hayır	Hayır
İstanbul	Besan	Operatör	Maliyet azalması / hız	Hayır	Evet	Hayır
İstanbul	Besan	Elektrikçi	Maliyet azalması	Hayır	Hayır	Hayır
İstanbul	Besan	Servis	Üretkenlik/ doğruluk / hız / kalite	Hayır	Hayır	Hayır
İstanbul	Besan	Mühendis, Developer	Maliyet azalması / hız	Hayır	Evet	Hayır
İstanbul	Besan	Tasarımcı	Üretkenlik	Hayır	Hayır	Hayır
İstanbul	Besan	Mühendis/ Teknisyen	Üretkenlik/ doğruluk	Hayır	Hayır	Hayır
İstanbul	Besan	Developer	Doğruluk / hız	Hayır	Hayır	Hayır
Tekirdağ	Dondurma	Operatör	Maliyet azalması / kalite	Evet	Evet	Evet
Tekirdağ	Dondurma	Operatör	Maliyet azalması / kalite	Evet	Evet	Evet
Konya	Dondurma	Operatör	Maliyet azalması / kalite	Evet	Hayır	Hayır
Konya	Dondurma	Operatör	Maliyet azalması / kalite	Evet	Evet	Evet

Şehir	Fabrika	Sistemi tasarlayan/ uygulayan uzman sistemin durumunu, operatör ile ilgili kriterleri izliyor ve raporluyor mu?	Operatör sistemde performans iyileştirmesi yapmak, daha verimli-etkin çalışmak için Cobot'un konfigürasyonunu değiştiriyor mu?	Hata ya da kaza durumunda sistemi tasarlayan/ uygulayan uzman sisteme uzaktan müdahale edebiliyor mu?	Cobot hatalarından öğrenip, önleyici önlemler alıyor ya da öğrendiği öngörülerini sistemi tasarlayan/ uygulayan uzmana gönderiyor mu?	Cobotların robotlara göre avantaj/dezavantajları nelerdir?
İstanbul	Besan	Hayır	Hayır	Hayır	Hayır	İşçi azalması
İstanbul	Besan	Hayır	Evet	Hayır	Hayır	Çok fonksiyonluluk
İstanbul	Besan	Hayır	Hayır	Hayır	Hayır	Hayır
İstanbul	Besan	Hayır	Hayır	Hayır	Hayır	Hayır
İstanbul	Besan	Hayır	Evet	Hayır	Hayır	Daha hızlı, güvenli, sorunsuz
İstanbul	Besan	Hayır	Hayır	Hayır	Hayır	Fazla iş avantajı, ayar ve müdahale noktası fazla dezavantajlı
İstanbul	Besan	Hayır	Evet	Hayır	Hayır	Cobotlara rahatlıkla müdahale edilebilir
İstanbul	Besan	Hayır	Hayır	Hayır	Hayır	Birçok işi aynı anda yapabiliyor
İstanbul	Besan	Hayır	Hayır	Hayır	Hayır	Değişkenlik
Tekirdağ	Dondurma	Evet	Hayır	Evet	Hayır	Daha küçük, insanlarla iç içe çalışabilmesi
Tekirdağ	Dondurma	Evet	Hayır	Evet	Hayır	Daha küçük, insanlarla iç içe çalışabilmesi
Konya	Dondurma	Hayır	Hayır	Evet	Hayır	Daha küçük, insanlarla iç içe çalışabilmesi
Konya	Dondurma	Hayır	Hayır	Hayır	Evet	

Findings:

The survey helped us to understand the depth of the interaction between Human-Cobot team from the operator perspective. On this survey, we used the descriptive model by Hancock, but also, we added our own dimension and attributes to understand the evolving relationship between humans and robots since Hancock study. Building our survey based on a Trust model helped us to understand the trust level, and the interaction quality as there is a strong correlation between these factors.

4.2.5 Processing the Outcome of Last Interview Data

As the last data collection step of the research, the survey data was shared with the new Unilever Turkey Supply Chain Director responsible from Cobot Operations. We first reviewed the Survey Data. He confirmed that the responses to the survey questions are consistent with his real-life observations. He also assessed their level of knowledge regarding the usage of Cobots, advantages, disadvantages, any new obstacles arisen by operators or not. Then we assessed “Adjusted Trust Model” by progressive development of codes and themes from data collected in 4 different data collection steps till the very last interview. He found all the new attributes and the new dimension of Cobot will be beneficial for FMCG in order to measure and calibrate the level of trust in Human Cobot interaction. (Table 4.12)

Table 4.12 *Data Analysis Steps for Document Analysis*

Initial Coding	Cobot Operator 3rd Party Monitoring Maintenance Reporting Employment Training Suppliers Survey Responses
Generating Themes	Cobot Operator Collaboration Operator Skill and Training Cobot Adoption
Refining Themes (Initial themes are validated)	Cobot Operator Collaboration Operator Skill and Training Cobot Adoption

Findings:

According to Supply Chain Director, there is a great focus and investment to increase the Cobot usage on the shop floor other. Unilever Turkey prefers Cobots to Robots. Robots are more industrial, fast and dangerous. Cobots are more suitable and safer to use on the shop floor to cooperate with human. Cobots cost less than industrial robots and have better pay back period. Unilever has a strong procedure to design, test and deploy each Cobot procured. There are simulation and deployment tests in terms of efficiency, speed and safety using 3D models. However, there are still manual work done on the shop floor, and they don't use the Cobots at full potential. In the last decade, Unilever operators are used to work with Cobots and they don't feel Cobots threatening their job. But still there is a trust issue on the shop floor which challenges the operational effectiveness. As analysed on the case study, the trust building role of 3rd party (Deployer) on different channels from training to maintenance was underestimated.

However, it is necessary to understand the nature of trust in on the social triad of Human-Cobot-Deployer for FMCG.

4.2.6 General Outcomes

Even though we have investigated 9 data collection methods, we eliminated 4 of them due to several reasons. And then we have applied 5 different data collection methods successfully but with a few difficulties (Table 4.13):

Table 4.13 *Difficulties on Data Collection Methods*

Data Collection Method	Difficulties
Non-Participant Observation	Duration of the observation was limited due to strict workplace and safety rules on shop floor.
Document analysis	Documents Requires expertise on the industry to understand and comment. Our knowledge and experience as researcher was limited
First Interview	We had only one subject matter expert to interviewed.
Survey	Our study population was small as there are limited number of operators.
Last Interview	The subject matter expert on the first interviewed were retired. Therefore, the second interview was done with hi successor. We had to repeat the history and explain the things again

Cyclical data approach helped us to use different data collection methodologies at different time. (Table 4.14) At the end of the data collection and analysis period we have seen that every outcome joined to build up our target Adjusted Trust Model.

Table 4.14 *Cyclical Approach to Build up Adjusted Trust Model*

Data Collection Method	Findings	Theoretical Mapping	Adjustments on the Trust Model
Non-participant Observation	A new dimension discovered	There are other parties on the shopfloor like engineer and technician interfering with Cobot and/or Operator. This finding is in line with a recent research (D.Cameron, E.C. Collins, 2021)	New Context: Deployer
Non-participant Observation	There is an issue with "Human Robot Interaction"	There are rules for "separation" than "collaboration"	No adjustment to Trust Model
Non-participant Observation	Safety has a framework	Safety rules are very clear and applied in discipline	No adjustment to Trust Model
Document Analysis	Documents were useful to gain an understanding of their meaning and derive some points to build up the constructs related with "Trust Models in HRI"	Deployer should be added as a new Context. New attributes should be added: Feedback Loop, Monitoring, Remote Intervention	New Context: Deployer New Attributes: feedback Loop, Monitoring, Remote Intervention
First Interview	Initial Themes are validated, and a few new attributes added to the Trust Model.	New attributes should be added: Interaction Design, Instruction for HR, Trust Calibration Cues	New attributes: Interaction Design, Instruction for HR, Trust Calibration Cues
Survey	The survey helped us to understand the depth of the interaction between Humand and Cobot team from the operator perspective	Existing and New attributes are surveyed to verify if Trust Model factors applicable onto FMCG	Existing and New attributes are validated by Operators
Last Interview	Initial themes are validated.	All the context and attributes are reviewed and approved.	Existing and new attributes are assessed and approved by Subject Matter Experts

When we applied cyclical approach, we came up with “Deployer Related Attributes,” which represent a pivotal outcome of our research, as it systematically delineates the specific attributes through which the deployer exerts influence on trust within human-robot collaboration. (Table 4.15) In this table, we categorize 11 attributes under four principal contexts—performance, attribute-based, ability-based, and tasking—encompassing elements such as feedback loops, monitoring, level of automation,

communication methods, failure rates, interaction design, and remote intervention. The empirical validation of these attributes, achieved through fieldwork and expert consensus, demonstrates that trust in Cobots is not solely a function of the robot and the human, but is critically dependent on the ongoing actions and design decisions of the deployer. This expanded model offers actionable insights for organizations aiming to enhance trust and facilitate the adoption of automation on the shop floor. In summary, Table 4.15 forms the foundation of our adjusted trust model, bridging theoretical constructs and practical application in the context of industrial human-robot collaboration.

Table 4.15 *The Deployer Model Attributes*

Deployer Related Attributes			
Context	KPI	Definition	Captured Research Methodology
Performance Related	Feedback Loop	Page 8, 15: MiR controller: Cobots have controller to set up the specific movement, to monitor the activities, and to troubleshoot for the errors like Timeout, Robot cannot read label, Emergency Break etc. A feedback loop is a mechanism that compares the actual output of a system with the desired output, and adjusts the input. Deployer has the skill and responsibility to design feedback control algorithms which compute commands to the actuators based upon the error between the current state of the robot and its target state.	Document Analysis, Survey
	Monitoring	Page 8, 15: MiR controller: On-line monitoring system tracks the physical conditions of the Cobot, while performing HRC processes. The monitoring system alerts a human operator or deployer whenever a cobot displays improper or erratic behavior.	Document Analysis, Survey

Table 4.16 *The Deployer Model Attributes*

Deployer Related Attributes			
Context	KPI	Definition	Captured Research Methodology
Performance Related	Feedback Loop	Page 8, 15: MiR controller : Cobots have controller to set up the specific movement, to monitor the activities, and to troubleshoot for the errors like Timeout, Robot cannot read label, Emergency Break etc. Feedback loop is A feedback loop is a mechanism that compares the actual output of a system with the desired output, and adjusts the input. Deployer has the skill and responsibility to design feedback control algorithms which compute commands to the actuators based upon the error between the current state of the robot and its target state.	Document Analysis, Survey
	Monitoring	Page 8, 15: MiR controller : On-line monitoring system tracks the physical conditions of the cobot while performing HRC processes. The monitoring system alerts a human operator or deployer whenever a cobot displays improper or erratic behaviour.	Document Analysis, Survey
	Level of automation	Page 3 : Show-casing automation for end-users to highlight potential benefits Cobot automation is a new technology in the field of robots and differs from traditional automation options. The main difference between cobots and traditional robots is the degree of sensitivity of a cobot. A cobot is equipped with sensors that ensure the cobot is sensitive to the environment and touch. The newest cobots use no programming at all. They learn their tasks from their human deployers. The deployer moves the cobot through the steps of the job and the cobot learns.	Document Analysis

Deployer Related Attributes			
Context	KPI	Definition	Captured Research Methodology
	Communication Method	Page 32: Changing the sound and light, Page 11 Notification tasks will notify the user with a message this can be in warning, error or information format. physical human–robot interaction is no longer a nuisance but instead an opportunity for improved human–machine communication and closer collaboration. Human–robot teams rely on embodied communication—a multimodal exchange of information through actions, touch, forceful interaction, biometric signals, verbal cues, and more. In its current form, communication is often designed by deployer and unidirectional and static over time.	Document Analysis
	Failure Rates	Accuracy and precision are set and tested via MiR Controller Despite their reliability, also Cobots are subjected to degradation and functional failures may influence their operation, leading to anomalous trajectories. In this context, Cobots can be controlled and programmed to ensure their expected performance.	Document Analysis
	False Alarms	Page 35 Time out errors, Page 36 Emergency Break Fault detection and diagnostics of the Cobots monitored by Controllers can be improved by setting different types of alarms by Deployer.	Document Analysis
Attribute Based	Interaction design	Cobots are developed to reduce users' workload. In this context, the human workers and Cobots share tasks and the workspace. Traditionally, design of such machinery has focused on functionality and safety. But we have seen that this is not enough. We need to have experience-driven design goals: fellowship and sympathy; inspiration; safety and trust; and accomplishment to have improved collaboration. (Ref UX for Cobots Article)	First Interview

Deployer Related Attributes			
Context	KPI	Definition	Captured Research Methodology
Ability Based	Instructions for HR	<i>Cobot controller designed and managed by deployer can monitor and log the activities for HR departments in order to understand if there is a misuse (training need), disuse (resistance) or abuse (underutilization or damage).</i>	<i>First Interview</i>
Tasking	Trust Calibration Cues	<i>Cobot manufacturers, programmers or deployers can get some feedbacks from the field in order to improve Cobot or Contextual Factors in Human Cobot Trust Construct.</i>	<i>First Interview, Survey</i>
	Task Type	<i>Page 11: User Tasks will open a pop up for the user which can include fields for the user to input. Operator of the Cobot can access to the controller designed by Deployer to change the settings of the tasks in the collaboration.</i>	<i>Document Analysis</i>
	Remote intervention	<i>Page 16: Put the IP of the robot followed by "/camera". In this case: 192.168.12.20/camera Deployer of the Cobot can monitor the physical conditions and stop/change the set up in case of an improper or erratic behaviour</i>	<i>Document Analysis, Survey</i>

5.VALIDATION AND IMPLEMENTATION OF THE DEPLOYER MODEL

Our Deployer model derived in Table 5.1 includes 11 attributes, $j=1,2,\dots,11$ grouped in 4 contexts as provided below in Table 5.1.

Table 5.1 *Attributes of the Deployer Model*

Context	Attributes	Index j
Performance Related	Feedback Loop	$j= 1$
	Monitoring	$j= 2$
	Level of automation	$j= 3$
	Communication Method	$j= 4$
	Failure Rates	$j= 5$
	False Alarms	$j= 6$
Attribute Based	Interaction design	$j= 7$
Ability Based	Instructions for HR	$j= 8$
Tasking	Trust Calibration Cues	$j= 9$
	Task Type	$j= 10$
	Remote intervention	$j= 11$

To ensure the reliability and validity of our Deployer Model with 11 deployer related attributes, we followed a structured three-step validation process:

1. **Significance Assessment of the Deployer Attributes:** We first evaluated whether each attribute of the Deployer model was perceived as important. By using the Fuzzy Delphi Method (FDM), we applied the Deployer model in a manufacturing environment to assess the significance of Deployer attributes in building trust with the cobot. The study was conducted among 15 manufacturing operators at Unilever. This step helped us confirm that the Deployer model addresses relevant and meaningful attributes. The details are provided in Section 5.1.
2. **Use-Case Implementations of the Deployer Model:** Next, we generated two use-cases where we applied the Deployer model in two FMCG companies, i.e., Unilever

(Section 5.2) and Benoplast (Section 5.3). By using FDM, we assessed the level of Deployer Attributes in each company. The use-cases were conducted among 11 operators at Unilever and 11 operators at Benoplast. This ensured that the model is grounded in observable reality rather than theoretical assumptions.

3. **Analysis of the Use-Case Performances:** Finally, we compared the Deployer performances at Unilever and Benoplast (Section 5.4). We showed that the Deployer model can be used to generate improvement directions to provide higher trust levels in human-robot collaboration. This step confirmed the model's usability and relevance for decision-making. We finalize our validation and implementation by referring to the limitations of our Deployer model validation (Section 5.5)

In the following sections, we provide the details of our validation and implementation steps at Unilever and Benoplast as the selected FMCG companies.

5.1 Significance Assessment of the Deployer Attributes at Unilever

Now we assess the significance of the 11 attributes our Deployer model in generating trust. To achieve this, we apply Fuzzy Delphi Method (FDM) among 15 operators in our case study environment at Unilever.

FDM is applied in 3 steps which enabled us to gather feedback directly from end users, ensuring the model's relevance and applicability in real-world cobot deployment scenarios:

1. Preparation of the questionnaire (Section 5.1.1)
2. Collecting data from the operators (Section 5.1.2)
3. Generation of the FDM scores (Section 5.1.3)

5.1.1 Preparation of the Questionnaire:

We prepared a questionnaire to assess the significance of the attributes of the Trust Model. The survey had 34 questions and composed of two main parts:

- a. Initial Trust Rating Question: A single question
 - b. Deployer Attributes Significance Ratings: 33 questions
- a. Initial Trust Rating Question:** The purpose of the question (Figure 5.1) was to gauge the respondent's overall trust level in working with cobots. We chose to define trust in human-robot collaboration through the lenses of physical harm, job performance impact, and psychological well-being because these dimensions consistently emerged as critical in both the literature and field observations. Foundational models like Hancock's and recent updates by Khavas et al. emphasize these factors as central to trust calibration (Hancock, 2011; Khavas et al., 2021). Factory Director feedback and survey validation further confirmed their relevance in real-world settings. This approach ensures that the trust model is both theoretically grounded and practically applicable.

Figure 5.1 *Initial Trust Rating Question*

Cobot'lar operatörlerin iş yükünü azaltmak için geliştirildi. Bu bağlamda, operatörler ve Cobot'lar görevleri ve çalışma alanını paylaşıyorlar.

Cobot ile beraber çalışırken kendinizi güvende hissediyor musunuz? Cobot'un size fiziksel zarar vermesi, beraber yaptığınız işe zarar vermesi, sizin iş tatmin ve motivasyonunuzu azaltması gibi sorunlara neden olacağını düşünüyor musunuz? Cobot ile işbirliğiniz açısından güven seviyenizi işaretlemenizi rica ederiz:

- 1: Çok düşük
- 2: Düşük
- 3: Orta
- 4: Yüksek
- 5: Çok yüksek

b. Deployer Attributes Significance Ratings: The purpose of this set of questions were to evaluate how important the deployer attributes are in contributing to the operator's sense of trust. The focus was the same as the first question: Physical harm, job performance impact, and psychological well-being; and the scale was 1 (Very Low) to 5 (Very High). The questionnaire is provided below in Table 5.2.

Table 5.2 *The Questionnaire for the Significance of Deployer Attributes*

Lütfen günlük çalışma rutininizi düşünerek aşağıdaki faktörlerin Cobot ile çalışırken kendinizi güvende hissetmeniz için ne kadar önemli olduğunu işaretleyiniz: (1: Çok önemsiz, 2:Önemsiz, 3:Kararsız, 4:Önemli, 5:Çok önemli)		
Deployer Attribute	Trust Dimension	Question
Geribildirim Döngüsü:	Kontrolör ya da tasarımcıya geri bildirim döngüsü olması kendinizi güvende hissetmeniz için ne kadar önemlidir?	Size fiziksel zarar vermesi açısından
	Cobot'ların belirli hareketi ayarlamak, aktiviteleri izlemek ve “zaman aşımı, robot etiketi okuyamıyor, acil durum durdurması” vb. hataları gidermek için kontrolleri vardır. Geri besleme döngüsü bir mekanizmadır. Cobot’la ilgili kontrollerin gerçek çıktısını beklenen çıktıyla karşılaştıran, bu durumlarla ilgili raporları tasarımcısına gönderen mekanizmadır.	Size psikolojik zarar vermesi açısından
		Beraber yaptığımız işe zarar vermesi açısından
İzleme	İzleme sisteminin olması kendinizi güvende hissetmeniz için ne kadar önemlidir?	Size fiziksel zarar vermesi açısından
	İzleme sistemi, Cobot'un fiziksel koşullarını ve beraber çalışma süreçlerini inceler. Bir Cobot uygunsuz veya kararsız davranış gösterdiğinde bir insan operatörü veya tasarımcıyı uyarır.	Size psikolojik zarar vermesi açısından
		Beraber yaptığımız işe zarar vermesi açısından
Otomasyon Seviyesi	Otomasyon seviyesinin iş isterlerine uygun olacak şekilde geliştirilmiş olması kendinizi güvende hissetmeniz için ne kadar önemlidir?	Size fiziksel zarar vermesi açısından

Lütfen günlük çalışma rutininizi düşünerek aşağıdaki faktörlerin Cobot ile çalışırken kendinizi güvende hissetmeniz için ne kadar önemli olduğunu işaretleyiniz: (1: Çok önemsiz, 2:Önemsiz, 3:Kararsız, 4:Önemli, 5:Çok önemli)

Deployer Attribute		Trust Dimension	Question
Otomasyon Seviyesi	Cobot otomasyonu, robotlar alanında yeni bir teknolojidir ve geleneksel otomasyon seçeneklerinden farklıdır. Bir cobot, cobot'un çevreye ve dokunmaya duyarlı olmasını sağlayan sensörlerle donatılmıştır. En yeni cobot'lar hiçbir programlama kullanmaz. Görevlerini tasarlayıcılardan öğrenirler. Tasarlayıcı cobot'u işin adımları boyunca hareket ettirir ve cobot öğrenir.	Size psikolojik zarar vermesi açısından	Q8
		Beraber yaptığınız işe zarar vermesi açısından	Q9
İletişim Metodu	İnsan ve Cobot ekip olarak çalışırken birbirleri ile etkin iletişimde olması güveni ne kadar etkiler?	Size fiziksel zarar vermesi açısından	Q10
	Ekip olarak eylemler, dokunma, güçlü etkileşim, biyometrik sinyaller, sözlü ipuçları ve daha fazlası yoluyla çok modlu bir bilgi alışverişi olan somutlaştırılmış iletişime güvenir. Mevcut haliyle iletişim genellikle tasarımcı tarafından tasarlanır, zaman içinde tek yönlü ve statiktir.	Size psikolojik zarar vermesi açısından	Q11
		Beraber yaptığınız işe zarar vermesi açısından	Q12
Arıza Oranları	Cobot'un normal çalışma düzenini bozacak ya da verimliliği düşürecek arızalarının oranının fazla olması güveni ne kadar etkiler?	Size fiziksel zarar vermesi açısından	Q13
	Cobot'lar da bozulmaya maruz kalıyor ve fonksiyonel arızalar operasyonlarını etkileyerek anormal yörüngelere yol açabilmektedir. Bu bağlamda Cobot'lar, beklenen performanslarını sağlamak için arıza oranları kontrol edilebilir ve programlanabilir.	Size psikolojik zarar vermesi açısından	Q14
		Beraber yaptığınız işe zarar vermesi açısından	Q15

Lütfen günlük çalışma rutininizi düşünerek aşağıdaki faktörlerin Cobot ile çalışırken kendinizi güvende hissetmeniz için ne kadar önemli olduğunu işaretleyiniz:
(1: Çok önemsiz, 2:Önemsiz, 3:Kararsız, 4:Önemli, 5:Çok önemli)

Deployer Attribute	Trust Dimension	Question
Yanlış Alarm	Cobot'un normal çalışma düzeni bozulmadığı halde oluşan hatalı alarmlar nedeniyle işin durumu ya da verimin azalması güveni ne kadar etkiler?	Size fiziksel zarar vermesi açısından Q16
	Zaman aşımı hataları, Acil Durum Durdurma gibi Cobot'ların arıza tespiti ve teşhisi,farklı alarm türlerinin ayarlanmasıyla iyileştirilebilir.	Size psikolojik zarar vermesi açısından Q17
	Beraber yaptığınız işe zarar vermesi açısından	Q18
Etkileşim Dizaynı	Cobot ile etkileşimde bulunmak için kullanılan fiziksel nesnelerin tasarımı ya da operatorün Cobotla beraber çalışma deneyiminin tasarımı güveni ne derece etkiler?	Size fiziksel zarar vermesi açısından Q19
	Geleneksel olarak Cobotların tasarımında işlevsellik ve güvenliğe odaklanmıştır. Ancak bunun yeterli olmadığını görülmüştür. Deneyim odaklı tasarım hedeflerine ihtiyacımız vardır. İşlev kadar operatörün ve Cobotun o işlevi yerine getirirken nasıl davranacağını, zorluk, tepki süresi, iletişim organı (ses, göz, el vs) açısından da tasarlamaktır.	Size psikolojik zarar vermesi açısından Q20
	Beraber yaptığınız işe zarar vermesi açısından	Q21
İK için Talimatlar	Cobot ile beraber çalışırken oluşan deneyimden oluşan insan kaynağı talimatlarının yerine getirilmesi güveni ne kadar etkiler?	Size fiziksel zarar vermesi açısından Q22
	Cobot denetleyicisi, yanlış kullanım (eğitim ihtiyacı), kullanılmama (direnc gösterme) veya kötüye kullanım (yetersiz kullanım veya hasar) olup olmadığını anlamak için İK departmanlarının faaliyetlerini izleyebilir ve günlük olarak kaydedebilir.	Size psikolojik zarar vermesi açısından Q23
	Beraber yaptığınız işe zarar vermesi açısından	Q24

Lütfen günlük çalışma rutininizi düşünerek aşağıdaki faktörlerin Cobot ile çalışırken kendinizi güvende hissetmeniz için ne kadar önemli olduğunu işaretleyiniz: (1: Çok önemsiz, 2:Önemsiz, 3:Kararsız, 4:Önemli, 5:Çok önemli)

Deployer Attribute		Trust Dimension	Question
Kalibrasyon İpuçlarına Güven	Cobot'a, operatöre ya da ortama dair alınan geribildirim ve ipuçlarının kullanılması ile güven modelini ne kadar kalibre edilebilir?	Size fiziksel zarar vermesi açısından	Q25
	Cobot üreticileri, programcıları veya dağıtıcıları, İnsan Cobot Güven Yapısında Cobot'u veya Bağlamsal Faktörleri geliştirmek ve iyileştirmek için sahadan bazı geri bildirimler alabilirler ve Cobota güven modelini kalibre edebilirler.	Size psikolojik zarar vermesi açısından	Q26
		Beraber yaptığınız işe zarar vermesi açısından	Q27
Görev Tipi	Cobot ile beraber çalışılan görev tiplerinin yeni, zor, karmaşık, çoklu ve tekrarlı olması gibi durumlar güveni ne kadar etkiler?	Size fiziksel zarar vermesi açısından	Q28
	Cobot'un operatörü ile işbirliğindeki birçok görev önceden tanımlanmıştır ya da görev tipi değişikçe tekrar ayarlanabilir. Görev tiplerinin yeni, zor, karmaşık, çoklu ve tekrarlı olması gibi değişik durumlar olabilir.	Size psikolojik zarar vermesi açısından	Q29
		Beraber yaptığınız işe zarar vermesi açısından	Q30
Uzaktan Müdahale	Cobotla ilgili bir uygunsuz ya da şüpheli durum olduğunda Cobot'a ya da ortama uzaktan müdahale edilebilir olması güveni ne derece etkiler?	Size fiziksel zarar vermesi açısından	Q31
	Cobot'un konuşlandırıcısı fiziksel koşulları izleyebilir ve uygunsuz veya kararsız bir davranış durumunda kurulumu durdurabilir/değiştirebilir.	Size psikolojik zarar vermesi açısından	Q32
		Beraber yaptığınız işe zarar vermesi açısından	Q33

5.1.2 Collecting Data from the Operators:

Unilever Supply Chain Director appointed 15 operators to participate in the survey. Attributes were accompanied by a short description to ensure consistent understanding among respondents.

The inclusion of contextual explanations for each attribute (e.g., how feedback loops or remote intervention work) enhanced the survey's reliability by reducing ambiguity. These questions were pre-tested with Unilever Supply Chain Director first, and then we got his formal approval to share with the target population. The questionnaire was sent to the panelists via email by Supply Chain Coordinators.

The collected scores in were structured to understand the significance of each Deployer attribute.

The first question served as a baseline trust indicator for the cobot. It is broad and subjective, capturing the respondent's general sentiment before diving into specific influences of this result. The responses for the initial trust rating question are provided in Table A7.1a. Accordingly, most operators rated their trust between 3 and 5, indicating generally high confidence, with one notable very low evaluation by OPR1 at level 1. The overall average score of 3.8 suggests that while most operators feel reasonably safe, there is still room for improvement.

5.1.3 Generation of the FDM scores

33 questions for Deployer attributes significance ratings were used to evaluate the significance of 11 Deployer attributes in terms of their perceived significance in preventing:

- Physical harm (e.g., injury from cobot malfunction) – Trust Dimension 1
- Psychological harm (e.g., stress, anxiety) – Trust Dimension 2

- Job performance impact (e.g., task disruption or inefficiency) – Trust Dimension 3

FDM analysis is applied respectively for each trust dimension. As an example, the FDM evaluation is provided below for the Trust Dimension 1. The FDM analysis for trust dimensions 2 and 3 are provided in Appendix G.

FDM Evaluation for the significance of the deployer attributes for trust dimension 1: Avoiding physical harm (e.g., injury from cobot malfunction)

15 of relevant Operators from Unilever Case are invited to the questionnaire as participants. The participant scores for the significance of the deployer attributes for Trust Dimension 1, i.e., avoiding Physical harm (e.g., injury from cobot malfunction) are provided in Table A7.2.

While applying FDM, the first task is the fuzzification of uncertain values, which basically uses triangular fuzzy numbers. This is followed by aggregation and defuzzification, where the outcomes from this process are used on the forecasting stage.

a. Fuzzification: The scores for each participant $i, i=1,2,\dots,15$ and Deployment Attribute $j=1,2,\dots,11$ in Table A7.2 are expressed as a set of fuzzy numbers W_{ij} . Each W_{ij} set has three values, namely the minimum value (a_{ij}), most likely value (b_{ij}), and the maximum value (c_{ij}) that are obtained by using the triangular fuzzy membership function in Table 5.3.

Table 5.3 *The Linguistic Scale and Their Equivalent Fuzzy Number*

Rating	Linguistic variables	Equivalent fuzzy number		
		a_{ij}	b_{ij}	c_{ij}
1	Hiç Katılmıyorum	1	1	2
2	Katılmıyorum	1	2	3
3	Az Katılıyorum	2	3	4
4	Katılıyorum	3	4	5
5	Oldukça katılıyorum	4	5	5

Accordingly, we provide the fuzzified scores of the Significance of the Deployer Attributes $j=1,2,\dots,11$ for each participant $i=1,2,\dots,15$ in Table A7.3. Hence, we obtain 15 fuzzified scores for each attribute $j=1,2,\dots,11$.

b. Aggregation: For each attribute $j=1,2,\dots,11$, the fuzzy numbers from all participants $i=1,2,\dots,15$ were aggregated to form a single fuzzy membership expression. Accordingly, we convert the fuzzified scores from 15 participants into a Single Fuzzy Membership Expression for Each Attribute $j=1,2,\dots,11$ in Table A7.4. Here, $a_j = \min_i(a_{ij})$, $b_j = \text{Geometric mean}_i(b_{ij})$, $c_j = \max_i(c_{ij})$.

c. Defuzzification: The aggregated fuzzy numbers were defuzzified (averaged) to obtain a crisp value for each attribute.

The FDM Scores for each attribute $j=1,2,\dots,11$ are calculated in Table A7.5 as the averages of a_j , b_j , and c_j scores. The averages of the original participant scores are also provided for each attribute $j=1,2,\dots,11$ for further comparison.

Table A7.5 provides the FDM Evaluation regarding the significance of the deployer attributes for the trust dimension 1, i.e., avoiding physical harm (e.g., injury from cobot malfunction).

In the rest of the FDM analysis, we repeat the FDM evaluations for the significance of the deployer attributes for the other trust dimensions. In Appendix G, Tables A7.6-A7.9 provide the FDM results regarding the significance of the deployer attributes for the trust dimension 2, i.e., avoiding psychological harm (e.g., stress, anxiety). Tables A7.10-A7.13 provide the FDM results regarding the significance of the deployer attributes for the trust dimension 3, i.e., job performance impact (e.g., task disruption or inefficiency).

d. Result: Table 5.4 provides the FDM scores as well as the averages of the original participant scores of 15 operators for each Deployer attribute $j, j=1,2,\dots,11$ and in each trust dimension respectively.

Table 5.4 *The significance of Deployer attributes on trust dimensions*

Deployer Attribute	Trust Dimension	Averages of the Original Participant Scores	DM Score
Geribildirim Döngüsü $j=1$	Size fiziksel zarar vermesi açısından	4.06	.29
	Size psikolojik zarar vermesi açısından	3.66	.15
	Beraber yaptığınız işe zarar vermesi açısından	3.86	.26
İzleme $j=2$	Size fiziksel zarar vermesi açısından	3.93	.31
	Size psikolojik zarar vermesi açısından	3.86	.27
	Beraber yaptığınız işe zarar vermesi açısından	3.93	.21
Otomasyon Seviyesi $j=3$	Size fiziksel zarar vermesi açısından	3.93	.21
	Size psikolojik zarar vermesi açısından	4.06	.31
	Beraber yaptığınız işe zarar vermesi açısından	3.86	.26
İletişim Metodu $j=4$	Size fiziksel zarar vermesi açısından	3,8	.15
	Size psikolojik zarar vermesi açısından	3,6	.04
	Beraber yaptığınız işe zarar vermesi açısından	4.00	.26
Arıza Oranları $j=5$	Size fiziksel zarar vermesi açısından	3.73	.18
	Size psikolojik zarar vermesi açısından	3.53	.15
	Beraber yaptığınız işe zarar vermesi açısından	3.73	.26
Yanlış Alarm $j=6$	Size fiziksel zarar vermesi açısından	3,6	.01
	Size psikolojik zarar vermesi açısından	3,6	.04
	Beraber yaptığınız işe zarar vermesi açısından	3.73	.28

Deployer Attribute	Trust Dimension	Averages of the Original Participant Scores	DM Score
Etkileşim Dizaynı j=7	Size fiziksel zarar vermesi açısından	3.73	.20
	Size psikolojik zarar vermesi açısından	3.93	.29
	Beraber yaptığınız işe zarar vermesi açısından	4.06	.73
İK için Talimatlar j=8	Size fiziksel zarar vermesi açısından	4.00	.66
	Size psikolojik zarar vermesi açısından	3.73	.19
	Beraber yaptığınız işe zarar vermesi açısından	3,8	.64
Kalibrasyon İpuçlarına Güven j=9	Size fiziksel zarar vermesi açısından	3.93	.34
	Size psikolojik zarar vermesi açısından	3.03	.31
	Beraber yaptığınız işe zarar vermesi açısından	4.00	.70
Görev Tipi j=10	Size fiziksel zarar vermesi açısından	3,8	.66
	Size psikolojik zarar vermesi açısından	3.86	.24
	Beraber yaptığınız işe zarar vermesi açısından	3.66	.10
Uzaktan Müdahale j=11	Size fiziksel zarar vermesi açısından	3.86	3.31
	Size psikolojik zarar vermesi açısından	3.73	.27
	Beraber yaptığınız işe zarar vermesi açısından	3.93	.67

Accordingly, all 11 deployment attributes received average scores in each of the three trust dimensions, i.e., of physical harm, job performance impact, and psychological well-being, indicating that every Deployer attribute was perceived as significant. The FDM scores are slightly lower than the arithmetic means due to the nature of the fuzzy evaluation that introduced more flexibility to the qualitative assessments. It is noted that

both the arithmetic means and the FDM scores evaluated all Deployer attributes as significant.

Next, assuming that the three trust dimensions have equal weights, we took the arithmetic means of their FDM scores to calculate the overall significance of each Deployer attribute j , $j=1,2,\dots,11$ respectively in Table 5.5.

Table 5.5 *The Overall Significance of Deployment Attributes on Trust*

Index j	Deployer Attribute	Overall Significance
1	Feedback Loop	3.88
2	Monitoring	3.93
3	Level of automation	3.97
4	Communication Method	3.80
5	Failure Rates	3.67
6	False Alarms	3.64
7	Interaction design	3.91
8	Instructions for HR	3.84
9	Trust Calibration Cues	3.96
10	Task Type	3.78
11	Remote intervention	3.84

According to the overall significances in Table 5.5, the top most significant Deployer attributes are identified as: Level of Automation, Trust Calibration Cues, and Monitoring—as validated through FDM. Level of Automation (Score: 3.97) reflects how much of the cobot's operation is automated versus requiring human intervention. It was rated the highest in significance, indicating that operators perceive automation level as a critical factor in building trust. High automation can reduce workload and errors but may also raise concerns about control and transparency. Trust Calibration Cues (Score: 3.96) help operators adjust their trust in cobots appropriately—neither overtrusting nor undertrusting. Examples include visual indicators, feedback mechanisms, and behavioral consistency. Their high score suggests that operators rely heavily on these cues to feel

confident and safe during collaboration. Monitoring (Score: 3.93) refers to the ability to observe and track cobot performance and status. It supports transparency and accountability, allowing operators to detect anomalies and intervene when necessary. Its high significance score highlights its role in maintaining situational awareness and reinforcing trust through visibility.

The analysis revealed that all identified deployer attributes were perceived as significant in generating trust, underscoring the inherently multidimensional nature of trust in human–cobot collaboration. Based on expert consensus gathered through the FDM, the newly proposed "Deployer-related" attributes were confirmed as both relevant and necessary for the Adjusted Trust Model. The FDM process validated their importance, ensuring that only contextually grounded and expert-approved attributes were retained.

Following the validation phase, the model was applied in two organizational settings—Unilever and Benoplast. This implementation allowed for the assessment of deployer maturity levels and the formulation of targeted recommendations to enhance trust in cobot integration within each organization.

5.2 Use-Case Implementation of the Deployer Model at Unilever

We assessed the level of Deployer attributes within Unilever’s current organizational and operational context, ensuring that the Adjusted Trust Model is anchored in observable realities rather than theoretical assumptions. Crucially, once again FDM played a central role in this process — not only validating and prioritizing the newly proposed Deployer attributes but also affirming their current levels. FDM process involved three repetitions, each corresponding to a set of 11 attributes with 33 questions in total (Table 5.6).

Table 5.6 *Questionnaire for the Assessment of Deployer Performance*

Deployer Related Attributes		Survey Questions		
Context	KPI	1st Question	2nd Question	3rd Question
Performance Related (Z1)	Feedback Loop (B11)	Sistemden otomatik olarak ya da operatörden sistemi tasarlayan/uygulayan uzmana alarm ya da bildirim gidiyor mu?	Gün içinde bir sorun olduğunda sistemi tasarlayan firma sorumlusuna herhangi bir alarm ya da bildirim gidiyor mu?	Herhangi bir konuda sistemi tasarlayan firma sorumlusuna alarm ya da bildirim gidiyor mu?
	Monitoring(B12)	Sistemi tasarlayan/uygulayan uzman sistemin durumunu, operator ile ilgili kriterleri izliyor ve raporluyor mu?	Sistemi tasarlayan firma operator ya da yönetim ekibi ile durjım ya da performansla dair bir rapor paylaşıyor mu?	Sistemi tasarlayan firma sorumlusu herhangi bir izleme ve kontrol aracı kullanıyor mu?
	Level of automation(B13)	Cobotun programlanması kolay mı?	Cobotun otomasyon seviyesini arttırmak ne kadar mümkün?	Otomasyonun herkes için erişilebilir olmasını sağlıyor mu?
	Communication Method(B14)	Cobot ile beraber çalışırken, parça alıp verme, bir işi devam ettirme, sözlü-yazılı komut verme, geri bildirim alma gibi iletişim ihtiyaçları oluyor mu?	Cobot firma yetkilisine Cobot ile etkileşim açısından önerilerde bulunmak gerekiyor mu?	Cobot ile iletişim yöntemleri yeterli mi?
	Failure Rates(B15)	Cobotun hata yapma oranı yüksek mi?	Cobot beraber çalışırken hiç hata yapıyor mu?	Cobot durma, hatalı aksiyon gibi üretimi, lojistiği ya da operasyonu etkileyen durumlar yaratıyor mu?
	False Alarms(B16)	Cobot hata mesajı veriyor mu?	Cobot sesli ya da yazılı sorun bildiriyor mu?	Cobot bir sorun durumunda operatöre ya da ilgili sorumluya sesli ya da yazılı bir uyarıda bulunuyor mu?

Deployer Related Attributes		Survey Questions		
Context	KPI	1st Question	2nd Question	3rd Question
Attribute Based (Z2)	Interaction design (B21)	Geliştirilmesi için bir uzman desteği gerekiyor mu?	Cobot firma yetkilisine Cobot ile etkileşim açısından önerilerde bulunmak gerekiyor mu?	Cobot ile beraber çalışırken, parça alıp verme, bir işi devam ettirme, sözlü-yazılı komut verme, geri bildirim alma gibi etkileşim ihtiyaçları oluyor mu?
Ability Based (Z3)	Instructions for HR(B31)	Cobot ile çalışırken verimlilik, süreklilik ve doğru kullanım gibi konularda kaynak yönetimini etkileyen öneriler çıkabiliyor mu?	Cobot ile çalışan operatörün verimliliği, bilgisi, kullanımını iyileştirecek tavsiyeler alınıyor mu?	Cobot operatörlerinin eğitim, farkındalık ve doğru kullanımı için sistemden geri bildirim ya da rapor alınıyor mu?
Tasking (Z4)	Trust Calibration Cues(B41)	Operatör sistemi tasarlayan/uygulayan uzmana geri bildirimde bulunuyor mu?	Cobot operatörlerinin Cobotlarla çalışırken sisteme güveninin artması için üretici firma ya da uygulayıcısı tarafından bir analiz yapılıyor mu?	Cobotlarla çalışırken daha güvenli hissetmesi için operatöre önerilerde bulunuluyor mu?
	Task Type(B42)	Operatör Cobot'ta yeni bir görev için programlama yapmak istese hangi sıklıkta firma yetkilisinden yardım alıyor?	Operatör firma yetkilisi olmadan yeni bir görev tanımlayabiliyor mu?	Operator Cobot'u eğitirken görev türünü hızlı bir şekilde değiştirebilecek sisteme sahip mi?
	Remote intervention(B43)	Hata ya da kaza durumunda sistemi tasarlayan/uygulayan uzman sisteme uzaktan müdahale edebiliyor mu?	Firma yetkilisi sorun olduğunda hangi sıklıkta sisteme uzaktan müdahale ediyor?	Firma yetkilisi sorun olduğunda yerinde müdahale mi etmek zorunda?

Even though we have one round of questionnaire, we used 3 set of questions for each attribute, to overcome the ambiguity associated with human responses through the fuzzy set theory. Therefore, we had 33 questions for 11 attributed resulted in 3 repetitions.

The evaluations are made by 5 Likert-Scale, i.e., (1: Strongly Disagree, 3: Neutral, 5: Strongly Agree). 15 of relevant Operators from Unilever Case are invited to the questionnaire, and 11 of them answered the questionnaire. We followed the same FDM steps in Section 5.1.3.

a) **Grouping & Fuzzification:** To ensure a robust evaluation of each deployer attribute (e.g., *Level of Automation*), three similar questions were asked to each operator. These questions were designed to capture different facets of the same attribute. Tables A7.16, Table A7.20 and Table A7.24 provide the answers given to the questionnaire for the first, second and the third set of questions respectively. FDM analysis is applied to each set of questions respectively in three repetitions. In each repetition, the related 11 questions (attributes) were considered, and each operator's responses were converted into triangular fuzzy numbers (a_{ij} , b_{ij} , c_{ij}) using a linguistic scale by using the triangular fuzzy membership function in Table 5.3 The results of fuzzifications are provided in Table A7.17, Table A7.21, Table A7.25 for repetitions 1, 2, and 3.

b) **Aggregation:** For each attribute, the fuzzy numbers from all participants were aggregated to form a single fuzzy membership expression The results of aggregations are provided in Table A7.18, Table A7.22, Table A7.26 for repetitions 1, 2, and 3.

c) **Defuzzification:** The aggregated fuzzy numbers were defuzzified (averaged) to obtain a crisp value for each attribute. The results of aggregations are provided in Table A7.19, Table A7.23, Table A7.27 for repetitions 1, 2, and 3.

d) **Result:** The attributes were ranked by their average scores, indicating their perceived levels in the organization. Essentials attributes are identified by comparing with FDM threshold which is calculated by the average of all de-fuzzified weights and estimated as 3.03 (Table 5.7).

Table 5.7 *The Deployer Attributes Performances at Unilever*

Index j	Deployer Attributes	FDM Scores	Averages of the Original Participant Scores
1	Feedback Loop	2.74	2.36
2	Monitoring	2.91	2.97
3	Level of Automation	2.87	2.76
4	Comm Method	3.23	3.48
5	Failure Rates	3.26	3.55
6	False Alarms	3.10	3.45
7	Interaction Design	3.28	3.97
8	Instructions for HR	3.05	3.33
9	Trust Calibration Cues	3.05	3.33
10	Task Type	2.65	2.73
11	Remote Intervention	3.13	2.79
Average		3.03	3.16

These attributes were then ranked according to their organizational levels (see Table 5.8), ensuring that the model reflects actual deployment dynamics rather than theoretical assumptions.

Table 5.8 *The Deployer Attributes Performances at Unilever - Ranked*

Index j	Deployer Attributes	FDM Scores	Ranking
7	Interaction Design	3.28	1
5	Failure Rates	3.26	2
4	Comm Method	3.23	3
11	Remote Intervention	3.13	4
6	False Alarms	3.10	5
8	Instructions for HR	3.05	6
9	Trust Calibration Cues	3.05	7
2	Monitoring	2.91	8
3	Level of Automation	2.87	9
1	Feedback Loop	2.74	10
10	Task Type	2.65	11

This ranking process was instrumental in:

- **Focusing the process development** in the weakest attributes
- **Streamlining complexity** by emphasizing the attributes with the highest expert agreement.

5.3 Use-Case Implementation of the Deployer Model at Benoplast

In this section, we have conducted a second implementation of our model in Benoplast.

Benoplast is one of the top manufacturers in Europe, specializing in plastic crates, containers, and pallets. They offer innovative, long-lasting, and powerful product solutions for challenging industrial conditions. Benoplast provides production, rental, recycling, and logistics operation services with reusable, traceable, and environmentally friendly products. Additionally, Benoplast utilizes collaborative robots (cobots) in their operations to enhance productivity and efficiency. These cobots work alongside human operators to perform tasks such as packaging, palletizing, and production line feeding, ensuring a seamless integration of automation and human labor.

The second implementation step was aimed to enable us to gather expert opinions and insights, ensuring that our proposed trust models are both robust and applicable to the Turkish FMCG industry. In the Benoplast case study, we applied the **FDM** to validate and prioritize trust-related factors in human-robot collaboration, using the same structured approach previously applied at Unilever. The goal was to assess whether the trust dimensions identified in the Unilever context—**physical harm, job performance impact, and psychological well-being**—would hold in a different organizational and operational environment.

The process involved gathering expert input from Benoplast operators and technical staff, who evaluated the level of Deployer attributes. Following the same procedure in Section 5.2 we applied the FDM in Benoplast to obtain the Deployer Attributes Performances in Table 5.9. The details of the application of FDM at Benoplast are provided in Tables A7.28 - A7.39.

Table 5.9 *The Deployer Attributes Performances at Benoplast*

Index j	Deployer Attributes	FDM scores	Averages Original Participant Scores
1	Feedback Loop	3.72	3.82
2	Monitoring	3.77	3.48
3	Level of Automation	3.95	3.30
4	Comm Method	4.09	3.79
5	Failure Rates	3.59	3.70
6	False Alarms	3.71	3.73
7	Interaction Design	4.18	3.27
8	Instructions for HR	4.29	3.67
9	Trust Calibration Cues	3.52	3.33
10	TaskType	3.64	3.67
11	Remote Intervention	4.08	3.61
Average		3.87	3.58

In Table 5.10 we compare the Deployer attributes performances of Unilever and Benoplast by using the FDM evaluations.

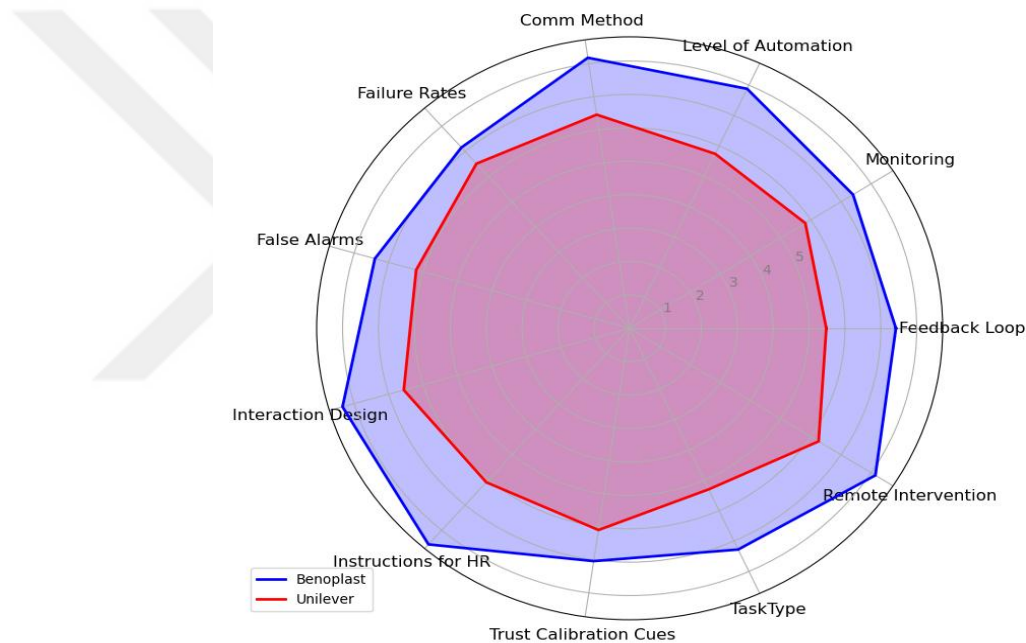
Table 5.10 *Comparison of Deployer Attributes Performances in Unilever vs Benoplast*

Index j	Deployer Attributes	Benoplast	Unilever
		FDM Score	FDM score
1	Feedback Loop	3.72	2.74
2	Monitoring	3.77	2.91
3	Level of Automation	3.95	2.87
4	Communication Method	4.09	3.23
5	Failure Rates	3.59	3.26
6	False Alarms	3.71	3.10
7	Interaction Design	4.18	3.28
8	Instructions for HR	4.29	3.05
9	Trust Calibration Cues	3.52	3.05
10	Task Type	3.64	2.65
11	Remote Intervention	4.08	3.13

5.4 Analysis of the Deployer Performances at Unilever and Benoplast

The comparative radar chart analysis between **Benoplast** and **Unilever** reveals meaningful distinctions in how each company evaluates Deployer attributes in human-robot collaboration (Figure 5.2).

Figure 5.2 *Comparative Radar-Chart for the Deployer Attributes Performances: Benoplast vs. Unilever*



Benoplast consistently scored higher across nearly all 11 trust dimensions, with particularly strong emphasis **on Instructions for HR, Interaction Design, and Communication Method**. These elevated scores suggest a more structured and human-centered approach to integrating Cobots, likely reflecting Benoplast's operational emphasis on clarity, usability, and workforce alignment.

In contrast, Unilever's scores, while still robust, were generally lower—especially in areas like **Feedback Loop**, **Monitoring**, and **Task Type**. This may indicate a more selective or phased approach to trust calibration, possibly due to different organizational maturity levels in automation or varying expectations from Cobots in their workflows.

The divergence in factor selection and scoring validates the flexibility of the Deployer model. It underscores that trust is not a one-size-fits-all construct; rather, it is shaped by each company's unique operational needs, technological readiness, and cultural context. Therefore, it is both expected and acceptable for different organizations to adopt distinct sets of trust factors for calibration. This adaptability enhances the model's relevance and applicability across diverse industrial settings.

This study shows that the Trust model is versatile and can be adapted to various contexts. The new set of factors identified for Benoplast can be effectively used for Trust Calibration, ensuring that the interactions between operators and Cobots are optimized according to the specific needs of the company.

The best outcome of trust calibration in the context of your Fuzzy Delphi Method (FDM) study with Benoplast is to provide managerial advice. This advice can be used to guide factory directors, engineers, or managers towards achieving better excellence in their operations.

The managerial advice based on the Benoplast FDM results includes the following key points:

1. **Enhance Communication and Feedback Loops:** Establish clear communication channels between operators and deployers. Ensure that operators can provide feedback on robot performance and that deployers can monitor and address any issues promptly.

2. **Improve Training and Competency:** Invest in regular training programs for operators to enhance their skills and confidence in working with robots. This will help in building trust and reducing resistance to automation.
3. **Optimize Interaction Design:** Focus on designing interactions that are intuitive and user-friendly. This includes ensuring that robots are easy to program and configure, and that operators can easily adapt to changes in robot behavior.
4. **Monitor and Report Performance:** Implement systems to continuously monitor robot performance and operator interactions. Use this data to identify areas for improvement and to ensure that robots are functioning as expected.
5. **Address Safety Concerns:** Ensure that safety protocols are strictly followed and that robots are designed to operate safely alongside humans. This includes regular maintenance and emergency response procedures.

By following these recommendations, factory directors, engineers, and managers can create a more collaborative and efficient environment, ultimately leading to higher trust in their human-robot collaboration.

5.5 Limitations of the Deployer Model

While this study provides valuable insights into trust dynamics in Human-Robot Interaction (HRI) within the FMCG sector, several limitations should be acknowledged:

1. **Single case study design for the significance assessment:** The significance assessment of the Deployer attributes was conducted within a single organization—Unilever—which, while rich in context and access, limits the generalizability of the findings. Organizational culture, digital maturity, and operational structure at Unilever may not reflect those of other FMCG companies or industries.

2. **Context-Specific Insights:** Use-case implementations took place in only two manufacturing organizations. The trust-related challenges and collaborative dynamics observed were merely shaped by Unilever's and Benoplast's transformation journeys. As such, the findings may not fully capture variations that could emerge in different organizational or cultural settings.
3. **Temporal Constraints:** The study captures trust at a specific point in time. However, trust is a dynamic construct that evolves with changes in technology, team composition, and organizational priorities. A longitudinal approach would be needed to observe how trust calibration and cue design shift over time.
4. **Qualitative Method Dependence:** The research relies heavily on qualitative methods such as interviews, document analysis, and thematic coding. While these methods are well-suited for exploring complex phenomena, they are also subject to interpretive bias and may lack the statistical generalizability of quantitative approaches.
5. **Limited Sample Size for FDM:** FDM was applied with a relatively small group of experts. While it helped prioritize key Deployer attributes, the results reflect potential significance of the Deployer attributes rather than definitive conclusions. Broader participation across multiple companies would enhance the validation of the Deployer model and the reliability of the findings.
6. **Conceptual Boundaries of Trust:** The study focused on physical harm, job performance impact, and psychological well-being dimensions of trust. However, trust is a multifaceted concept influenced by technical, social, and contextual factors. Future research should explore additional dimensions of trust and refine its conceptualization to avoid narrow interpretations.

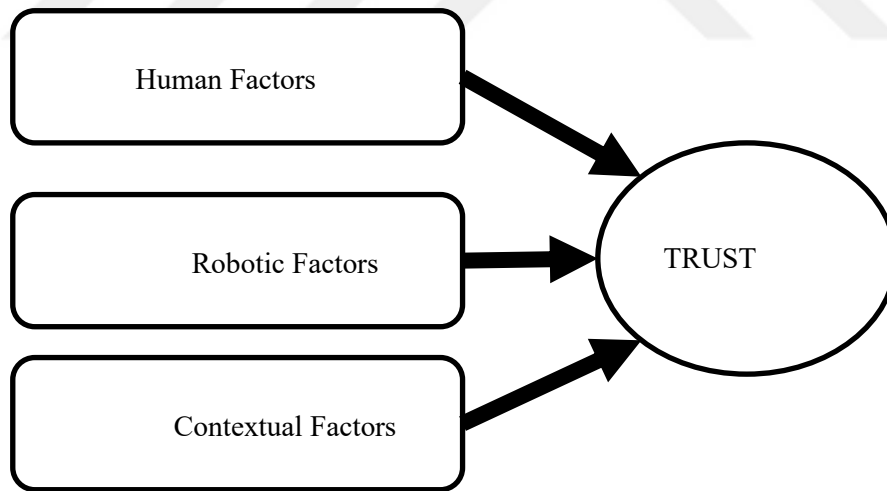
6. CONCLUSION

6.1 Evaluation of Results

When we researched the level of trust working with Cobots, we found out that **the current trust level is not at the desired level** of Company authorities i.e., Supply Chain Director, Factory Manager, Manufacturing Engineer. And also, we have seen that Operators perceive the relationship between Deployer in Human-Cobot collaboration is **weak or not direct**. Therefore, there are 2 important factors on this particular case study to be resolved: 1. weak relationship and 2. low level of trust.

Our targeted efforts were to provide data to feed and expand our reference Human Robot Trust Model (Figure 6.1) to adjust into FMCG industry.

Figure 6.1 *Human-Robot Trust Model Hancock 2011, 2020*



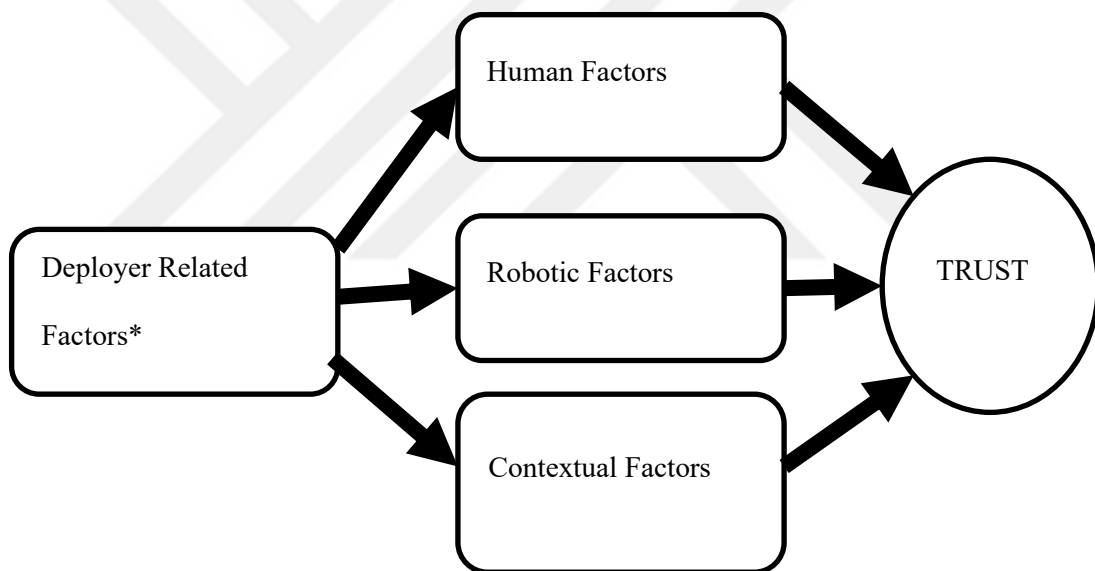
We have seen that all factors which were originally hypothesized were still valid for our Case Study of Unilever Turkey. Perhaps and most importantly, we discovered the new constructs qualifying an elaborated Trust Model for FMCG by the help of our cyclical data collection and analysis efforts.

Starting from our preliminary study, we reliably captured the key elements of interest and seen that the main actors of interaction treated **a person**(deployer) deploying the robot to the user and setting in the context “not so important” in general. Even though a programmer, vendor, deployer, or an engineer setting robot for HRI may consider themselves to be external to the relation, this person giving the the ‘shape’ of the collaboration by his/her own knowledge and experience. So called “Deployer” is the interested external actor who brought the scenario into “being”. The operator’s perceived relationship with the Deployer might be in different occasions: training, set up, break & fix, performance reporting etc. may influence his/her view towards the interactions with the Cobot. As explained in Unilever Cobot Operating Manuel(Appendix C), the interaction from Deployer to Cobot includes the production of Cobot behaviours through direct control of a robot using UniteFlow control software by activating predefined roles, setting up instruments, or developing architectures to generate a targeted behaviour. Therefore, we argue that the deployer sets the context in which a cobot may be used to perform a specific or joint task with the user.

In line with our findings from both the Preliminary Study (2019) and the subsequent Case Study, Cameron and Collins (2021) aptly describe the social triad of trust relations: “Trust in Cobots may depend on the communication and trust towards the deployer as well as trust towards the robot; any measurement of trust the user may have of the robot may also reflect how much trust the user has in the deployer.” The structured nature of our model enabled us to move beyond abstract theorization and offer a clearly defined framework for analyzing trust in Human & Cobot. By establishing distinct categories and relationships—particularly the inclusion of the deployer as a third actor—we provided a systematic lens through which trust dynamics can be empirically

examined. This structure not only enhances clarity but also facilitates replicability and comparative analysis across studies. Furthermore, the empirically grounded foundation of our model, built through both our 2019 Preliminary Study and subsequent Case Study, ensures that our theoretical propositions are supported by real-world observations and user experiences. Crucially, we incorporated the deployer into our Reference Trust Model (Figure 6.2), thereby extending the conceptual landscape of trust in Cobots with a structured and empirically grounded framework.

Figure 6.2 *Adjusted Human-Robot Trust Model for FMCG*



Although the operators mostly think that there is **a weak relationship** between the operator and the 3rd party (programmer, technician, engineer, vendor), Supply Chain Director mentioned about the importance of this relationship to be turned into “**a strong relationship**” in order to work in the most efficient. And also, Supply Chain Director mentioned about the data and insights flowing between these two entities through different communication channels like regular trainings, incident handling process, maintenance activities, and Digital Factory Operating System (i.e. remote monitoring and

configuration software developed for Unilever Turkey). Those efforts should be used in an organized manner to strengthen the relationship between two entities.

In a typical FMCG set up, the training of human about the deployed Cobot system or else everyday interaction between human and Cobot is limited. On the other hand, there is an important entity “Deployer” who is a master on leveraging the effectiveness in every dimension from safety to trust, quality to performance. Deployers can increase overall equipment effectiveness for Cobots associated with different kind of activities from programming to performance monitoring. However, operators are not accustomed using the full potential of such a skilled master in their real-life operations, and their trust building activities such as feedback on the scenario, questionnaires, interviews, performance appraisals etc. are missing between two entities.

In order to meet the existing demands for our research area “HRI in FMCG”, we found out that collaboration should be supported by high level of trust. Therefore, we proposed an **Adjusted Trust model**(Table 28) to evolve from Hancock Trust Model (Figure 3) by considering the factors below:

- Considering our Preliminary Actor Network Study, and the social triad of trust relation by Cameron and Collins, the new dimension **Deployer** should be added to the general trust model: Human + Robot + Contextual Factors + Deployer (**new**)
- Using cyclical data approach, we worked on at different times and in different data collection methodologies. At the end, everything came together, and we bounded each step together to map with our target Trust Model (Table 28).
- Even though there are arbitrary attempts by Unilever Supply Chain Function to increase Cobot usage, there is still an improvement area. Number of Cobots are not at the desired level or not utilized as much. Therefore, Trust Models can be used to

measure and calibrate the relationship by the help of existing and new attributes. In order to accomplish this, we can use trust cue design taxonomy by de Visser et. al, (2014), and collect trust evidence from the decision and execution stages of information processing. Trust Calibration Cues (TCC:i.e. factors for tasking/collaboration on our study) can be designed to assist with understanding and transparency with specific collaboration scenarios on the shop-floor workflow. This kind of calibration will take time and effort of both operator and deployer. On this endeavour, Unilever Turkey can use our new **Adjusted Trust Model** (Table 6.1) as a main tool, and the result can be used as a baseline to start the strategic improvement initiatives.

Table 6.1 *The Adjusted Trust Model with New Trust Constructs for FMCG*

Robot Related			Human Related	
Performance Related	Attribute Based	Appearance Related	Ability Based	Characterize Based
Dependability	Proximity/Co-location	Appearance	Attentional Capacity/Engagement	Gender
Reliability of Robots	Robot Personality	Anthropomorphism	Expertise / Amount of Training	Age
Behavior	Adaptability		Competency	Race
Predictability	Robot Type		Operator Workload	Culture
Level of automation	Robot Function		Prior Experience	Education
Communication Method	Feedback Loop		Situation Awareness	Expectancy
Failure Rates				Personality Traits
False Alarms				Attitude Towards Robots
Transparency				Comfort w Robots
Productivity (new)				Propensity to Trust
Cost Saving(new)				Self-confidence
Speed(new)				Satisfaction
Accuracy(new)				Self-Efficacy
Quality(new)				

Table 6.2 *The Adjusted Trust Model with New Trust Constructs for FMCG*

Contextual Factors		Deployer Related (new)			
Team Collaboration	Tasking	Performance Related	Attribute Based	Ability Based	Tasking
Tenure	Task Type	Feedback Loop (new)	Interaction design (new)	Instructions for HR (new)	Trust Calibration Cues (new)
Team Conflict	Task Complexity	Monitoring (new)			Task Type (new)
In-group membership	Multi-tasking Requirements	Level of automation (new)			Remote intervention (new)
Interaction Frequency	Physical Environment	Communication Method (new)			
Shared mental models		Failure Rates (new)			
Proximity/co-location		False Alarms (new)			
Role interdependence					
Team Composition					
Team cohesion					

Reference Trust model by Hancock can be adjusted with new attributes (shown as new on Table 6.1):

- **Between Deployer and Human:**

Ability based: Instructions for Human Resources Management

Performance Factors: Feedback Loop

Tasking: Trust Calibration Cues (TCCs)

- **Between Deployer and Robot:**

Attribute based factors: Interaction Design)

Performance Factors: Monitoring

Tasking: Trust Calibration Cues (TCCs)

- **Between Deployer and Contextual Factors:**

Performance based: KPIs/Measurements

Tasking: Trust Calibration Cues (TCCs)

Even though we have identified new attributes for the Adjusted Trust Model, we should assess their validity, and eliminate the non-essential ones. On our research study, it is difficult to quantify, and the evaluation process is dependent on subjective judgments. The FDM, on the other hand helped us reaching a consensus of respondent's opinions on the most important attributes. Although, some vague answers obtained because some constraints, e.g., lack of experience, knowledge, focus, might be difficult to quantify, and the evaluation process was dependent on subjective judgments, FDM overcame the issues of vague answers since it considers the fuzzy set theory when analyzing the respondents' answers. As a result of FDM validation we have seen that the below mentioned attributes are essential for the adjusted trust model:

1. Feedback Loop
2. Monitoring
3. Level of automation
4. Interaction design
5. Failure Rates
6. Communication Method
7. Trust Calibration Cues
8. Task Type
9. Remote intervention
10. False Alarms
11. Instructions for HR

In order to ensure that the models or frameworks proposed in this study are key robust and applicable to practical situations, second FDM applied to another company, and the results enhanced the reliability and applicability of the research findings. With the second case, we have seen a new set of attributes amongst our 11 potential attributes can be applicable, and this new set can create a new managerial advice for the leaders and operators. This advice can be subject to change according to the case we apply Trust Model Study. Considering our Adjusted Trust Model, the managerial advice is categorized into four different areas:

1. Human-Related Factors

These factors encompass the psychological and physical foundations of humans' trust in robots. Key elements include:

- **Trust in Decision-Making:** The extent to which humans trust the decision-making processes of robots.
- **Predictability and Reliability:** How predictable and reliable the robots are perceived to be.
- **Comfort in Interaction:** The level of comfort humans experience when interacting with robots.

2. Cobot-Related Factors

These factors pertain to the technical features and performance of Cobots (collaborative robots). Important aspects include:

- **Movement Speeds:** The speed at which robots move.
- **Strengths:** The physical capabilities of the robots.
- **Emergency Responses:** How robots respond in emergency situations.

- **Overall Reliability:** The general reliability of the robots in performing tasks.

3. Contextual Factors

These factors involve the environment and conditions in which human-robot interaction occurs. Relevant factors include:

- **Work Environment Layout:** The physical layout of the work environment.
- **Placement of Robots:** Where robots are positioned within the workspace.
- **Safety:** The safety measures in place in areas where robots operate.

4. Deployer-Related Factors

These factors relate to the individuals who manage and implement the integration of robots into work processes. This category includes:

- **Measures and Procedures:** The steps taken to ensure safe and effective use of robots.
- **Training:** The training provided to employees and operators.
- **Developer Actions:** Actions taken by developers to facilitate the integration of robots.

6.2 Discussions & Further Studies

From Hancock's original study in 2011 to today, many factors hypothesized in trust models have been tested by academicians to verify the aspects of the operator's role. With Cameron and Collins in 2021, we have seen the importance of external agents like developers, designers, or vendors of specific HRI systems affecting the trustworthy relationship. In our study, we have also observed that many actors involved in the

interaction create knowledge around Cobots. However, there are very limited studies regarding external actors analyzed for Trust in Robots.

In light of our present findings, we addressed the deployer as an important actor, but there might be different actors, and researchers should focus more on studying this area to explore the actors and understand how they change Trust relations.

Another fact is that we have seen new attributes added to the existing context of the Hancock model. With the help of FDM, we have determined the position or rank of every item or variable. The current study successfully applied the Fuzzy Delphi Method (FDM) to identify and prioritize the most critical attributes influencing trust in Human-Robot Interaction (HRI). However, it is important to emphasize that the selection of 7 out of 11 attributes does **not** imply the exclusion or irrelevance of the remaining 4. Rather, this outcome reflects a **ranking of perceived importance** based on expert consensus under limited data conditions. The current findings represent a **potential importance map**—a radar-like snapshot of applicability, and FDM served as a **diagnostic tool** to surface the most prominent attributes under current constraints.

To build on this foundation, future research should:

- **Expand the sample size** by conducting the importance survey across a broader range of companies and sectors.
- **Analyze both dependent and independent variables** (e.g., trust as the outcome, and contextual, technical, and social factors as inputs) to understand their interrelationships more comprehensively.
- **Validate the model across diverse operational environments**, which would help refine the trust framework and improve its generalizability.

This approach transforms the current radar-like perspective into a more robust and empirically validated trust model—one that is grounded in broader industry input and capable of informing real-world Human-Robot Interaction (HRI) design and deployment. To strengthen the generalizability and applicability of the Adjusted Trust Model, we propose applying a similar methodology across diverse case studies. This would allow for further evaluation and validation of the model (or similar trust models) by capturing variations in both dependent (e.g., trust) and independent variables across different organizational and operational contexts.

In our study with FMCG, we have seen that Cobots are still in cages, and very strict rules are applied. Even though these rules are necessary, they limit interaction. Cages are useful to mitigate the risk of accidents and protect operators. But there might be other ways to manage the risk and increase interaction by moving Cobots out of cages.

Cobots are capable of sharing the same workspace as humans, and many are designed to be power and force limited to reduce the chance of injury from a potential collision between humans and operators. ISO/TS 15066 rules that a comprehensive risk assessment according to EN/ISO 12100 be carried out at the point of use. With that assessment, the risk can be calculated. If the risk is none, then Cobots can be out of cages. With that, we might see better collaboration and, therefore, better visibility of trust in the FMCG environment. Therefore, we think trust can be calibrated in FMCG by using models like the Adjusted Trust Model.

While this study provides valuable insights through a single Case Study analysis, we acknowledge the importance of validating the Adjusted Trust Model across a broader and more diverse population. While the findings are context-specific, Unilever's position as a leading global FMCG company also lends the case **representative value**. The trust-

related challenges and collaborative structures observed are reflective of broader industry trends, making the insights potentially transferable to similar organizations. By applying Case Study methodology across different organizational contexts, researchers can test the robustness, generalizability, and applicability of the model. Such comparative studies would not only strengthen the empirical foundation of the trust framework but also uncover potential sector-specific or cultural variations that may influence trust dynamics.

We would like to emphasize the inherently complex and context-dependent nature of the **trust phenomenon**, particularly in the domain of Human-Robot Interaction (HRI). Understanding how trust is formed, maintained, and calibrated within specific environments is essential for researchers aiming to develop meaningful and applicable models.

Our scholarly focus in this study was on **intra-team trust**, **teamwork**, and **collaboration**, and the research design was tailored accordingly. However, trust is not a one-size-fits-all construct. It is shaped by cultural, organizational, technological, and interpersonal dynamics that vary across settings. Therefore, future researchers working in similar domains must pay close attention to the **conceptualization phase** of their studies. This is critical to avoid overly narrow definitions or subjective interpretations of trust that may limit the validity or applicability of their findings.

We recommend that future studies:

- Explore trust across **diverse organizational contexts** to capture a broader range of influencing factors.
- Consider both **dependent and independent variables** in trust relationships, including contextual cues, actor roles, and system behaviors.

- Use **multi-method approaches** to triangulate findings and deepen understanding of trust dynamics.

By doing so, researchers can contribute to a more nuanced and generalizable understanding of trust, which is essential for designing effective, trustworthy systems and fostering sustainable human-robot collaboration.

According to an article on Industrial Engineering News (IEN, 2019) by Anis Zenadji, Cobots are very well established in many industries, and their capabilities have become the workforce norm. The top 10 industries benefiting from Cobots are:

- Manufacturing
- Logistics
- Healthcare
- Construction
- Oil and Gas
- Agriculture
- Automotive
- Food Processing
- Textile
- Law Enforcement (example: assistant police officers)

Apart from the very practical contribution to FMCG, this research can further urge other industries to develop similar trust models or adapt the trust model provided by this study based on or inspired by these research outcomes. Additionally, we can apply similar

trust models to different technology areas like Artificial Intelligence copilot products and solutions where human operators suffer from low levels of collaboration. Furthermore, trust in automation is crucial as it can significantly enhance efficiency and reliability in various sectors. By integrating insights from social science, we can better understand the dynamics of trust and collaboration between humans and automated systems, leading to more effective and harmonious interactions.

Finally, we would like to use the result of trust calibration to provide managerial advice. In the context of our study on the Trust Model and its application to different companies, there are several additional managerial advice areas that could be explored in further studies. Here are some suggestions:

1. Customization and Personalization

- Tailored Solutions: Develop customized solutions for different departments or tasks, recognizing that trust factors may vary across different contexts.
- User Profiles: Create user profiles to personalize robot interactions based on individual preferences and comfort levels.

2. Safety and Risk Management

- Enhanced Safety Protocols: Develop and implement enhanced safety protocols to mitigate risks associated with human-robot interactions.
- Emergency Preparedness: Ensure that there are clear and effective emergency response plans in place for any incidents involving robots.

3. Cross-Functional Collaboration

- Interdepartmental Collaboration: Foster collaboration between different departments (e.g., IT, HR, Operations) to ensure a holistic approach to integrating robots.
- Stakeholder Engagement: Engage with all relevant stakeholders, including employees, managers, and external partners, to gather diverse perspectives and insights.

4. Cultural and Organizational Change

- Change Management: Implement change management strategies to help employees adapt to the integration of robots into their workflows.
- Cultural Shift: Promote a cultural shift towards embracing technology and innovation, fostering a positive attitude towards robots.

5. Ethical Considerations

- Ethical Guidelines: Develop and adhere to ethical guidelines for the deployment and use of robots, ensuring that human dignity and rights are respected.
- Transparency: Maintain transparency in how robots are used and the data they collect, building trust through openness.

6. Innovation and Future Trends

- Adoption of Emerging Technologies: Stay informed about emerging technologies and trends in robotics and AI and consider their potential impact on trust.

- Pilot Programs: Implement pilot programs to test new technologies and approaches in a controlled environment before full-scale deployment.

7. Regulatory Compliance

- Compliance Monitoring: Ensure that the deployment and use of robots comply with relevant regulations and standards.
- Proactive Engagement: Engage proactively with regulatory bodies to stay ahead of potential changes in the regulatory landscape.

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APPENDICES

APPENDIX A . ACTOR NETWORK THEORY ANALYSIS

Preliminary Study with Surveys

Table A1 Responses to the Surveys from Unilever on ANT Study

Sorular	Cevaplar1	Cevaplar2	Cevaplar3	Cevaplar4
Tarih	3.01.2020	3.01.2020	3.01.2020	3.01.2020
Ülke	Türkiye	Türkiye	Türkiye	Türkiye
Şirket	Unilever	Unilever	Unilever	Unilever
Şehir	İstanbul / Tekirdag / Kocaeli / Rize	İstanbul / Tekirdag / Kocaeli / Rize	İstanbul / Tekirdag / Kocaeli / Rize	İstanbul / Tekirdag / Kocaeli / Rize
Fabrika	Ev ve Kişisel Bakım / Gıda / Dondurma	Ev ve Kişisel Bakım / Gıda / Dondurma	Ev ve Kişisel Bakım / Gıda / Dondurma	Ev ve Kişisel Bakım / Gıda / Dondurma
Kullanıcının Rolü	Operator/ Mühendis / Tasarımcı/ Developer/ Fabrika Direktörü	Operator/ Mühendis / Tasarımcı/ Developer/ Fabrika Direktörü	Operator / Mühendis/ Tasarımcı/ Developer/ Fabrika Direktörü	Operator/ Mühendis/ Tasarımcı / Developer/ Fabrika Direktörü
Kullanılan Cobot Marka/Model	Fanuc/ Universal Robots / Kuka	Fanuc/ Universal Robots / Kuka	Fanuc/ Universal Robots / Kuka	Fanuc/ Universal Robots / Kuka
Cobot'un İşlevi	paketleme/ kolileme/ paletleme/ hat ürün besleme	paketleme/ kolileme/ paletleme/ hat ürün besleme	paketleme/ kolileme/ paletleme/ hat ürün besleme	paketleme/ kolileme/ paletleme/ hat ürün besleme
Cobot'la çalışırken en çok etkileşime geçilen kişiler	Operator/Mühendis /Tasarımcı/Developer/Fabrika Direktörü	Operator/Mühendis/ Tasarımcı /Developer/Fabrika Direktörü	Operator /Mühendis/Tasarımcı/Developer/Fabrika Direktörü	Operator /Mühendis/Tasarımcı/Developer/Fabrika Direktörü
Cobot'un sağladığı fayda	üretkenlik/ maliyet azalması / doğruluk / hız / kalite	üretkenlik/ maliyet azalması / doğruluk / hız / kalite	üretkenlik/ maliyet azalması / doğruluk / hız / kalite	üretkenlik/ maliyet azalması / doğruluk / hız / kalite

Sorular	Cevaplar1	Cevaplar2	Cevaplar3	Cevaplar4
Cobot'un konfigürasyon/customizasyon kolaylığı	az / orta / yüksek	az / orta / yüksek	az / orta / yüksek	az / orta / yüksek
Cobot'un konfigürasyon değişiklik sayısı / ay	1 / 12ay	1	0	4
Cobot'la beraber çalışırken meydana gelen kaza sayısı / ay	0	-	0	0
Cobot'un ortalama arıza sayısı / ay	1 / 1ay	1	4	2
Cobot'la çalışma ile ilgili engeller	güvenlik / yüksek fiyat / tasarım sorunları / donanım sorunları / yazılım sorunları / operator eğitim eksikliği	güvenlik / yüksek fiyat / tasarım sorunları / donanım sorunları / yazılım sorunları / operator eğitim eksikliği	güvenlik / yüksek fiyat / tasarım sorunları / donanım sorunları / yazılım sorunları / operator eğitim eksikliği	güvenlik / yüksek fiyat/ tasarım sorunları / donanım sorunları / yazılım sorunları / operator eğitim eksikliği

Sorular	Cevaplar5	Cevaplar6	Cevaplar7	Cevaplar8
Tarih	3.01.2020	3.01.2020	3.01.2020	3.01.2020
Ülke	Türkiye	Türkiye	Türkiye	Türkiye
Şirket	Unilever	Unilever	Unilever	Unilever
Şehir	İstanbul / Tekirdag / Kocaeli / Rize	İstanbul / Tekirdag / Kocaeli / Rize	İstanbul / Tekirdag / Kocaeli / Rize	İstanbul / Tekirdag / Kocaeli / Rize
Fabrika	Ev ve Kişisel Bakım / Gıda / Dondurma	Ev ve Kişisel Bakım / Gıda / Dondurma	Ev ve Kişisel Bakım / Gıda / Dondurma	Ev ve Kişisel Bakım / Gıda / Dondurma
Kullanıcının Rolü	Operator/ Mühendis /Tasarımcı/Developer/Fabrika Direktörü	Operator/Mühendis/Tasarımcı/ Developer /Fabrika Direktörü	Operator/ Mühendis /Tasarımcı/Developer/Fabrika Direktörü	Operator /Mühendis/Tasarımcı/Developer/Fabrika Direktörü
Kullanılan Cobot Marka/Model	Fanuc/ Universal Robots /Kuka	Fanuc/ Universal Robots /Kuka	Fanuc/ Universal Robots /Kuka	Fanuc/ Universal Robots /Kuka

Sorular	Cevaplar5	Cevaplar6	Cevaplar7	Cevaplar8
Cobot'un İşlevi	paketleme/ kolileme / paletleme /hat ürün besleme	paketleme / kolileme / paletleme /hat ürün besleme	paketleme/ kolileme / paletleme /hat ürün besleme	paketleme / kolileme / paletleme /hat ürün besleme
Cobot'la çalışırken en çok etkileşime geçilen kişiler	Operator /Mühendis/Tasarımcı/Developer/Fabrika Direktörü	Operator /Mühendis/Tasarımcı/Developer/Fabrika Direktörü	Operator/ Mühendis /Tasarımcı/ Developer /Fabrika Direktörü	Operator /Mühendis/Tasarımcı/Developer/Fabrika Direktörü
Cobot'un sağladığı fayda	üretkenlik/ maliyet azalması / doğruluk / hız / kalite	üretkenlik/ maliyet azalması / doğruluk / hız / kalite	üretkenlik/ maliyet azalması / doğruluk / hız / kalite	üretkenlik/ maliyet azalması / doğruluk / hız / kalite
Cobot'un konfigürasyon/customizasyon kolaylığı	az / orta / yüksek	az / orta / yüksek	az / orta / yüksek	az / orta / yüksek
Cobot'un konfigürasyon değişiklik sayısı / ay	1	2	3	0
Cobot'la beraber çalışırken meydana gelen kaza sayısı / ay	0	3	0	0
Cobot'un ortalama arıza sayısı / ay	4	2	1 / 24 ay	4
Cobot'la çalışma ile ilgili engeller	güvenlik / yüksek fiyat / tasarım sorunları / donanım sorunları / yazılım sorunları / operator eğitim eksikliği	güvenlik / yüksek fiyat / tasarım sorunları / donanım sorunları / yazılım sorunları / operator eğitim eksikliği	güvenlik / yüksek fiyat / tasarım sorunları / donanım sorunları / yazılım sorunları / operator eğitim eksikliği	güvenlik / yüksek fiyat / tasarım sorunları / donanım sorunları / yazılım sorunları / operator eğitim eksikliği

Sorular	Cevaplar9	Cevaplar10	Cevaplar11
Tarih	3.01.2020	3.01.2020	3.01.2020
Ülke	Türkiye	Türkiye	Türkiye
Şirket	Unilever	Unilever	Unilever

Sorular	Cevaplar9	Cevaplar10	Cevaplar11
Şehir	İstanbul / Tekirdag / Kocaeli / Rize	İstanbul / Tekirdag / Kocaeli / Rize	İstanbul / Tekirdag / Kocaeli / Rize
Fabrika	Ev ve Kişisel Bakım / Gıda / Dondurma	Ev ve Kişisel Bakım / Gıda / Dondurma	Ev ve Kişisel Bakım / Gıda / Dondurma
Kullanıcının Rolü	Operator/Mühendis/Tasarımcı/Developer/ Fabrika Direktörü	Operator/ Mühendis /Tasarımcı/Developer/Fabrika Direktörü	Operator /Mühendis/Tasarımcı/Developer/Fabrika Direktörü
Kullanılan Cobot Marka/Model	Fanuc/ Universal Robots /Kuka	Fanuc/ Universal Robots /Kuka	Fanuc/Universal Robots/Kuka/ ABB
Cobot'un İşlevi	paketlenme/kolileme /paletleme/hat ürün besleme	paketlenme/kolileme/paletleme /hat ürün besleme	paketlenme/ kolileme /paletleme/hat ürün besleme
Cobot'la çalışırken en çok etkileşime geçilen kişiler	Operator /Mühendis/Tasarımcı/Developer/Fabrika Direktörü	Operator/ Mühendis /Tasarımcı/ Developer /Fabrika Direktörü	Operator /Mühendis/Tasarımcı/Developer/Fabrika Direktörü
Cobot'un sağladığı fayda	üretkenlik/ maliyet azalması / doğruluk / hız / kalite	üretkenlik/ maliyet azalması / doğruluk / hız / kalite	üretkenlik/ maliyet azalması / doğruluk / hız / kalite
Cobot'un konfigürasyon/customizasyon kolaylığı	az / orta / yüksek	az / orta / yüksek	az / orta / yüksek
Cobot'un konfigürasyon değişiklik sayısı / ay	0	0	4
Cobot'la beraber çalışırken meydana gelen kaza sayısı / ay	0	0	0
Cobot'un ortalama arıza sayısı / ay	4	0	2
Cobot'la çalışma ile ilgili engeller	güvenlik / yüksek fiyat / tasarım sorunları / donanım sorunları / yazılım sorunları / operator eğitim eksikliği	güvenlik / yüksek fiyat / tasarım sorunları / donanım sorunları / yazılım sorunları / operator eğitim eksikliği	güvenlik / yüksek fiyat / tasarım sorunları / donanım sorunları / yazılım sorunları / operator eğitim eksikliği

Preliminary Study with IT/OT Interview

From: Aktas, Sirin <Sirin.Aktas@unilever.com>

Sent: Friday, January 10, 2020 10:37 AM

To: Dikmen, Emre <Emre.Dikmen@unilever.com>

Subject: Besan Factory Case Study - IT/OT Engineer Interview

Dear Emre,

Regarding my PHD study at Technology, Society, Design, Ozyegin University, I would like to make an interview with you to gather some data for my end term essay for DTS 502A, STS Studies. Can you please answer the below questions with your experience as IT/OT Engineer observing and supporting automation projects & operations in Unilever Turkey Factories?

Please answer the questions regarding the human cobot interaction in Besan Factory.

1. Who are the actors involved to work with cobots in Besan Factory?
2. Do actors share the same objective? And what is their main objective?
3. What are the improvement areas in this allied groups to have better results in collaboration?
4. Is there any lack of competency designing, developing or using cobots in this factory?
5. What are the workplace constraints? Why do cobots work in fences?
6. Can you please compare the efficiency of the interaction working with cobots in this factory with others you are observing?

Thanks

Sirin Aktas

From: Dikmen, Emre

Sent: Cuma, Ocak 10, 2020 13:17

To: Aktas, Sirin

Subject: RE: Besan Factory Case Study - IT/OT Engineer Interview

Dear Sirin,

Please find my answers below:

1. Who are the actors involved to work with cobots in Besan Factory?

- * End of line and packaging operators
- * Repair & Maintenance Team (technicians)
- * Manufacturing Engineers
- * Manufacturing Manager
- * Factory Director

2. Do actors share the same objective? And what is their main objective?

* Yes, their main objective is to keep Cobots at planned & desired configuration and working level. Once Cobots are programmed, Cobots start to do desired procedure till the next configuration. During this phase main objective of the actors is tracking Cobot's performance and reporting unexpected cases & situations. Maintenance team always work close with the end of line and packaging operators in order to act as quick as possible when faults or failures happen. Instead of co-operating with Cobots, operators mainly do observation to the Cobots work. Sub procedure of the operation is discrete e.g.: once cobot do its job then operator will continue to second job, there is no intersection points of these two jobs.

3. What are the improvement areas in this allied groups to have better results in collaboration?

* Since Unilever applies and follows strict safety regulations for both employees and equipment, Cobot – Human interaction is limited due to Cobots were surrounded by fence and every door of the fence has an emergency sensor that deactivates the cobot operation once door is opened. However, Cobots were designed and produced to work together with humans. With their accurate, precise and fast acting capabilities they are very helpful for operators and maintenance team. I believe one of the most easy area to improve human – cobot collaboration is to use cobots during maintenance period because they can reach dangerous parts of the machines and able to reach longer distances comparing to human technician.

4. Is there any lack of competency designing, developing or using cobots in this factory?

* Yes. Even though Cobots are easy to program and develop - comparing to other industrial robots, only factory maintenance engineers are given permission to modify the design for only limited modifications. If the design requires more detailed update, usually vendors are summoned as technical service. But hopefully Besan factory has started to change this phenomenon into reduce dependencies to vendors for these particular operations. Right now, factory maintenance team has started to develop necessary skills for Cobot design and development.

5. What are the workplace constraints? Why do cobots work in fences?

* Actually, the reason of putting Cobots to work in barriers basically relies on the idea of investment of Cobots were basically being more feasible comparing to industrial robotic arms. In other words, initial plan was investing in industrial robotic

arms and all the environmental design applied as like industrial robotic arms, but once the engineering calculations done it is observed that required speed, pay load capacity, reaching area (Maximum Envelope Space) and Forward Kinematic Solution can be covered by a Cobot as well for particular operation. If the operation does not require high accuracy and high speed, Cobots considered to achieve same goal with cheaper price comparing to industrial robotic arms. Basically, in Besan factory and other factories of Unilever, Cobots are designed to work as traditional industrial robotic arms, there wasn't human – machine co-operation has intended thus, Unilever SHE department classified Cobots as same as other industrial robots and took necessary precautions like barriers, light curtains etc.

6. Can you please compare the efficiency of the interaction working with cobots in this factory with others you are observing?

* Even if in Besan factory (and the rest) Cobots are behaved like industrial robots, main difference of Cobot usage in Besan factory comparing the others; significant installation amount of the Cobot design includes 3 – Axis movement of Cobot's base part, therefore complete body of Cobot itself. I believe, It enables operators and engineers to consider future Cobot installations to be more collaborative. In my opinion, with the appropriate simulation and demonstration safety regulations able to support more human Cobot collaboration.

Best regards,

Emre

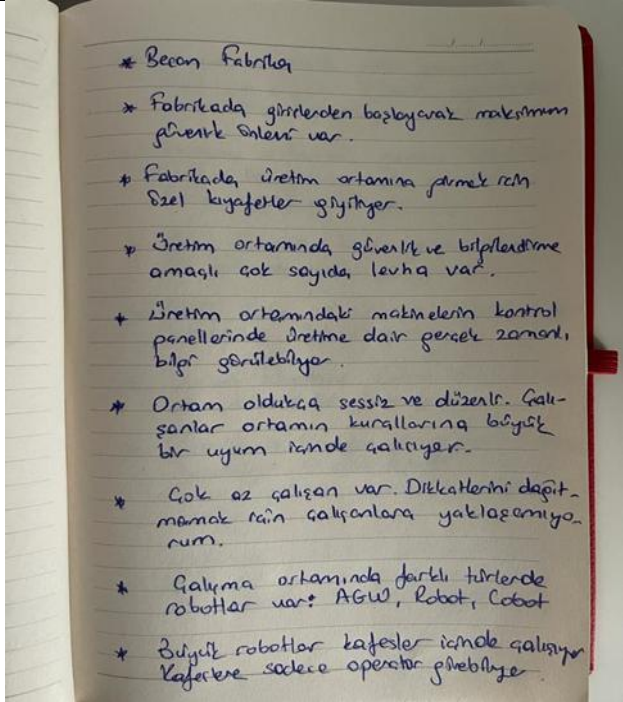
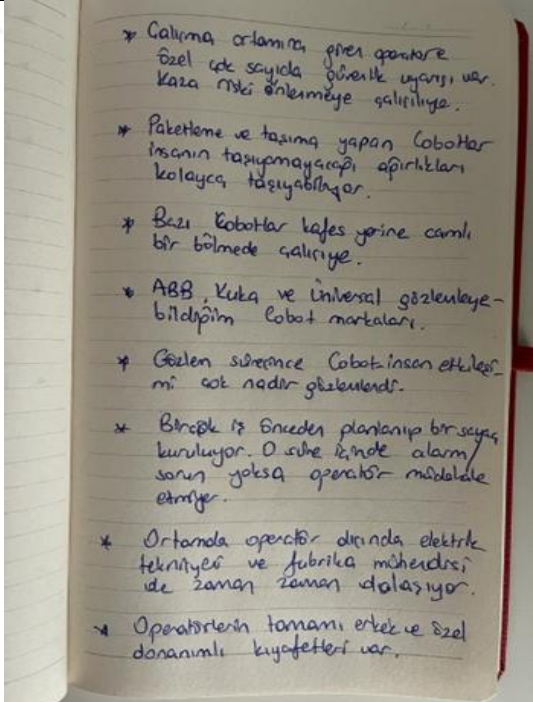
APPENDIX B . NON-PARTICIPANTOBSERVATION

Table B1 *Non-Participant Observation Record*

Date and Time	March, 2021
Location	Unilever Besan Factory
Researcher	Şirin Aktaş
Research Topic	TRUST MODELS IN HRI - CASE STUDY WITH UNILEVER

Data Collection for Non-Participant Observation

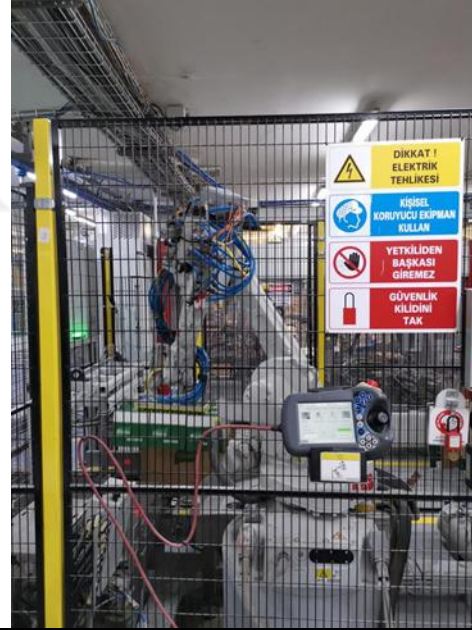
Table B2 Field Notes and Photographs

Field Notes	
 * Beton Fabrika * Fabrikada gürültüden başlayarak maksimum gürültü seviyesi var. * Fabrikada, üretim ortamına girmek için özel kıyafetler giyiliyor. * Üretim ortamında güvenlik ve bilgilendirme amaçlı çok sayıda levha var. * Üretim ortamındaki makinelerin kontrol panellerinde üretime dair gerçek zamanlı bilgi görülebiliyor. * Ortam oldukça sessiz ve düzenli. Çalışanlar ortamın kurallarına büyük bir uyum içinde kalıyor. * Çok az çalışan var. Dikkatlerini dağıtmamak için çalışanlara yaklaşılmıyor. * Çalışma ortamında farklı türlerde robotlar var: AGV, Robot, Cobot * Büyük robotlar kafesler içinde çalışıyor. Kafeslere sadece operatör girebiliyor.	 * Çalışma ortamında özel operatör özel işte sayıda güvenlik uyarısı var. Kaza riski önlemeye çalışılıyor. * Paketleme ve taşıma yapan Cobotlar insanın taşıyamayacağı ağırlıkları kolayca taşıyabiliyor. * Bazı robotlar kafes yerine camlı bir bölmede çalışıyor. * ABB, Kuka ve Universal gözlemlenebilir robot markaları. * Gözlem süresince Cobot-insan etkileşimi çok nadir gözlemlendi. * Basit iş süreci planlanıp bir süreç kuruluyor. O süreç içinde alarm sorunu yoksa operatör müdahale etmiyor. * Ortamda operatör dışında elektrik teknisyeni ve fabrika mühendisi de zaman zaman dolaşıyor. * Operatörlerin tamamı erkek ve özel donanımlı kıyafetleri var.

Photographs



Photographs



Photographs



Photographs



Findings for Non-Participant Observation

Table B3 Findings Related with Non- Participant Observation

Robot Related					
Performance Related	Findings	Attribute Based	Findings	Apperance Related	Findings
Dependability	Not observed	Proximity/Co-location	Proximity is limited. They are all in fences or glass panels	Appearance	Cobots with different apparats according to their tasks
Reliability of Robots	Not observed	Robot Personality	Not observed	Anthropomorphism	Not observed
Behavior	Not observed	Adaptability	Not observed		
Predictability	Not observed	Robot Type	Cobot		
Level of automation	Large number of Cobots on the shop floor				
Communication Method	There is a scheduled jobs to follow up by Operator. Operator visits the Cobot whenever the job finishes.				
Failure Rates	Observed on Photo1: "Duruş"				
False Alarms	Not observed				
Transparency	Not observed				

Human Related			
Ability Based	Findings	Character Based	Findings
Attentional Capacity/Engagement	<i>Engagement is limited</i>	Gender	<i>Man</i>
Expertise / Amount of Training	<i>Not observed</i>	Age	<i>Estimation is 30-45</i>
Competency	<i>Not observed</i>	Race	<i>Turkish</i>
Operator Workload	<i>Not too much</i>	Culture	<i>Turkish</i>
Prior Experience	<i>Not observed</i>	Education	<i>Not observed</i>
Situation Awareness	<i>Not observed</i>	Expectancy	<i>Not observed</i>
		Personality Traits	<i>Not observed</i>
		Attitude Towards Robots	<i>Not observed</i>
		Comfort with Robots	<i>Not observed</i>
		Propensity to Trust	<i>Not observed</i>
		Self-confidence	<i>Not observed</i>
		Satisfaction	<i>Not observed</i>
		Self-Efficacy	<i>Not observed</i>

Contextual Factors			
Team Colaboration	Findings	Tasking	Findings
Tenure	<i>Not observed</i>	Task Type	<i>Packaging</i>
Team Conflict	<i>Not observed</i>	Task Complexity	<i>High</i>
In-group membership	<i>there is a 1-1 mapping. 1 operator is assigned to 1 Cobot</i>	Multi-tasking Requirements	<i>Not observed</i>
Interaction Frequecny	<i>There is a scheduled jobs to follow up by Operator. Operator visits the Cobot whenever the job finishes.</i>	Physical Environment	<i>Safety and security restrictions are high. There are many signs, labels, and floor markings. There are many fences and glass panels seperated from production pipelines.</i>
Shared mental models	<i>Not observed</i>		
Proximity/co-location	<i>Proximity is limited. They are all in fences or glass panells</i>		
Role interdependence	<i>Not observed</i>		
Team Composition	<i>there is a 1-1 mapping. 1 operator is assigned to 1 Cobot</i>		
Team cohesion	<i>there is a 1-1 mapping. 1 operator is assigned to 1 Cobot</i>		



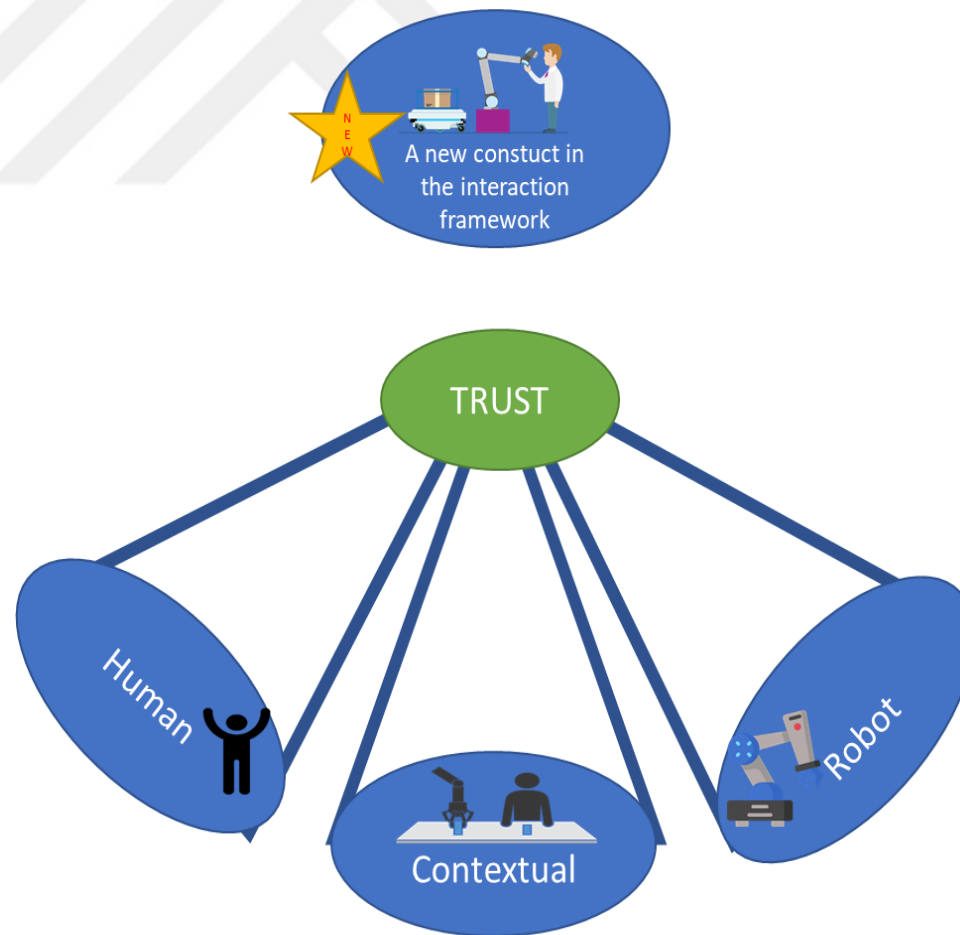
Other Findings	
A new dimension discovered	There are other parties on the shop floor like engineer and technician.
There is an issue with "Human Robot Interaction"	There are rules for "seperation" than"collaboration"
Safety has a framework	Safety rules are very clear and applied in discipline

Report for Non-Participant Observation

As a researcher, I had limited access to Cobots and Operators on the field because of the very strict safety and access rules on the factory production area. And also, i didn't want to interfere the relation and the team work. Therefore i have chosen non-participant observation as an unobstructive qualitative research strategy for gathering the data about the constructs of “Trust Models in HRI” without directly interacting. I visited Besan Factory, and observed the different types of Cobots working with Operator on packing activity.

During the visit, I observed Cobot, Operator and the environment: the type of the work, frequency of the joint tasks, safety cautions, and other parties involved. I jotted down my field notes,and took photos of the day.

Figure B1 *Human Robot Interaction Framework with New Construct*



APPENDIX C . DOCUMENT ANALYSIS

Table C1 *Document Analysis Record*

Date and Time	April, 2021
Location	Unilever Besan Factory, Konya IC, Corlu IC
Researcher	Şirin Aktaş
Research Topic	TRUST MODELS IN HRI-CASE STUDY WITH UNILEVER

Data Collection for Document Analysis

Table C2 *Documents used for Document Analysis*

Collaborative Robotics Briefing for Factory Directors	 NR_2017_Summary-COBOT.pptx	Document created at June, 2017
Cobot Operating Manual for Operators	 SOP_Cobot%20Operating%20Manual.docx	Document created at February, 2020

Findings for Document Analysis

Table C3 *Data Analysis Steps for Document Analysis*

Initial Coding	Getting to know the data in hand Coding sentences and word groups as initial meanings/themes
Generating Themes	Collating codes into potential themes
Thematic Mapping	Identifying patterns Mapping with Themes
Refining Themes	Generating clear definitions and relations between themes
Report	Findings

Table C4 *Findings with Document Analysis*

Document #1	Coloborative Robotics Briefing for Factory Directors
Initial Coding	collaborative robots Cobots Technology Objective New World Change Safety Cost Market Fast Agile changing set of business & consumer needs Super-users Early Adopters Change leaders Safety Quality Finance support
Generating Themes	Reshaping FMCG Supply Chain Cobots Usage Adoption Framework

Table C5 *Thematic Mapping for the First Document*

Robot Related					
Performance Related	Findings	Attribute Based	Findings	Apperance Related	Findings
Dependability	<i>slide 4</i>	Proximity/Co-location	<i>Not mapped</i>	Appearance	<i>Not mapped</i>
Reliability of Robots	<i>Slide 6</i>	Robot Personality	<i>Not mapped</i>	Anthropomorphism	<i>Not mapped</i>
Behavior	<i>Slide 6,9, 22</i>	Adaptability	<i>Slide 6,9, 22</i>		
Predictability	<i>Slide 6,22</i>	Robot Type	<i>Slide 6..23</i>		
Level of automation	<i>Slide 5,22</i>				
Communication Method	<i>Slide 6</i>				
Failure Rates	<i>Not mapped</i>				
False Alarms	<i>Not mapped</i>				
Transparency		<i>Not mapped</i>			

Human Related			
Ability Based	Findings	Character Based	Findings
Attentional Capacity/Engagement	Slide 6,7,8	Gender	Not mapped
Expertise / Amount of Training	Slide 6,7,8, 22	Age	Not mapped
Competency	Slide 6,7,8, 22	Race	Not mapped
Operator Workload	Slide 6, 22	Culture	Not mapped
Prior Experience	Not mapped	Education	Not mapped
Situation Awareness	Slide 8	Expectancy	Not mapped
		Personality Traits	Not mapped
		Attitude Towards Robots	Not mapped
		Comfort with Robots	Not mapped
		Propensity to Trust	Not mapped
		Self-confidence	Not mapped
		Satisfaction	Not mapped
		Self-Efficacy	Not mapped

Contextual Factors			
Team Colaboration	Findings	Tasking	Findings
Tenure	Slide 22	Task Type	Slide 6,10
Team Conflict	Not mapped	Task Complexity	Slide 6,10
In-group membership	Not mapped	Multi-tasking Requirements	Slide 6,10
Interaction Frequecny	Not mapped	Physical Environment	Slide 6,8, 10, 21
Shared mental models	Not mapped		
Proximity/co-location	Not mapped		
Role interdependence	Not mapped		
Team Composition	Not mapped		
Team cohesion	Not mapped		

Table C6 *Refining Themes on Thematic Mapping for the First*

Refining Themes (Initial themes are validated)	Reshaping FMCG Supply Chain
	Cobots Usage
	Adoption Framework
Document	Cobot Operating Manual for Operators
Initial Coding	Trainer
	Function
	Safety
	System Requirements
	Handler Unit
	Mobile Unit
	Set Up
	Workflows
	Tasks
	Program
	Calibration
	Modifying
	Troubleshooting
	Error
	Solution
	Emergency
	Test
Generating Themes	Cobot Set Up
	Cobot Calibration
	Deployer
	Cobot Technical Issues & Resolution
Refining Themes (Initial themes are validated)	Deployer should be added as a new theme with new attributes like Feedback Loop, Monitoring, Remote Intervention
	Cobot Set Up
	Cobot Calibration
	Cobot Technical Issues & Resolution

Table C7 Thematic Mapping for the Second Document

Robot Related					
Performance Related	Findings	Attribute Based	Findings	Appearance Related	Findings
Dependability	<i>Program Structure editor helps to do adjustments according to the conditions</i>	Proximity/Co-location	<i>Not mapped</i>	Appearance	<i>Page 5,6 Green Handling Unit, Blue Mobile Unit & Yellow is the emergency stop</i>
Reliability of Robots	<i>Not mapped</i>	Robot Personality	<i>Page 31 By selecting the upload button, you can upload a sound you into the MiR library, such as Steve voice!</i>	Anthropomorphism	<i>Page 31 By selecting the upload button, you can upload a sound you into the MiR library, such as Steve voice!</i>
Behavior	<i>Device Calibration & Teaching Mode available to set up the necessary movement</i>	Adaptability	<i>Page 5 Green Handling Unit, Blue Mobile Unit & Yellow is the emergency stop</i>		
Predictability	<i>Page 11 Notification tasks, notifying the user with a message this can be in warning, error or information format.</i>	Robot Type	<i>Cobot mentioned on different Pages : 1,2,3,4,5,6,7, 18,21,29,30,31,32,35</i>		
Level of automation	<i>Not mapped</i>				

Performance Related	Findings	Attribute Based	Findings	Appearance Related	Findings
Communication Method	<i>Page 32 Changing the sound and light, Page 11 Notification tasks will notify the user with a message this can be in warning, error or information format.</i>				
Failure Rates	<i>Accuracy and precision are set and tested via MiR Controller</i>				
False Alarms	<i>Page 35 Time out errors, Page 36 Emergency Break</i>				
Transparency	<i>Not mapped</i>				

Contextual Factors			
Team Collaboration	Findings	Tasking	Findings
Tenure	<i>Not mapped</i>	Task Type	<i>Not mapped</i>
Team Conflict	<i>Not mapped</i>	Task Complexity	<i>Not mapped</i>
In-group membership	<i>Not mapped</i>	Multi-tasking Requirements	<i>Not mapped</i>
Interaction Frequency	<i>Not mapped</i>	Physical Environment	<i>Not mapped</i>
Shared mental models	<i>Not mapped</i>		
Proximity/co-location	<i>Not mapped</i>		
Role interdependence	<i>Not mapped</i>		
Team Composition	<i>Not mapped</i>		
Team cohesion	<i>Not mapped</i>		

Human Related			
Ability Based	Findings	Character Based	Findings
Attentional Capacity/Engagement	<i>Page 3: Show-casing automation for end-users to highlight potential benefits</i>	Gender	<i>Not mapped</i>
Expertise / Amount of Training	<i>Page 4: Before Use</i>	Age	<i>Not mapped</i>
Competency	<i>Page 4: Before Use</i>	Race	<i>Not mapped</i>
Operator Workload	<i>Not mapped</i>	Culture	<i>Not mapped</i>
Prior Experience	<i>Page 4: Before Use, Safety-Third Party Equipment</i>	Education	<i>Not mapped</i>
Situation Awareness	<i>Not mapped</i>	Expectancy	<i>Not mapped</i>
		Personality Traits	<i>Not mapped</i>
		Attitude Towards Robots	<i>Not mapped</i>
		Comfort with Robots	<i>Not mapped</i>
		Propensity to Trust	<i>Not mapped</i>
		Self-confidence	<i>Not mapped</i>
		Satisfaction	<i>Not mapped</i>
		Self-Efficacy	<i>Not mapped</i>

Table C8 Refining Themes for Document Analysis

Refining Themes (Initial themes are validated)	Deployer should be added as a new theme with new attributes like Feedback Loop, Monitoring, Remote Intervention Cobot Set Up Cobot Calibration Cobot Technical Issues & Resolution
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Table C9 *Deployer as a New Construct*

Deployer			
Performance Related	Findings	Tasking	Findings
Feedback Loop	Page 8, 15: MiR controller	Remote intervention	Page 16: Put the IP of the robot followed by “/camera”. In this case: 192.168.12.20/camera
Monitoring	Page 8, 15: MiR controller	Tasking	Page 11: User Tasks will open a pop up for the user which can include fields for the user to input.
Level of automation	Page 3: Show-casing automation for end-users to highlight potential benefits		
Communication Method	Page 32: Changing the sound and light, Page 11 Notification tasks will notify the user with a message this can be in warning, error or information format.		
Failure Rates	Accuracy and precision are set and tested via MiR Controller		
False Alarms	Page 35 Time out errors, Page 36 Emergency Break		

Report for Document Analysis

Document analysis was used as a qualitative research technique in this Case Study of Unilever Turkey. The process involved evaluating electronic documents to interpret them, gain an understanding of their meaning and derive some points to build up the constructs related with “Trust Models in HRI”. The documents provided by Factory Director were the presentation named as “Collaborative robotics Briefing for Factory Directors” and a training document named as “Cobot Operating Manual”. I studied the content and structure of the documents to identify the content, and understand the themes related with my research area.

APPENDIX D . FIRST INTERVIEW

Table D1 *First Interview Record*

Date and Time	May, 2021
Location	Unilever Besan Factory, Konya IC, Corlu IC
Researcher	Şirin Aktaş
Research Topic	TRUST MODELS IN HRI-CASE STUDY WITH UNILEVER
Person to be interviewed	Nuretdin Nal-Supply Chain Director

Data Collection for First Interview

Table D2 *Data Analysis Steps for First Interview*

Interview Preparation	Interview was done with Unilever Turkey Supply Chain Director responsible from Cobot Operations. It was semi-structured interview with a mixture of prepared questions and prompt questions. The questions prepared in advance were aimed to check the validity of the findings from the previous steps of Data Collection and Analysis. Additionally, I asked prompt questions to understand his expert point of view on Human Cobot Interaction and the importance of Trust Calibration for Unilever. The answers to these questions in turn generated a new set of data to analyze for Unilever Turkey.
Interview Questions	How Cobots in Unilever positioned? What is the latent need for HRI in Unilever? How do you think about Cobots & Trust? Do you think cobots are effective in Unilever? What and How to measure their performance?
Interview Record	

Findings for First Interview

Table D3 *Findings with First Interview*

Interview with Nuretdin Nal - Supply Chain Director	
Initial Coding	Safety Risk Interaction Design Deployer Set up Deployment Cobot Fence Robot AGW Tasking Operator Collaboration Interaction Teamwork Payback Cost Saving Effectiveness Performance Packaging Failures Intervention Adoption Production Loss Misuse Damage Job loss

Generating Themes	Interaction Design Instructions for HR Trust Calibration Safety Saving
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Report for First Interview

Table D4 *Thematic Analysis for First Interview*

Robot Related					
Performance Related	Findings	Attribute Based	Findings	Apperance Related	Findings
Dependability	<i>Not mapped</i>	Proximity/ Co-location	<i>Limited access</i>	Appearance	<i>Not mapped</i>
Reliability of Robots	<i>Type of the task</i>	Robot Personality	<i>Not mapped</i>	Anthropomorphism	<i>Not mapped</i>
Behavior	<i>There is no partnering with Operator.</i>	Adaptability	<i>There are many configurations and sensors set up according to</i>		
Predictability	<i>Cobots are pre-defined/standard for a specific task. The predictability is high.</i>	Robot Type	<i>Cobots are used on the shop floor. Robots and AGWs are the other types of automation working at factories.</i>		
Level of automation	<i>There are different sensors on the Cobot to increase the automation and interaction</i>				

Communication Method	<i>There is a limited access to the fences, and physical interaction prohibited. The deployer or operator can use configuration/codes to "set the tone of communication". And also, Cobots can be remotely interrupted if any failure.</i>				
Failure Rates	<i>Lower than Robots as the tasks assigned to Cobots are simple/ standard/ repetitive.</i>				
False Alarms	<i>There is a "loss tree" analysis would be applied to Cobots to monitor alarms, maintenance and configuration parameters.</i>				
Transparency	<i>There is non-value added activities defined. The role of Cobot, and segregation of duties are clearly defined and communicated.</i>				
Added value: Productivity	<i>Cobots effectiveness are measured, and deployers are monitoring the "stops", "failures", "maintenance" activities to understand the throughput.</i>				
Added value: Cost Saving	<i>Saving is the main driver, and yet there is no return on Cobots investment. But they have seen the saving using the other type of industrial automations.</i>				
Added value: Speed	<i>Cobots are replacing the repetitive tasks, and they are fast and agile</i>				
Added value: Accuracy	<i>There are measurements by Deployer on the accuracy and effectiveness.</i>				
Added value: Quality	<i>Some quality issues are on the shop floor, but not related with the Cobot but "materials & products"</i>				

Contextual Factors			
Team Collaboration	Findings	Tasking	Findings
Tenure	<i>Improving by time. It is better than 1 year ago</i>	Task Type	<i>simple/standard/repetitive.</i>
Team Conflict	<i>Not mentioned</i>	Task Complexity	<i>Low</i>
In-group membership	<i>Very limited. They dont work in the same workspace for the same task. One finishes and then the others start the next task.</i>	Multi-tasking Requirements	<i>There are multitasking requirements, but limited with the strict safety rules</i>
Interaction Frequecny	<i>Rare or none</i>	Physical Environment	<i>Cobots working in fences. The fences have strict access rules. If something happens in the fence there are alarms and controls to inform authorities.</i>
Shared mental models	<i>Rare or none</i>		
Proximity/co-location	<i>Limited access. Cobots are working in fences.</i>		
Role interdependence	<i>Very limited. They don't work in the same workspace for the same task. One finishes and then the others start the next task.</i>		
Team Composition	<i>There is no cooperation or collaboration. Roles are segregated.</i>		
Team cohesion	<i>There is no cooperation or collaboration. Roles are segregated.</i>		

Deployer			
Performance Related	Findings	Tasking	Findings
Feedback Loop	<i>Loss Tree will be used to collect data, analyse and make the necessary changes</i>	Remote intervention	<i>Not mentioned</i>
Monitoring	<i>There is a "loss tree" analysis would be applied by Deployer to Cobots to monitor alarms, maintenance and configuration parameters.</i>	Tasking	<i>Deployer design the interaction, type of the task and the role of Cobot in the specific task</i>
Level of automation	<i>Cobots are flexible than Robots. Deployer decide on the standards of "safety, quality, accuracy etc". And also, deployer decide on both hardware and software specs.</i>		
Communication Method	<i>There is a limited access to the fences, and physical interaction prohibited. The deployer or operator can use configuration/codes to "set the tone of communication". And also, Cobots can be remotely interrupted if any failure.</i>		
Failure Rates	<i>Lower than Robots as the tasks assigned to Cobots are simple/standard/repetitive. Even with this fact, Cobots are decided to be used in fences. There are a few minor issues related with "materials" used for the task, not the Cobot itself.</i>		
False Alarms	<i>There is a "loss tree" analysis would be applied by Deployer to Cobots to monitor alarms, maintenance and configuration parameters.</i>		

Refining Themes (Initial themes are validated)	<u>Interaction Design</u>	Themes are validated and a few attributes added to the Trust Model
	<u>Instructions for HR</u>	
	<u>Trust Calibration</u>	
	<u>Safety</u>	
	<u>Saving</u>	

Deployer		
Performance Related	Findings	Attribute Based
		Interaction design

Report

Interview was done with Unilever Turkey Supply Chain Director responsible from Cobot Operations. It was semi-structured interview with a mixture of prepared questions and prompt questions. The questions prepared in advance were aimed to check the validity of the findings from the previous steps of Data Collection and Analysis. Additionally, I asked prompt questions to understand his expert point of view on Human Cobot Interaction and the importance of Trust Calibration for Unilever. Thematic analysis was used to analyze the data

collected. The themes for the interview were Interaction Design, instructions for Human Resource Management, Trust Calibration, Safety and Cost Saving. The answers to the questions in turn generated a new set of attributes to be analyzed for Unilever Turkey:

- Interaction Design: Cobots are easy to programme, fast to set up and enable flexibility within automation. Deployer should be able to understand the process and the interaction need first and then complete the deployment with the necessary hardware and software configurations.

- Instructions for Human Resource Management: Collaboration requires a team work. Human resources are should define the roles and responsibilities for each part of the interaction. The instruction for Cobot should be given the deployer for Cobot design, the instructions for Operator should be given directly the Operator group as trainings, workshops, change management activities.

- Trust Calibration Cues: As Cobots used for a while in this company, they have started to learn how to increase the engagement by doing some adjustments on the Cobot, Operator or the environment to increase the trust level of the interaction.

APPENDIX E . SURVEY

Table E1 *Survey Record*

Date and Time	June, 2022
Location	Unilever Besan Factory, Konya IC, Corlu IC
Researcher	Şirin Aktaş
Research Topic	TRUST MODELS IN HRI-CASE STUDY WITH UNILEVER

Data Collection for Survey

Table E2 *Data Analysis Steps for Survey*

Survey Design	The survey was designed to apply to Cobot Operators, and there are 26 questions on the survey. There were categorical questions which were simple, specific and direct to get neutral answers. Survey answers were combined with Comments (Yorumlar) column to add details, examples, and thoughts if required
Survey Application	The survey was on Excel Sheets and shared with 11 operators from 3 different factories in 3 different cities via email. The results were gathered back via email between 17.05.2022 and 25.05.2022.
Survey Data and Analysis	

Table E3 *Survey Template*

Sorular	Cevaplar	Yorumlar
Tarih	Gün/Ay/Yıl	
Ülke	Türkiye	
Şirket	Unilever	
Şehir	İstanbul/ Tekirdağ / Kocaeli / Rize	
Fabrika	Ev ve Kişisel Bakım / Gıda / Dondurma	
Kullanıcının Rolü	Operator/ Mühendis/ Tasarımcı/ Developer/ Fabrika Direktörü	
Kullanıcının Eğitim Durumu	Lise/Üniversite/Diğer	
Kullanıcının Sektör Tecrübesi (kaç yıl)		
Kullanıcının Cobotlarla Çalışma Deneyim Süresi (Kaç yıl)		
Kullanılan Cobot Marka/Model	Fanuc/ Universal Robots/ Kuka	
Cobot'un İşlevi	Paketleme/ kolileme/ paletleme/ hat ürün besleme	
Cobot'la çalışırken en çok etkileşime geçilen kişiler	Operatör/Mühendis/Tasarımcı/Developer/ Fabrika Direktörü	
Cobot'un sağladığı fayda	Üretkenlik/ maliyet azalması / doğruluk / hız / kalite	
Cobot-Operatör birlikte çalışma modelinizde sistemi konfigure eden/yöneten operator dışında biri var mı?	Evet / Hayır	Evet ise kim olduğunu tanımlar mısınız?
Operatör sistemi tasarlayan/uygulayan uzmana geri bildirimde bulunuyor mu?	Evet / Hayır	Evet ise nasıl geri bildirimde bulunduğunu açıklar mısınız?

Sorular	Cevaplar	Yorumlar
Sistemden otomatik olarak ya da operatörden sistemi tasarlayan/uygulayan uzmana alarm ya da bildirim gidiyor mu?	Evet / Hayır	Evet ise ne tür alarmlar/bildirimler olduğunu örnekler misiniz?
Sistemi tasarlayan/uygulayan uzman sistemin durumunu, operatör ile ilgili kriterleri izliyor ve raporluyor mu?	Evet / Hayır	Evet ise hangi kriterleri izleyip raporladığını örnekler misiniz?
Operatör sistemde performans iyileştirmesi yapmak, daha verimli-etkin çalışmak için Cobot'un konfigürasyonunu değiştiriyor mu?	Evet / Hayır	Evet ise hangi sıklıkta/hangi durumlarda yaptığını açıklar mısınız?
Hata ya da kaza durumunda sistemi tasarlayan/uygulayan uzman sisteme uzaktan müdahale edebiliyor mu?	Evet / Hayır	Evet ise hangi sıklıkta ve ne tür müdahaleler olduğunu örnekler misiniz?
Cobot hatalarından öğrenip, önleyici önlemler alıyor ya da öğrendiği öngörülerini sistemi tasarlayan/uygulayan uzmana gönderiyor mu?	Evet / Hayır	Evet ise örnek verebilir misiniz?
Cobotların robotlara göre avantaj /dezavantajları nelerdir?		

Sorular	Cevaplar	Yorumlar
Cobotların kullanım ömürleri asıl? Çok fazla parça değiştiriyor musunuz?		
Cobotları yan ekipmanlar ile kullanıyor musunuz? (Kamera sistemi, data sistemleri)		
Bir den fazla cobot koordineli çalışıyor mu?		
Cobotların kullanımı kolay mı? Operatorler olarak arızaların % kaçını yapabiliyorsunuz?		
Cobotlar gelen ambalaj malzemelerindeki hataları tolere edebiliyor mu? Yoksa küçük duruşlar mı yaşıyorsunuz?		

Findings for Survey

Table E4 *Responses of Survey*

Sorular	Cevaplar	Yorumlar	Type of The Question	Factors	Attributes	Potential/ Existing
Tarih	Gün/Ay/Yıl		General Demographic	Not applicable	Not applicable	Existing
Ülke	Türkiye		General Demographic	Not applicable	Not applicable	Existing
Şirket	Unilever		General Demographic	Not applicable	Not applicable	Existing
Şehir	İstanbul / Tekirdağ / Kocaeli / Rize		General Demographic	Not applicable	Not applicable	Existing
Fabrika	Ev ve Kişisel Bakım / Gıda / Dondurma		General Demographic	Not applicable	Not applicable	Existing
Kullanıcının Rolü	Operatör/Mühendis/Tasarımcı/Developer/Fabrika Direktörü		Human Related	Team Collaboration	Team Composition	Existing
Kullanıcının Eğitim Durumu	Lise/Üniversite/Diğer		Human Related	Character Based	Education	Existing
Kullanıcının Sektör Tecrübesi (kaç yıl)			Human Related	Ability Based	Expertise / Amount of Training	Existing
Kullanıcının Cobotlarla Çalışma Deneyim Süresi (kaç yıl)			Human Related	Ability Based	Prior Experience	Existing
Kullanılan Cobot Marka/Model	Fanuc/Universal Robots/Kuka		Robot Related	Attribute Based	Robot Type	Existing
Cobot'un İşlevi	Paketleme/kolileme/paletleme/hat ürün besleme		Robot Related	Attribute Based	Robot Type	Existing

Sorular	Cevaplar	Yorumlar	Type of The Question	Factors	Attributes	Potential/ Existing
Cobot'la çalışırken en çok etkileşime geçilen kişiler	Operatör/ Mühendis/ Tasarımcı/ Developer/Fabrika Direktörü		Contextual	Team Collaboration	Team Composition	Existing
Cobot'un sağladığı fayda	Üretkenlik/ maliyet azalması / doğruluk / hız / kalite		Robot Related	Performance Related	Added Value	Potential
Cobot-Operatör birlikte çalışma modelinizde sistemi konfigure eden/yöneten operator dışında biri var mı?	Evet / Hayır	Evet ise kim olduğunu tanımlar mısınız?	Contextual	Team Collaboration	In-group membership	Existing
Operatör sistemi tasarlayan/uygulayan uzmana geri bildirimde bulunuyor mu?	Evet / Hayır	Evet ise nasıl geri bildirimde bulunduğunu açıklar mısınız?	Deployer Related	Tasking	Trust Calibration Cues	Potential
Sistemden otomatik olarak ya da operatörden sistemi tasarlayan/ uygulayan uzmana alarm ya da bildirim gidiyor mu?	Evet / Hayır	Evet ise ne tür alarmlar/bildirimler olduğunu örnekler misiniz?	Deployer Related	Performance Related	Feedback Loop	Potential
Sistemi tasarlayan/ uygulayan uzman sistemin durumunu, operator ile ilgili kriterleri izliyor ve raporluyor mu?	Evet / Hayır	Evet ise hangi kriterleri izleyip raporladığını örnekler misiniz?	Deployer Related	Performance Related	Monitoring	Potential
Operatör sistemde performans iyileştirmesi yapmak, daha verimli-etkin çalışmak için Cobot'un konfigürasyonunu değiştiriyor mu?	Evet / Hayır	Evet ise hangi sıklıkta/hangi durumlarda yaptığını açıklar mısınız?	Human Related	Ability Based	Competency	Existing
Hata ya da kaza durumunda sistemi tasarlayan/uygulayan	Evet / Hayır	Evet ise hangi sıklıkta ve ne tür müdahaleler	Deployer Related	Performance Related	Remote intervention	Potential

Sorular	Cevaplar	Yorumlar	Type of The Question	Factors	Attributes	Potential/ Existing
uzman sisteme uzaktan müdahale edebiliyor mu?		olduğunu örnekler misiniz?				
Cobot hatalarından öğrenip, önleyici önlemler alıyor ya da öğrendiği öngörülerini sistemi tasarlayan/uygulayan uzmana gönderiyor mu?	Evet / Hayır	Evet ise örnek verebilir misiniz?	Robot Related	Attribute Based	Feedback Loop	Existing
Cobotların robotlara göre avantaj /dezavantajları nelerdir?			Robot Related	Performance Related	Added Value	Potential
Cobotların kullanım ömürleri nasıl? Çok fazla parça değiştiriyor musunuz?			Robot Related	Performance Related	Failure Rates	Existing
Cobotları yan ekipmanlar ile kullanıyor musunuz? (kamera sistemi, data sistemleri)			Robot Related	Attribute Based	Adaptability	Existing
Bir den fazla cobot koordineli çalışıyor mu?			Contextual	Team Collaboration	In-group membership	Existing
Cobotların kullanımı kolay mı? Operatorler olarak arızaların % kaçını yapılabiliyorsunuz?			Human Related	Ability Based	Competency	Existing
Cobotlar gelen ambalaj malzemelerindeki hataları tolere edebiliyor mu? Yoksa küçük duruşlar mı yaşıyorsunuz?			Robot Related	Performance Related	Predictability	Existing

Table E5 *Thematic Analysis for Survey*

Robot Related					
Performance Related	Findings	Attribute Based	Findings	Apperance Related	Findings
Dependability	<i>Not mapped</i>	Proximity/Co-location	<i>Not mapped</i>	Appearance	<i>Not mapped</i>
Reliability of Robots	<i>Not mapped</i>	Robot Personality	<i>Not mapped</i>	Anthropomorphism	<i>Not mapped</i>
Behavior	<i>Not mapped</i>	Adaptability	<i>Mapped with Survey question</i>		
Predictability	<i>Not mapped</i>	Robot Type	<i>Mapped with Survey question</i>		
Level of automation	<i>Not mapped</i>				
Communication Method	<i>Not mapped</i>				
Failure Rates	<i>Mapped with Survey question</i>				
False Alarms	<i>Not mapped</i>				
Transparency	<i>Not mapped</i>				
Added value: Productivity	<i>Mapped with Survey question</i>				
Added value: Cost Saving	<i>Mapped with Survey question</i>				
Added value: Speed	<i>Mapped with Survey question</i>				
Added value: Accuracy	<i>Mapped with Survey question</i>				
Added value: Quality	<i>Mapped with Survey question</i>				

Human Related			
Ability Based	Findings	Character Based	Findings
Attentional Capacity/Engagement	<i>Not mapped</i>	Gender	<i>Not mapped</i>
Expertise / Amount of Training	<i>Mapped with Survey question</i>	Age	<i>Not mapped</i>
Competency	<i>Mapped with Survey question</i>	Race	<i>Mapped with Survey question</i>
Operator Workload	<i>Not mapped</i>	Culture	<i>Mapped with Survey question</i>
Prior Experience	<i>Mapped with Survey question</i>	Education	<i>Mapped with Survey question</i>
Situation Awareness	<i>Not mapped</i>	Expectancy	<i>Mapped with Survey question</i>
		Personality Traits	<i>Not mapped</i>
		Attitude Towards Robots	<i>Mapped with Survey question</i>
		Comfort with Robots	<i>Mapped with Survey question</i>
		Propensity to Trust	<i>Mapped with Survey question</i>
		Self-confidence	<i>Mapped with Survey question</i>
		Satisfaction	<i>Mapped with Survey question</i>
		Self-Efficacy	<i>Mapped with Survey question</i>

Contextual Factors			
Team Colaboration	Findings	Tasking	Findings
Tenure	<i>Not mapped</i>	Task Type	<i>Not mapped</i>
Team Conflict	<i>Not mapped</i>	Task Complexity	<i>Not mapped</i>
In-group membership	<i>Mapped with Survey question</i>	Multi-tasking Requirements	<i>Not mapped</i>
Interaction Frequency	<i>Not mapped</i>	Physical Environment	<i>Not mapped</i>
Shared mental models	<i>Not mapped</i>		
Proximity/co-location	<i>Not mapped</i>		
Role interdependence	<i>Not mapped</i>		
Team Composition	<i>Mapped with Survey question</i>		
Team cohesion	<i>Not mapped</i>		

Deployer Related							
Performance Related	Findings	Attribute Based	Findings	Ability Based	Findings	Tasking	Findings
Feedback Loop	<i>Mapped with Survey question</i>	Interaction design	<i>Not mapped</i>	Instructions for HR	<i>Not mapped</i>	Trust Calibration Cues	<i>Mapped with Survey question</i>
Monitoring	<i>Mapped with Survey question</i>					Task Type	<i>Mapped with Survey question</i>
Level of automation	<i>Not mapped</i>					Remote intervention	<i>Mapped with Survey question</i>
Communication Method	<i>Not mapped</i>						
Failure Rates	<i>Not mapped</i>						
False Alarms	<i>Not mapped</i>						

Report for Survey

Trust Model with new possible constructs was assessed by a survey applied to operators working for Unilever Turkey using Cobots on different production activities. The survey was applied to 11 different operators at 3 factories in 3 different cities: Istanbul, Konya, Tekirdağ.

In this case study, we have seen 5 different types of Cobots and Cobot Vendors active for packaging, parceling, palletizing, feeding the production line. Users interacting with Cobots are mostly senior operators with average 14 years of experience and average 4 years working with Cobots. They are working in a collaborative environment with Cobots and other parties like technician, engineer, developer or other operators. When I asked questions regarding the everyday usage of Cobots to understand if they are working smoothly by ensuring safety, interaction, and collaboration, all the operators agreed on efficient co-working on different aspects.

Finally, I asked questions to understand if any other party is involved into the closed loop of Human and Cobot, and I saw that all of them described a 3rd party on different activities. However, their relationship with this 3rd party is not strong as half of them don't feedback to this 3rd party, and they are not aware that this 3rd party is responsible for monitoring the interaction loop and fixing the issues if necessary.

APPENDIX F . LAST INTERVIEW

Table F1 *Last Interview Record*

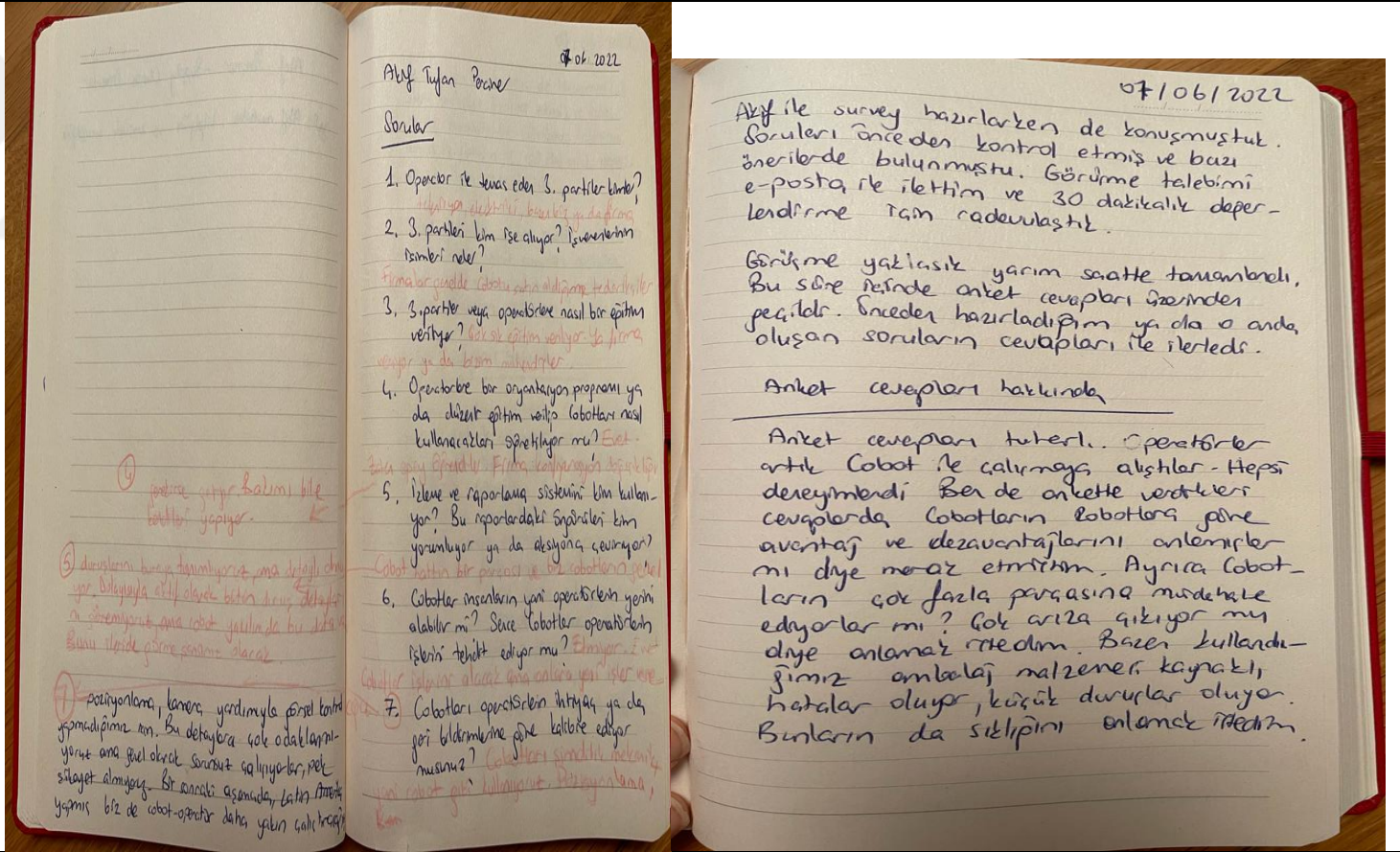
Date and Time	June, 2022
Location	Unilever Besan Factory, Konya IC, Corlu IC
Researcher	Şirin Aktaş
Research Topic	TRUST MODELS IN HRI-CASE STUDY WITH UNILEVER
Person to be interviewed	Akif Perçiner - Supply Chain Director

Data Collection for Last Interview

Table F2 *Data Analysis Steps for Last Interview*

Interview Preperation	As the last data collection step of the research, the survey data was shared with Unilever Turkey Supply Chain Director responsible from Cobot Operations. It was semi-structured interview with a mixture of prepared questions and prompt questions. The questions prepared in advance were aimed to refine the answers of Operators already surveyed. Additionally, I asked prompt questions to understand his expert point of view on Human Cobot Interaction and the importance of Trust Calibration for Unilever.
Interview Questions	1. Who is the 3rd party resource interacted with Operator? 2. How is the sourcing of 3rd party person done? What are the names of the outsource resource providers? 3. How is the training done by the operator or 3rd party resource? 4. Any orientation program or regular training regarding Cobots usage for operators? 5. Who is using the monitoring and reporting system? How do you interpret/action on the insights reported? 6. Can Cobot replace operator? Do they feel Cobots threatening their employment? 7. Do you ever calibrate the Cobots according to Operator needs or feedbacks?

Interview Notes



Findings for Last Interview

Table F3 *Findings with First Interview*

Interview with Akif Perçiner - Supply Chain Director	
Initial Coding	Cobot Operator 3rd Party Monitoring Maintenance Reporting Employment Training Suppliers Survey Responses
Generating Themes	Cobot Operator Collaboration Operator Skill and Training Cobot Adoption Thematic Mapping

Table F4 *Thematic Analysis for Last Interview*

Robot Related					
Performance Related	Findings	Attribute Based	Findings	Apperance Related	Findings
Dependability	<i>Assesed</i>	Proximity/Co-location	<i>Assesed</i>	Appearance	<i>Assesed</i>
Reliability of Robots	<i>Assesed</i>	Robot Personality	<i>Assesed</i>	Anthropomorphism	<i>Assesed</i>
Behavior	<i>Assesed</i>	Adaptability	<i>Assesed</i>		
Predictability	<i>Assesed</i>	Robot Type	<i>Assesed</i>		
Level of automation	<i>Assesed</i>				
Communication Method	<i>Assesed</i>				
Failure Rates	<i>Assesed</i>				
False Alarms	<i>Assesed</i>				
Transparency	<i>Assesed</i>				
Added value : Productivity	<i>Assesed</i>				
Added value : Cost Saving	<i>Assesed</i>				
Added value : Speed	<i>Assesed</i>				
Added value : Accuracy	<i>Assesed</i>				
Added value : Quality	<i>Assesed</i>				

Human Related			
Ability Based	Findings	Character Based	Findings
Attentional Capacity/Engagement	<i>Assesed</i>	Gender	<i>Assesed</i>
Expertise / Amount of Training	<i>Assesed</i>	Age	<i>Assesed</i>
Competency	<i>Assesed</i>	Race	<i>Assesed</i>
Operator Workload	<i>Assesed</i>	Culture	<i>Assesed</i>
Prior Experience	<i>Assesed</i>	Education	<i>Assesed</i>
Situation Awareness	<i>Assesed</i>	Expectancy	<i>Assesed</i>
		Personality Traits	<i>Assesed</i>
		Attitude Towards Robots	<i>Assesed</i>
		Comfort with Robots	<i>Assesed</i>
		Propensity to Trust	<i>Assesed</i>
		Self-confidence	<i>Assesed</i>
		Satisfaction	<i>Assesed</i>
		Self-Efficacy	<i>Assesed</i>

Contextual Factors			
Team Colaboration	Findings	Tasking	Findings
Tenure	<i>Assesed</i>	Task Type	<i>Assesed</i>
Team Conflict	<i>Assesed</i>	Task Complexity	<i>Assesed</i>
In-group membership	<i>Assesed</i>	Multi-tasking Requirements	<i>Assesed</i>
Interaction Frequecny	<i>Assesed</i>	Physical Environment	<i>Assesed</i>
Shared mental models	<i>Assesed</i>		
Proximity/co-location	<i>Assesed</i>		
Role interdependence	<i>Assesed</i>		
Team Composition	<i>Assesed</i>		
Team Cohesion	<i>Assesed</i>		

Deployer							
Performance Related	Findings	Attribute Based	Findings	Ability Based	Findings	Tasking	Findings
Feedback Loop	Assesed	Interaction design	Assesed	Instructions for HR	Assesed	Trust Calibration Cues	Assesed
Monitoring	Assesed					Task Type	Assesed
Level of automation	Assesed					Remote intervention	Assesed
Communication Method	Assesed						
Failure Rates	Assesed						
False Alarms	Assesed						

Refining Themes (Initial themes are validated)	Cobot Operator Collaboration Operator Skill and Training Cobot Adoption
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Report for Last Interview

As the last data collection step of the research, the survey data was shared with Unilever Turkey Supply Chain Director responsible from Cobot Operations. It was semi-structured interview with a mixture of prepared questions and prompt questions. The questions prepared in advance were aimed to refine the answers of Operators already surveyed. Additionally, I asked prompt questions to understand his opinion regarding the survey, the aim of this research and the future of Cobots at Unilever. The answers to these questions are verified the result of our data analysis based on different steps from non-participant observation to the Survey. He is approved and validated the need to add a new construct to Trust Models in order to adapt to the real-life context o

APPENDIX G . VALIDATION SURVEYS & FDM

Table G1 *Significance Survey*

Cobot'lar operatörlerin iş yükünü azaltmak için geliştirildi. Bu bağlamda, operatörler ve Cobot'lar görevleri ve çalışma alanını paylaşıyorlar.

1. “Cobot ile beraber çalışırken kendinizi güvende hissediyor musunuz? Cobot’un size fiziksel zarar vermesi, beraber yaptığınız işe zarar vermesi, sizin iş tatmin ve motivasyonunuzu azaltması gibi sorunlara neden olacağını düşünüyor musunuz? Cobot ile işbirliğiniz açısından güven seviyenizi işaretlemenizi rica ederiz:

1:Çok düşük	2:Düşük	3:Orta	4:Yüksek	5:Çok yüksek
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2. Lütfen günlük çalışma rutininizi düşünerek aşağıdaki faktörlerin Cobot ile çalışırken kendinizi güvende hissetmeniz için ne kadar önemli olduğunu işaretleyiniz:

(1:Çok önemsiz, 2:Önemsiz, 3:Kararsız, 4:Önemli, 5:Çok önemli)

	Faktör	1	2	3	4	5
	Kontrolör ya da tasarımcıya geri bildirim döngüsü olması kendinizi güvende hissetmeniz için ne kadar önemlidir?					
Geribildirim Döngüsü:	Cobot'ların belirli hareketi ayarlamak, aktiviteleri izlemek ve “zaman aşımı, robot etiketi okuyamıyor, acil durum durdurması” vb. hataları gidermek için kontrolleri vardır. Geri besleme döngüsü bir mekanizmadır. Cobot’la ilgili kontrollerin gerçek çıktısını beklenen çıktıyla karşılaştıran, bu durumlarla ilgili raporları tasarımcısına gönderen mekanizmadır.	Size fiziksel zarar vermesi açısından	Size psikolojik zarar vermesi açısından	Beraber yaptığınız işe zarar vermesi açısından		

Faktör		1	2	3	4	5
İzleme	İzleme sisteminin olması kendinizi güvende hissetmeniz için ne kadar önemlidir?	Size fiziksel zarar vermesi açısından Size psikolojik zarar vermesi açısından Beraber yaptığınız işe zarar vermesi açısından				
	İzleme sistemi, Cobot'un fiziksel koşullarını ve beraber çalışma süreçlerini inceler. Bir cobot uygunsuz veya kararsız davranış gösterdiğinde bir insan operatörü veya tasarımcıyı uyarır.					
Otomasyon Seviyesi	Otomasyon seviyesinin iş isterlerine uygun olacak şekilde geliştirilmiş olması kendinizi güvende hissetmeniz için ne kadar önemlidir?	Size fiziksel zarar vermesi açısından Size psikolojik zarar vermesi açısından Beraber yaptığınız işe zarar vermesi açısından				
	Cobot otomasyonu, robotlar alanında yeni bir teknolojidir ve geleneksel otomasyon seçeneklerinden farklıdır. Bir cobot, cobot'un çevreye ve dokunmaya duyarlı olmasını sağlayan sensörlerle donatılmıştır. En yeni cobot'lar hiçbir programlama kullanmaz. Görevlerini tasarımcılardan öğrenirler. Tasarımcı cobot'u işin adımları boyunca hareket ettirir ve cobot öğrenir.					
İletişim Metodu	İnsan ve Cobot ekip olarak çalışırken birbirleri ile etkin iletişimde olması güveni ne kadar etkiler?	Size fiziksel zarar vermesi açısından Size psikolojik zarar vermesi açısından Beraber yaptığınız işe zarar vermesi açısından				
	Ekip olarak eylemler, dokunma, güçlü etkileşim, biyometrik sinyaller, sözlü ipuçları ve daha fazlası yoluyla çok modlu bir bilgi alışverişi olan somutlaştırılmış iletişime güvenir. Mevcut haliyle iletişim genellikle tasarımcı tarafından tasarlanır, zaman içinde tek yönlü ve statiktir.					

Faktör		1	2	3	4	5
Arıza Oranları	Cobot'un normal çalışma düzenini bozacak ya da verimliliği düşürecek arızalarının oranının fazla olması güveni ne kadar etkiler?	Size fiziksel zarar vermesi açısından				
	Cobot'lar da bozulmaya maruz kalıyor ve fonksiyonel arızalar operasyonlarını etkileyerek anormal yörüngelere yol açabilmektedir. Bu bağlamda Cobot'lar, beklenen performanslarını sağlamak için arıza oranları kontrol edilebilir ve programlanabilir.	Size psikolojik zarar vermesi açısından Beraber yaptığınız işe zarar vermesi açısından				
Yanlış Alarm	Cobot'un normal çalışma düzeni bozulmadığı halde oluşan hatalı alarmlar nedeniyle işin durması ya da verimin azalması güveni ne kadar etkiler?	Size fiziksel zarar vermesi açısından				
	Zaman aşımı hataları, Acil Durum Durdurma gibi Cobot'ların arıza tespiti ve teşhisi,farklı alarm türlerinin ayarlanmasıyla iyileştirilebilir.	Size psikolojik zarar vermesi açısından Beraber yaptığınız işe zarar vermesi açısından				
Etkileşim Dizaynı	Cobot ile etkileşimde bulunmak için kullanılan fiziksel nesnelerin tasarımı ya da operatorün Cobotla beraber çalışma deneyiminin tasarımı güveni ne derece etkiler?	Size fiziksel zarar vermesi açısından				
	Geleneksel olarak Cobotların tasarımında işlevsellik ve güvenliğe odaklanmıştır. Ancak bunun yeterli olmadığını görülmüştür. Deneyim odaklı tasarım hedeflerine ihtiyacımız vardır. İşlev kadar operatörün ve Cobotun o işlevi yerine getirirken nasıl davranacağını, zorluk, tepki süresi, iletişim organı (ses, göz, el vs) açısından da tasarlamaktır.	Size psikolojik zarar vermesi açısından Beraber yaptığınız işe zarar vermesi açısından				

Faktör		1	2	3	4	5
İK için Talimatlar	Cobot ile beraber çalışırken oluşan deneyimden oluşan insan kaynağı talimatlarının yerine getirilmesi güveni ne kadar etkiler?	Size fiziksel zarar vermesi açısından	Size psikolojik zarar vermesi açısından	Beraber yaptığınız işe zarar vermesi açısından		
	Cobot denetleyicisi, yanlış kullanım (eğitim ihtiyacı), kullanılmama (direnc gösterme) veya kötüye kullanım (yetersiz kullanım veya hasar) olup olmadığını anlamak için İK departmanlarının faaliyetlerini izleyebilir ve günlük olarak kaydedebilir.					
Kalibrasyon İpuçlarına Güven	Cobot'a, operatöre ya da ortama dair alınan geribildirim ve ipuçlarının kullanılması ile güven modelini ne kadar kalibre edilebilir?	Size fiziksel zarar vermesi açısından	Size psikolojik zarar vermesi açısından	Beraber yaptığınız işe zarar vermesi açısından		
	Cobot üreticileri, programcıları veya dağıtıcıları, İnsan Cobot Güven Yapısında Cobot'u veya Bağlamsal Faktörleri geliştirmek ve iyileştirmek için sahadan bazı geri bildirimler alabilirler ve Cobota güven modelini kalibre edebilirler.					
Görev Tipi	Cobot ile beraber çalışılan görev tiplerinin yeni, zor, karmaşık, çoklu ve tekrarlı olması gibi durumlar güveni ne kadar etkiler?	Size fiziksel zarar vermesi açısından	Size psikolojik zarar vermesi açısından	Beraber yaptığınız işe zarar vermesi açısından		
	Cobot'un operatörü ile işbirliğindeki birçok görev önceden tanımlanmıştır ya da görev tipi değişikçe tekrar ayarlanabilir. Görev tiplerinin yeni, zor, karmaşık, çoklu ve tekrarlı olması gibi değişik durumlar olabilir.					

Faktör		1	2	3	4	5
Uzaktan Müdahale	Cobotla ilgili bir uygunsuz ya da şüpheli durum olduğunda Cobot'a ya da ortama uzaktan müdahale edilebilir olması güveni ne derece etkiler?					
	Cobot'un konuşlandırıcısı fiziksel koşulları izleyebilir ve uygunsuz veya kararsız bir davranış durumunda kurulumu durdurabilir/değiştirebilir.	Size fiziksel zarar vermesi açısından	Size psikolojik zarar vermesi açısından	Beraber yaptığınız işe zarar vermesi açısından		

Table G2 *Answers to the Significance Survey at Unilever*

a. Initial Trust Rating Question: A single question

	OPR1	OPR2	OPR3	OPR4	OPR5	OPR6	OPR7	OPR8	OPR9	OPR10	OPR11	OPR12	OPR13	OPR14	OPR15	Average	Min	Max
Trust Level /1st question)	1.00	4.00	5.00	5.00	4.00	4.00	5.00	3.00	3.00	4.00	4.00	4.00	3.00	4.00	4.00	3.8	1	5

b. Deployer Attributes Significance Ratings: Physical harm (e.g., injury from cobot malfunction) – Trust Dimension 1

Faktör			Opr1	Opr2	Opr3	Opr4	Opr5	Opr6	Opr7	Opr8	Opr9	Opr10	Opr11	Opr12	Opr13	Opr14	Opr15
Geribildirim Döngüsü:	Kontrolör ya da tasarımcıya geri bildirim döngüsü olması kendinizi güvende hissetmeniz için ne kadar önemlidir?	Size fiziksel zarar vermesi açısından	5	5	5	4	5	4	5	2	2	5	3	3	4	4	5
İzleme	İzleme sisteminin olması kendinizi güvende hissetmeniz için ne kadar önemlidir?	Size fiziksel zarar vermesi açısından	4	5	5	3	5	5	5	3	3	5	2	3	2	5	4
Otomasyon Seviyesi	Otomasyon seviyesinin iş isterlerine uygun olacak şekilde geliştirilmiş olması kendinizi güvende hissetmeniz için ne kadar önemlidir?	Size fiziksel zarar vermesi açısından	4	5	5	4	5	4	4	3	3	5	1	3	4	4	5
İletişim Metodu	İnsan ve Cobot ekip olarak çalışırken birbirleri ile etkin iletişimde olması güveni ne kadar etkiler?	Size fiziksel zarar vermesi açısından	4	5	3	3	5	4	5	1	3	5	3	4	4	4	4
Arıza Oranları	Cobot'un normal çalışma düzenini bozacak ya da verimliliği düşürecek arızalarının oranının fazla olması güveni ne kadar etkiler?	Size fiziksel zarar vermesi açısından	3	5	4	3	5	3	4	5	4	5	1	3	3	3	5
Yanlış Alarm	Cobot'un normal çalışma düzeni bozulmadığı halde oluşan hatalı alarmlar nedeniyle işin durması ya da verimin azalması güveni ne kadar etkiler?	Size fiziksel zarar vermesi açısından	1	5	1	3	5	3	4	5	3	5	3	4	3	4	5
Etkileşim Dizaynı	Cobot ile etkileşimde bulunmak için kullanılan fiziksel nesnelerin tasarımı ya da operatörün Cobotla beraber çalışma deneyiminin tasarımı güveni ne derece etkiler?	Size fiziksel zarar vermesi açısından	1	5	5	3	4	4	5	5	3	5	3	2	3	4	4
İK için Talimatlar	Cobot ile beraber çalışırken oluşan deneyimden oluşan insan kaynağı talimatlarının yerine getirilmesi güveni ne kadar etkiler?	Size fiziksel zarar vermesi açısından	4	5	5	3	4	3	5	5	3	5	3	2	4	5	4
Kalibrasyon İpuçlarına Güven	Cobot'a, operatöre ya da ortama dair alınan geribildirim ve ipuçlarının kullanılması ile güven modelini ne kadar kalibre edilebilir?	Size fiziksel zarar vermesi açısından	5	4	4	3	5	5	5	5	3	5	2	2	1	5	5
Görev Tipi	Cobot ile beraber çalışılan görev tiplerinin yeni, zor, karmaşık, çoklu ve tekrarlı olması gibi durumlar güveni ne kadar etkiler?	Size fiziksel zarar vermesi açısından	3	5	4	3	5	5	3	5	3	5	4	3	1	4	4
Uzaktan Müdahale	Cobotla ilgili bir uygunsuz ya da şüpheli durum olduğunda Cobot'a ya da ortama uzaktan müdahale edilebilir olması güveni ne derece etkiler?	Size fiziksel zarar vermesi açısından	5	4	5	4	3	4	5	5	3	5	2	2	2	5	4

c. Deployer Attributes Significance Ratings: Psychological harm (e.g., stress, anxiety)

– Trust Dimension 2

Faktör			Opr1	Opr2	Opr3	Opr4	Opr5	Opr6	Opr7	Opr8	Opr9	Opr10	Opr11	Opr12	Opr13	Opr14	Opr15
Geribildirim Döngüsü:	Cobot'ların belirli hareketi ayarlamak, aktiviteleri izlemek ve "zaman aşımı, robot etiketi okuyamıyor, acil durum durdurması" vb. hataları gidermek için kontrolleri vardır. Geri besleme döngüsü bir mekanizmadır. Cobot'la ilgili kontrollerin gerçek çıktısını beklenen çıktıyla karşılaştırarak, bu durumlarla ilgili raporları tasarımcısına gönderen mekanizmadır.	Size psikolojik zarar vermesi açısından	2	4	5	4	5	4	3	3	2	5	3	3	3	4	5
İzleme	İzleme sistemi, Cobot'un fiziksel koşullarını ve beraber çalışma süreçlerini inceler. Bir cobot uygunsuz veya kararsız davranış gösterdiğinde bir insan operatörü veya tasarımcıyı uyarır.	Size psikolojik zarar vermesi açısından	2	5	5	4	5	4	5	2	3	5	4	2	3	4	5
Otomasyon Seviyesi	Cobot otomasyonu, robotlar alanında yeni bir teknolojidir ve geleneksel otomasyon seçeneklerinden farklıdır. Bir cobot, cobot'un çevreye ve dokunmaya duyarlı olmasını sağlayan sensörlerle donatılmıştır. En yeni cobot'lar hiçbir programlama kullanmaz. Görevlerini tasarlayıcılardan öğrenirler. Tasarımcıyı cobot'u için adımları boyunca hareket ettirir ve cobot öğrenir.	Size psikolojik zarar vermesi açısından	2	5	5	5	5	4	5	3	3	5	3	3	4	4	5
İletişim Metodu	Ekip olarak eylemler, dokunma, güçlü etkileşim, biyometrik sinyaller, sözlü ipuçları ve daha fazlası yoluyla çok modlu bir bilgi alışverişi olan somutlaştırılmış iletişime güvenir. Mevcut haliyle iletişim genellikle tasarımcı tarafından tasarlanır, zaman içinde tek yönlü ve statiktir.	Size psikolojik zarar vermesi açısından	2	5	1	3	4	4	4	3	3	5	3	4	4	4	5
Arıza Oranları	Cobot'lar da bozulmaya maruz kalıyor ve fonksiyonel arızalar operasyonlarını etkileyerek anormal yörüngelere yol açabilmektedir. Bu bağlamda Cobot'lar, beklenen performanslarını sağlamak için arıza oranları kontrol edilebilir ve programlanabilir.	Size psikolojik zarar vermesi açısından	3	5	4	3	5	3	3	5	4	5	1	3	3	3	3
Yanlış Alarm	Zaman aşımı hataları, Acil Durum Durdurma gibi Cobot'ların arıza tespiti ve teşhisi, farklı alarm türlerinin ayarlanmasıyla iyileştirilebilir.	Size psikolojik zarar vermesi açısından	1	5	1	4	4	3	5	5	3	5	3	2	4	4	5
Etkileşim Dizaynı	Geleneksel olarak Cobotların tasarımında işlevsellik ve güvenliğe odaklanmıştır. Ancak bunun yeterli olmadığını görmüştür. Deneyim odaklı tasarım hedeflerine ihtiyacımız vardır. İşlev kadar operatörün ve Cobotun o işlevi yerine getirirken nasıl davranacağını, zorluk, tepki süresi, iletişim organı (ses, göz, el vs) açısından da tasarlamaktır.	Size psikolojik zarar vermesi açısından	2	5	5	4	5	4	4	4	3	5	3	2	4	4	5
İK için Talimatlar	Cobot denetleyicisi, yanlış kullanım (eğitim ihtiyacı), kullanılmama (direnc gösterme) veya kötüye kullanım (yetersiz kullanım veya hasar) olup olmadığını anlamak için İK departmanlarının faaliyetlerini izleyebilir ve günlük olarak kaydedebilir.	Size psikolojik zarar vermesi açısından	1	5	5	5	4	4	4	5	3	5	2	3	1	4	5
Kalibrasyon İpuçlarına Güven	Cobot üreticileri, programcıları veya dağıtıcıları, İnsan Cobot Güven Yapısında Cobot'u veya Bağlamsal Faktörleri geliştirmek ve iyileştirmek için sahadan bazı geri bildirimler alabilirler ve Cobot'a güven modelini kalibre edebilirler.	Size psikolojik zarar vermesi açısından	2	4	4	4	5	5	5	5	3	5	3	3	2	4	5
Görev Tipi	Cobot'un operatörü ile işbirliğindeki birçok görev önceden tanımlanmıştır ya da görev tipi değiştiğinde tekrar ayarlanabilir. Görev tiplerinin yeni, zor, karmaşık, çoklu ve tekrarlı olması gibi değişik durumlar olabilir.	Size psikolojik zarar vermesi açısından	1	5	4	4	4	5	4	5	3	5	4	3	3	4	4
Uzaktan Müdahale	Cobot'un konuşlandırıcısı fiziksel koşulları izleyebilir ve uygunsuz veya kararsız bir davranış durumunda kurulumu durdurabilir/değiştirebilir.	Size psikolojik zarar vermesi açısından	2	4	5	4	5	5	4	5	3	5	2	1	2	4	5

c. Deployer Attributes Significance Ratings: Job performance impact (e.g., task disruption or inefficiency) – Trust Dimension 3

Fakir			Opr1	Opr2	Opr3	Opr4	Opr5	Opr6	Opr7	Opr8	Opr9	Opr10	Opr11	Opr12	Opr13	Opr14	Opr15
Geribildirim Döngüsü:	Cobot'ların belirli hareketi ayarlamak, aktiviteleri izlemek ve "zaman aşımı, robot etiketi okuyamıyor, acil durum durdurması" vb. hataları gidermek için kontrolleri vardır. Geri besleme döngüsü bir mekanizmadır. Cobot'la ilgili kontrollerin gerçek çıktısını beklenen çıktıyla karşılaştıran, bu durumlarla ilgili raporları tasarımcısına gönderen mekanizmadır.	Beraber yaptığınız işe zarar vermesi açısından	3	5	5	4	5	4	4	3	2	5	3	3	3	4	5
İzleme	İzleme sistemi, Cobot'un fiziksel koşullarını ve beraber çalışma süreçlerini inceler. Bir cobot uygunsuz veya kararsız davranış gösterdiğinde bir insan operatörü veya tasarımcıyı uyarır.	Beraber yaptığınız işe zarar vermesi açısından	4	5	5	5	5	4	5	1	3	5	2	3	2	5	5
Otomasyon Seviyesi	Cobot otomasyonu, robotlar alanında yeni bir teknolojidir ve geleneksel otomasyon seçeneklerinden farklıdır. Bir cobot, cobot'un çevreye ve dokunmaya duyarlı olmasını sağlayan sensörlerle donatılmıştır. En yeni cobot'lar hiçbir programlama kullanmaz. Görevlerini tasarlayıcılardan öğrenirler. Tasarımcı cobot'u işin adımları boyunca hareket ettirir ve cobot öğrenir.	Beraber yaptığınız işe zarar vermesi açısından	4	5	4	3	2	4	5	5	3	5	3	3	4	4	4
İletişim Metodu	Ekip olarak eylemler, dokunma, güçlü etkileşim, biyometrik sinyaller, sözlü ipuçları ve daha fazlası yoluyla çok modlu bir bilgi alışverişi olan somutlaştırılmış iletişime güvenir. Mevcut haliyle iletişim genellikle tasarımcı tarafından tasarlanır, zaman içinde tek yönlü ve statiktir.	Beraber yaptığınız işe zarar vermesi açısından	4	5	4	3	4	4	5	4	3	5	2	4	4	4	5
Arıza Oranları	Cobot'lar da bozulmaya maruz kalıyor ve fonksiyonel arızalar operasyonlarını etkileyerek anormal yörüngelere yol açabilmektedir. Bu bağlamda Cobot'lar, beklenen performanslarını sağlamak için arıza oranları kontrol edilebilir ve programlanabilir.	Beraber yaptığınız işe zarar vermesi açısından	3	5	4	4	5	3	3	5	4	5	2	3	3	3	4
Yanlış Alarm	Zaman aşımı hataları, Acil Durum Durdurma gibi Cobot'ların arıza tespiti ve teşhisi, farklı alarm türlerinin ayarlanmasıyla iyileştirilebilir.	Beraber yaptığınız işe zarar vermesi açısından	3	5	1	3	4	3	4	5	3	5	3	4	4	4	5
Etkileşim Dizaynı	Geleneksel olarak Cobotların tasarımında işlevsellik ve güvenliğe odaklanmıştır. Ancak bunun yeterli olmadığını görülmüştür. Deneyim odaklı tasarım hedeflerine ihtiyacımız vardır. İşlev kadar operatörün ve Cobotun o işlevi yerine getirirken nasıl davranacağını, zorluk, tepki süresi, iletişim organı (ses, göz, el vs) açısından da tasarlamaktır.	Beraber yaptığınız işe zarar vermesi açısından	4	5	5	4	4	5	3	5	3	5	3	3	3	4	5
İK için Talimatlar	Cobot denetleyicisi, yanlış kullanım (eğitim ihtiyacı), kullanılmama (direnc gösterme) veya kötüye kullanım (yetersiz kullanım veya hasar) olup olmadığını anlamak için İK departmanlarının faaliyetlerini izleyebilir ve günlük olarak kaydedebilir.	Beraber yaptığınız işe zarar vermesi açısından	3	5	5	4	4	5	5	3	3	5	2	2	2	4	5
Kalibrasyon İpuçlarına Güven	Cobot üreticileri, programcıları veya dağıtıcıları, İnsan Cobot Güven Yapısında Cobot'u veya Bağlamsal Faktörleri geliştirmek ve iyileştirmek için sahada bazı geri bildirimler alabilirler ve Cobot'a güven modelini kalibre edebilirler.	Beraber yaptığınız işe zarar vermesi açısından	4	4	4	5	5	4	5	5	3	5	3	2	2	4	5
Görev Tipi	Cobot'un operatörü ile işbirliğindeki birçok görev önceden tanımlanmıştır ya da görev tipi değiştiğinde tekrar ayarlanabilir. Görev tiplerinin yeni, zor, karmaşık, çoklu ve tekrarlı olması gibi değişik durumlar olabilir.	Beraber yaptığınız işe zarar vermesi açısından	3	5	4	4	4	5	3	5	3	5	3	1	3	4	3
Uzaktan Müdahale	Cobot'un konuşlandırıcısı fiziksel koşulları izleyebilir ve uygunsuz veya kararsız bir davranış durumunda kurulumu durdurabilir/değiştirir.	Beraber yaptığınız işe zarar vermesi açısından	4	3	5	4	5	4	4	5	3	5	3	2	3	4	5

FDM Evaluation 1

Significance of the Deployer Attributes for Trust Dimension 1: Avoiding Physical harm (e.g., injury from cobot malfunction)

Table G3 Participant Scores at Unilever: Significance of the Deployer Attributes $j=1,2,\dots,11$ for Each Participant $i=1,2,\dots,15$ (for Trust Dimension 1)

	Operator1	Operator2	Operator3	Operator4	Operator5	Operator6	Operator7	Operator8	Operator9	Operator10	Operator11	Operator12	Operator13	Operator14	Operator15
Attribute 1	5	5	5	4	5	4	5	2	2	5	3	3	4	4	5
Attribute 2	4	5	5	3	5	5	5	3	3	5	2	3	2	5	4
Attribute 3	4	5	5	4	5	4	4	3	3	5	1	3	4	4	5
Attribute 4	4	5	3	3	5	4	5	1	3	5	3	4	4	4	4
Attribute 5	3	5	4	3	5	3	4	5	4	5	1	3	3	3	5
Attribute 6	1	5	1	3	5	3	4	5	3	5	3	4	3	4	5
Attribute 7	1	5	5	3	4	4	5	5	3	5	3	2	3	4	4
Attribute 8	4	5	5	3	4	3	5	5	3	5	3	2	4	5	4
Attribute 9	5	4	4	3	5	5	5	5	3	5	2	2	1	5	5
Attribute 10	3	5	4	3	5	5	3	5	3	5	4	3	1	4	4
Attribute 11	5	4	5	4	3	4	5	5	3	5	2	2	2	5	4

Table G4 Fuzzification of the Significance of the Deployer Attributes $j=1,2,\dots,11$ for Each Participant $i=1,2,\dots,15$ (for Trust Dimension 1)

Participant i	Step2: Fuzzification		
Attributes	a _{ij}	b _{ij}	c _{ij}
Attribute j=1	4	5	5
Attribute j=2	3	4	5
Attribute j=3	3	4	5
Attribute j=4	3	4	5
Attribute j=5	2	3	4
Attribute j=6	1	1	2
Attribute j=7	1	1	2
Attribute j=8	3	4	5
Attribute j=9	4	5	5
Attribute j=10	2	3	4
Attribute j=11	4	5	5

Participant i=2	a _{ij}	b _{ij}	c _{ij}
Attribute j=1	4	5	5
Attribute j=2	4	5	5

Participant i	Step2: Fuzzification		
Attribute j=3	4	5	5
Attribute j=4	4	5	5
Attribute j=5	4	5	5
Attribute j=6	4	5	5
Attribute j=7	4	5	5
Attribute j=8	4	5	5
Attribute j=9	3	4	5
Attribute j=10	4	5	5
Attribute j=11	3	4	5

Participant i=3	a _{ij}	b _{ij}	c _{ij}
Attribute j=1	4	5	5
Attribute j=2	4	5	5
Attribute j=3	4	5	5
Attribute j=4	2	3	4
Attribute j=5	3	4	5
Attribute j=6	1	1	2
Attribute j=7	4	5	5
Attribute j=8	4	5	5
Attribute j=9	3	4	5
Attribute j=10	3	4	5
Attribute j=11	4	5	5

Participant i=4	a _{ij}	b _{ij}	c _{ij}
Attribute j=1	3	4	5
Attribute j=2	2	3	4
Attribute j=3	3	4	5
Attribute j=4	2	3	4
Attribute j=5	2	3	4
Attribute j=6	2	3	4
Attribute j=7	2	3	4
Attribute j=8	2	3	4
Attribute j=9	2	3	4
Attribute j=10	2	3	4
Attribute j=11	3	4	5

Participant i=5	a _{ij}	b _{ij}	c _{ij}
Attribute j=1	4	5	5
Attribute j=2	4	5	5
Attribute j=3	4	5	5

Participant i	Step2: Fuzzification		
Attribute j=4	4	5	5
Attribute j=5	4	5	5
Attribute j=6	4	5	5
Attribute j=7	3	4	5
Attribute j=8	3	4	5
Attribute j=9	4	5	5
Attribute j=10	4	5	5
Attribute j=11	2	3	4

Participant i=6	a _{ij}	b _{ij}	c _{ij}
Attribute 1	3	4	5
Attribute 2	4	5	5
Attribute 3	3	4	5
Attribute 4	3	4	5
Attribute 5	2	3	4
Attribute 6	2	3	4
Attribute 7	3	4	5
Attribute 8	2	3	4
Attribute 9	4	5	5
Attribute 10	4	5	5
Attribute 11	3	4	5

Participant i=7	a _{ij}	b _{ij}	c _{ij}
Attribute 1	4	5	5
Attribute 2	4	5	5
Attribute 3	3	4	5
Attribute 4	4	5	5
Attribute 5	3	4	5
Attribute 6	3	4	5
Attribute 7	4	5	5
Attribute 8	4	5	5
Attribute 9	4	5	5
Attribute 10	2	3	4
Attribute 11	4	5	5

Participant i=8	a _{ij}	b _{ij}	c _{ij}
Attribute 1	1	2	3
Attribute 2	2	3	4
Attribute 3	2	3	4
Attribute 4	1	1	2

Participant i	Step2: Fuzzification		
Attribute 5	4	5	5
Attribute 6	4	5	5
Attribute 7	4	5	5
Attribute 8	4	5	5
Attribute 9	4	5	5
Attribute 10	4	5	5
Attribute 11	4	5	5

Participant i=9	a _{ij}	b _{ij}	c _{ij}
Attribute 1	1	2	3
Attribute 2	2	3	4
Attribute 3	2	3	4
Attribute 4	2	3	4
Attribute 5	3	4	5
Attribute 6	2	3	4
Attribute 7	2	3	4
Attribute 8	2	3	4
Attribute 9	2	3	4
Attribute 10	2	3	4
Attribute 11	2	3	4

Participant i=10	a _{ij}	b _{ij}	c _{ij}
Attribute 1	4	5	5
Attribute 2	4	5	5
Attribute 3	4	5	5
Attribute 4	4	5	5
Attribute 5	4	5	5
Attribute 6	4	5	5
Attribute 7	4	5	5
Attribute 8	4	5	5
Attribute 9	4	5	5
Attribute 10	4	5	5
Attribute 11	1	5	5

Participant i=11	a _{ij}	b _{ij}	c _{ij}
Attribute 1	2	3	4
Attribute 2	1	2	3
Attribute 3	1	1	2
Attribute 4	2	3	4
Attribute 5	1	1	2

Participant i	Step2: Fuzzification		
Attribute 6	2	3	4
Attribute 7	2	3	4
Attribute 8	2	3	4
Attribute 9	1	2	3
Attribute 10	3	4	5
Attribute 11	1	2	3

Participant i=12	a _{ij}	b _{ij}	c _{ij}
Attribute 1	2	3	4
Attribute 2	2	3	4
Attribute 3	2	3	4
Attribute 4	3	4	5
Attribute 5	2	3	4
Attribute 6	3	4	5
Attribute 7	1	2	3
Attribute 8	1	2	3
Attribute 9	1	2	3
Attribute 10	2	3	4
Attribute 11	1	2	3

Participant i=13	a _{ij}	b _{ij}	c _{ij}
Attribute 1	3	4	5
Attribute 2	1	2	3
Attribute 3	3	4	5
Attribute 4	3	4	5
Attribute 5	2	3	4
Attribute 6	2	3	4
Attribute 7	2	3	4
Attribute 8	3	4	5
Attribute 9	1	1	2
Attribute 10	1	1	2
Attribute 11	1	2	3

Participant i=14	a _{ij}	b _{ij}	c _{ij}
Attribute 1	3	4	5
Attribute 2	4	5	5
Attribute 3	3	4	5
Attribute 4	3	4	5
Attribute 5	2	3	4
Attribute 6	3	4	5

Participant i	Step2: Fuzzification		
Attribute 7	3	4	5
Attribute 8	4	5	5
Attribute 9	4	5	5
Attribute 10	3	4	5
Attribute 11	4	5	5

Participant i=15	a_ij	b_ij	c_ij
Attribute 1	4	5	5
Attribute 2	3	4	5
Attribute 3	4	5	5
Attribute 4	3	4	5
Attribute 5	4	5	5
Attribute 6	4	5	5
Attribute 7	3	4	5
Attribute 8	3	4	5
Attribute 9	4	5	5
Attribute 10	3	4	5
Attribute 11	3	4	5

Table G5 *Converting the Participant Scores into a Single Fuzzy Membership Expression For Each Attribute (For Trust Dimension 1)*

Attributes	$a_j = \min_i(a_{ij})$	$b_j = \text{Geometric mean}_i(b_{ij})$	$c_j = \max_i(c_{ij})$
Attribute j=1	1	3.88	5
Attribute j=2	1	3.92	5
Attribute j=3	1	3.63	5
Attribute j=4	1	3.44	5
Attribute j=5	1	3.54	5
Attribute j=6	1	3.04	5
Attribute j=7	1	3.61	5
Attribute j=8	2	3.99	5
Attribute j=9	1	4.03	5
Attribute j=10	2	3.99	5
Attribute j=11	1	3.94	5

Table G6 Defuzzification: The FDM Scores and the Averages of the Original Participant Scores for the Significance of the Deployer Attributes (for Trust Dimension1)

Attributes	FDM Scores	Averages of the Original Participant Scores
Attribute 1	3.29	4.07
Attribute 2	3.31	3.93
Attribute 3	3.21	3.93
Attribute 4	3.15	3.80
Attribute 5	3.18	3.73
Attribute 6	3.01	3.60
Attribute 7	3.20	3.73
Attribute 8	3.66	4.00
Attribute 9	3.34	3.93
Attribute 10	3.66	3.80
Attribute 11	3.31	3.87

FDM Evaluation 2

Significance of the Deployer Attributes for Trust Dimension 2, i.e., Avoiding Psychological harm (e.g., stress, anxiety)

Table G7 Participant Scores at Unilever: Significance of the Deployer Attributes $j=1,2,...,11$ for Each Participant $i=1,2,...,15$ (for Trust Dimension 2)

	Operator1	Operator2	Operator3	Operator4	Operator5	Operator6	Operator7	Operator8	Operator9	Operator10	Operator11	Operator12	Operator13	Operator14	Operator15
Attribute 1	2	4	5	4	5	4	3	3	2	5	3	3	3	4	5
Attribute 2	2	5	5	4	5	4	5	2	3	5	4	2	3	4	5
Attribute 3	2	5	5	5	5	4	5	3	3	5	3	3	4	4	5
Attribute 4	2	5	1	3	4	4	4	3	3	5	3	4	4	4	5
Attribute 5	3	5	4	3	5	3	3	5	4	5	1	3	3	3	3
Attribute 6	1	5	1	4	4	3	5	5	3	5	3	2	4	4	5
Attribute 7	2	5	5	4	5	4	4	4	3	5	3	2	4	4	5
Attribute 8	1	5	5	5	4	4	4	5	3	5	2	3	1	4	5
Attribute 9	2	4	4	4	5	5	5	5	3	5	3	3	2	4	5
Attribute 10	1	5	4	4	4	5	4	5	3	5	4	3	3	4	4
Attribute 11	2	4	5	4	5	5	4	5	3	5	2	1	2	4	5

Table G8 *Fuzzification of the Significance of the Deployer Attributes $j=1,2,...,11$ for Each Participant $i=1,2,...,15$ (for Trust Dimension 2)*

Step2: Fuzzification			
Participant i=1	a _{ij}	b _{ij}	c _{ij}
Attribute 1	1	2	3
Attribute 2	1	2	3
Attribute 3	1	2	3
Attribute 4	1	2	3
Attribute 5	2	3	4
Attribute 6	1	1	2
Attribute 7	1	2	3
Attribute 8	1	1	2
Attribute 9	1	2	3
Attribute 10	1	1	2
Attribute 11	1	2	3
Participant i=2	a _{ij}	b _{ij}	c _{ij}
Attribute 1	3	4	5
Attribute 2	4	5	5
Attribute 3	4	5	5
Attribute 4	4	5	5
Attribute 5	4	5	5
Attribute 6	4	5	5
Attribute 7	4	5	5
Attribute 8	4	5	5
Attribute 9	3	4	5
Attribute 10	4	5	5
Attribute 11	3	4	5
Participant i=3	a _{ij}	b _{ij}	c _{ij}
Attribute 1	4	5	5
Attribute 2	4	5	5
Attribute 3	4	5	5
Attribute 4	1	1	2
Attribute 5	3	4	5
Attribute 6	1	1	2
Attribute 7	4	5	5
Attribute 8	4	5	5
Attribute 9	3	4	5
Attribute 10	3	4	5
Attribute 11	4	5	5

Participant i=4	a _{ij}	b _{ij}	c _{ij}
Attribute 1	3	4	5
Attribute 2	3	4	5
Attribute 3	4	5	5
Attribute 4	2	3	4
Attribute 5	2	3	4
Attribute 6	3	4	5
Attribute 7	3	4	5
Attribute 8	4	5	5
Attribute 9	3	4	5
Attribute 10	3	4	5
Attribute 11	3	4	5

Participant i=5	a _{ij}	b _{ij}	c _{ij}
Attribute 1	4	5	5
Attribute 2	4	5	5
Attribute 3	4	5	5
Attribute 4	3	4	5
Attribute 5	4	5	5
Attribute 6	3	4	5
Attribute 7	4	5	5
Attribute 8	3	4	5
Attribute 9	4	5	5
Attribute 10	3	4	5
Attribute 11	4	5	5

Participant i=6	a _{ij}	b _{ij}	c _{ij}
Attribute 1	3	4	5
Attribute 2	3	4	5
Attribute 3	3	4	5
Attribute 4	3	4	5
Attribute 5	2	3	4
Attribute 6	2	3	4
Attribute 7	3	4	5
Attribute 8	3	4	5
Attribute 9	4	5	5
Attribute 10	4	5	5
Attribute 11	4	5	5

Participant i=7	a _{ij}	b _{ij}	c _{ij}
Attribute 1	2	3	4
Attribute 2	4	5	5

Attribute 3	4	5	5
Attribute 4	3	4	5
Attribute 5	2	3	4
Attribute 6	4	5	5
Attribute 7	3	4	5
Attribute 8	3	4	5
Attribute 9	4	5	5
Attribute 10	3	4	5
Attribute 11	3	4	5

Participant i=8	a _{ij}	b _{ij}	c _{ij}
Attribute 1	2	3	4
Attribute 2	1	2	3
Attribute 3	2	3	4
Attribute 4	2	3	4
Attribute 5	4	5	5
Attribute 6	4	5	5
Attribute 7	3	4	5
Attribute 8	4	5	5
Attribute 9	4	5	5
Attribute 10	4	5	5
Attribute 11	4	5	5

Participant i=9	a _{ij}	b _{ij}	c _{ij}
Attribute 1	1	2	3
Attribute 2	2	3	4
Attribute 3	2	3	4
Attribute 4	2	3	4
Attribute 5	3	4	5
Attribute 6	2	3	4
Attribute 7	2	3	4
Attribute 8	2	3	4
Attribute 9	2	3	4
Attribute 10	2	3	4
Attribute 11	2	3	4

Participant i=10	a _{ij}	b _{ij}	c _{ij}
Attribute 1	4	5	5
Attribute 2	4	5	5
Attribute 3	4	5	5
Attribute 4	4	5	5
Attribute 5	4	5	5

Attribute 6	4	5	5
Attribute 7	4	5	5
Attribute 8	4	5	5
Attribute 9	4	5	5
Attribute 10	4	5	5
Attribute 11	1	5	5

Participant i=11	a _{ij}	b _{ij}	c _{ij}
Attribute 1	2	3	4
Attribute 2	3	4	5
Attribute 3	2	3	4
Attribute 4	2	3	4
Attribute 5	1	1	2
Attribute 6	2	3	4
Attribute 7	2	3	4
Attribute 8	1	2	3
Attribute 9	2	3	4
Attribute 10	3	4	5
Attribute 11	1	2	3

Participant i=12	a _{ij}	b _{ij}	c _{ij}
Attribute 1	2	3	4
Attribute 2	1	2	3
Attribute 3	2	3	4
Attribute 4	3	4	5
Attribute 5	2	3	4
Attribute 6	1	2	3
Attribute 7	1	2	3
Attribute 8	2	3	4
Attribute 9	2	3	4
Attribute 10	2	3	4
Attribute 11	1	1	2

Participant i=13	a _{ij}	b _{ij}	c _{ij}
Attribute 1	2	3	4
Attribute 2	2	3	4
Attribute 3	3	4	5
Attribute 4	3	4	5
Attribute 5	2	3	4
Attribute 6	3	4	5
Attribute 7	3	4	5
Attribute 8	1	1	2

Attribute 9	1	2	3
Attribute 10	2	3	4
Attribute 11	1	2	3

Participant i=14	a _{ij}	b _{ij}	c _{ij}
Attribute 1	3	4	5
Attribute 2	3	4	5
Attribute 3	3	4	5
Attribute 4	3	4	5
Attribute 5	2	3	4
Attribute 6	3	4	5
Attribute 7	3	4	5
Attribute 8	3	4	5
Attribute 9	3	4	5
Attribute 10	3	4	5
Attribute 11	3	4	5

Participant i=15	a _{ij}	b _{ij}	c _{ij}
Attribute 1	4	5	5
Attribute 2	4	5	5
Attribute 3	4	5	5
Attribute 4	4	5	5
Attribute 5	2	3	4
Attribute 6	4	5	5
Attribute 7	4	5	5
Attribute 8	4	5	5
Attribute 9	4	5	5
Attribute 10	3	4	5
Attribute 11	4	5	5

Table G9 Converting the Participant Scores into a Single Fuzzy Membership Expression

For Each Attribute (For Trust Dimension 1)

	$a_j = \min_i(a_{ij})$	$b_j = \text{Geometric mean}_i(b_{ij})$	$c_j = \max_i(c_{ij})$
Attribute 1	1	3.46	5
Attribute 2	1	3.80	5
Attribute 3	1	3.92	5
Attribute 4	1	3.11	5
Attribute 5	1	3.44	5

Attribute 6	1	3.12	5
Attribute 7	1	3.87	5
Attribute 8	1	3.57	5
Attribute 9	1	3.94	5
Attribute 10	1	3.73	5
Attribute 11	1	3.80	5

Table G10 *Defuzzification: The FDM Scores and the Averages of the Original Participant Scores for the Significance of the Deployer Attributes (for Trust Dimension2)*

	Average(a1,b1,c1)	Arith. Mean
Attribute 1	3.15	3.67
Attribute 2	3.27	3.87
Attribute 3	3.31	4.07
Attribute 4	3.04	3.60
Attribute 5	3.15	3.53
Attribute 6	3.04	3.60
Attribute 7	3.29	3.93
Attribute 8	3.19	3.73
Attribute 9	3.31	3.93
Attribute 10	3.24	3.87
Attribute 11	3.27	3.73

FDM Evaluation 3

Significance of the Deployer Attributes for Trust Dimension 3, i.e., Job performance impact

Table G11 Participant Scores at Unilever: Significance of the Deployer Attributes $J=1,2,...,11$ For Each Participant $I=1,2,...,15$ (For Trust Dimension 3)

	Operator1	Operator2	Operator3	Operator4	Operator5	Operator6	Operator7	Operator8	Operator9	Operator10	Operator11	Operator12	Operator13	Operator14	Operator15
Attribute 1	3	5	5	4	5	4	4	3	2	5	3	3	3	4	5
Attribute 2	4	5	5	5	5	4	5	1	3	5	2	3	2	5	5
Attribute 3	4	5	4	3	2	4	5	5	3	5	3	3	4	4	4
Attribute 4	4	5	4	3	4	4	5	4	3	5	2	4	4	4	5
Attribute 5	3	5	4	4	5	3	3	5	4	5	2	3	3	3	4
Attribute 6	3	5	1	3	4	3	4	5	3	5	3	4	4	4	5
Attribute 7	4	5	5	4	4	5	3	5	3	5	3	3	3	4	5
Attribute 8	3	5	5	4	4	5	5	3	3	5	2	2	2	4	5
Attribute 9	4	4	4	5	5	4	5	5	3	5	3	2	2	4	5
Attribute 10	3	5	4	4	4	5	3	5	3	5	3	1	3	4	3
Attribute 11	4	3	5	4	5	4	4	5	3	5	3	2	3	4	5

Table G12 Fuzzification of the Significance of the Deployer Attributes $j=1,2,...,11$ for Each Participant $i=1,2,...,15$ (for Trust Dimension 3)

Step2: Fuzzification			
Participant i=1	a _{ij}	b _{ij}	c _{ij}
Attribute 1	2	3	4
Attribute 2	3	4	5
Attribute 3	3	4	5
Attribute 4	3	4	5
Attribute 5	2	3	4
Attribute 6	2	3	4
Attribute 7	3	4	5
Attribute 8	2	3	4
Attribute 9	3	4	5
Attribute 10	2	3	4
Attribute 11	3	4	5

Participant i=2	a_ij	b_ij	c_ij
Attribute 1	4	5	5
Attribute 2	4	5	5
Attribute 3	4	5	5
Attribute 4	4	5	5
Attribute 5	4	5	5
Attribute 6	4	5	5
Attribute 7	4	5	5
Attribute 8	4	5	5
Attribute 9	3	4	5
Attribute 10	4	5	5
Attribute 11	2	3	4

Participant i=3	a_ij	b_ij	c_ij
Attribute 1	4	5	5
Attribute 2	4	5	5
Attribute 3	3	4	5
Attribute 4	3	4	5
Attribute 5	3	4	5
Attribute 6	1	1	2
Attribute 7	4	5	5
Attribute 8	4	5	5
Attribute 9	3	4	5
Attribute 10	3	4	5
Attribute 11	4	5	5

Participant i=4	a_ij	b_ij	c_ij
Attribute 1	3	4	5
Attribute 2	4	5	5
Attribute 3	2	3	4
Attribute 4	2	3	4
Attribute 5	3	4	5
Attribute 6	2	3	4
Attribute 7	3	4	5
Attribute 8	3	4	5
Attribute 9	4	5	5
Attribute 10	3	4	5
Attribute 11	3	4	5

Participant i=5	a_ij	b_ij	c_ij
Attribute 1	4	5	5
Attribute 2	4	5	5

Attribute 3	1	2	3
Attribute 4	3	4	5
Attribute 5	4	5	5
Attribute 6	3	4	5
Attribute 7	3	4	5
Attribute 8	3	4	5
Attribute 9	4	5	5
Attribute 10	3	4	5
Attribute 11	4	5	5

Participant i=6	a _{ij}	b _{ij}	c _{ij}
Attribute 1	3	4	5
Attribute 2	3	4	5
Attribute 3	3	4	5
Attribute 4	3	4	5
Attribute 5	2	3	4
Attribute 6	2	3	4
Attribute 7	4	5	5
Attribute 8	4	5	5
Attribute 9	3	4	5
Attribute 10	4	5	5
Attribute 11	3	4	5

Participant i=7	a _{ij}	b _{ij}	c _{ij}
Attribute 1	3	4	5
Attribute 2	4	5	5
Attribute 3	4	5	5
Attribute 4	4	5	5
Attribute 5	2	3	4
Attribute 6	3	4	5
Attribute 7	2	3	4
Attribute 8	4	5	5
Attribute 9	4	5	5
Attribute 10	2	3	4
Attribute 11	3	4	5

Participant i=8	a _{ij}	b _{ij}	c _{ij}
Attribute 1	2	3	4
Attribute 2	1	1	2
Attribute 3	4	5	5
Attribute 4	3	4	5
Attribute 5	4	5	5

Attribute 6	4	5	5
Attribute 7	4	5	5
Attribute 8	2	3	4
Attribute 9	4	5	5
Attribute 10	4	5	5
Attribute 11	4	5	5

Participant i=9	a _{ij}	b _{ij}	c _{ij}
Attribute 1	1	2	3
Attribute 2	2	3	4
Attribute 3	2	3	4
Attribute 4	2	3	4
Attribute 5	3	4	5
Attribute 6	2	3	4
Attribute 7	2	3	4
Attribute 8	2	3	4
Attribute 9	2	3	4
Attribute 10	2	3	4
Attribute 11	2	3	4

Participant i=10	a _{ij}	b _{ij}	c _{ij}
Attribute 1	4	5	5
Attribute 2	4	5	5
Attribute 3	4	5	5
Attribute 4	4	5	5
Attribute 5	4	5	5
Attribute 6	4	5	5
Attribute 7	4	5	5
Attribute 8	4	5	5
Attribute 9	4	5	5
Attribute 10	4	5	5
Attribute 11	2	5	5

Participant i=11	a _{ij}	b _{ij}	c _{ij}
Attribute 1	2	3	4
Attribute 2	1	2	3
Attribute 3	2	3	4
Attribute 4	1	2	3
Attribute 5	1	2	3
Attribute 6	2	3	4
Attribute 7	2	3	4
Attribute 8	1	2	3

Attribute 9	2	3	4
Attribute 10	2	3	4
Attribute 11	2	3	4

Table G13 *Converting the Participant Scores into a Single Fuzzy Membership Expression for Each Attribute (For Trust Dimension 3)*

	$a_j = \min_i(a_{ij})$	$b_j = \text{Geometric mean}_i(b_{ij})$	$c_j = \max_i(c_{ij})$
Attribute 1	1	3.77	5
Attribute 2	1	3.64	5
Attribute 3	1	3.77	5
Attribute 4	1	3.79	5
Attribute 5	1	3.77	5
Attribute 6	1	3.29	5
Attribute 7	2	4.09	5
Attribute 8	1	3.84	5
Attribute 9	2	4.20	5
Attribute 10	2	3.91	5
Attribute 11	2	4.01	5

Table G14 *Defuzzification: The FDM Scores and the Averages of the Original Participant Scores for the Significance of the Deployer Attributes (for Trust Dimension3)*

	Average(a1,b1,c1)	Arith. Mean
Attribute 1	3.26	3.91
Attribute 2	3.21	4.00
Attribute 3	3.26	3.91
Attribute 4	3.26	4.00
Attribute 5	3.26	3.73
Attribute 6	3.10	3.73
Attribute 7	3.70	4.07
Attribute 8	3.28	3.80
Attribute 9	3.73	4.00
Attribute 10	3.64	3.67
Attribute 11	3.67	3.93

Use-Case Implementation of the Deployer Model at Unilever

Table G15 *Survey for the Assessment of Deployer Performance at Unilever*

Tanımlayıcı Bilgiler	
Tarih (Lütfen Gün/Ay/Yıl şeklinde tarih giriniz)	.../12/2023
Ülke	Türkiye
Şirket	Unilever
Şehir	İstanbul
Fabrika	Besan
Kullanıcının Rolü	Operator
Kullanıcının Eğitim Durumu (Lise/Üniversite/Diğer birini yazınız)	
Kullanıcının Sektör Tecrübesi (kaç yıl)	
Kullanıcının Cobotlarla Çalışma Deneyim Süresi(kaç yıl)	
Kullanılan Cobot Marka/Model (Fanuc/Universal Robots/Kuka vb. birini veya birkaçını yazabilirsiniz)	
Cobot'un İşlevi (paketleme/kolileme/paletleme/hat ürün besleme vb. birini veya birkaçını yazabilirsiniz)	
Lütfen aşağıdaki soruları cevaplarken sağ taraftaki Cevaplar sütununu doldurunuz. Herbir soru için Cobotlarla günlük çalışma rutininizi düşünerek 7 cevap seçeneğinden size en uygun olanı seçiniz.	
Sorular	Cevaplar
Cobot ile beraber çalışırken, parça alıp verme, bir işi devam ettirme, sözlü-yazılı komut verme, geri bildirim alma gibi iletişim ihtiyaçları oluyor mu?	
Cobot gerektiğinde hata mesajı veriyor mu?	
Sistemden otomatik olarak ya da operatörden sistemi tasarlayan/uygulayan uzmana alarm ya da bildirim gidiyor mu?	
Sistemi tasarlayan/uygulayan uzman sistemin durumunu, operatör ile ilgili kriterleri izliyor ve raporluyor mu?	
Cobotun programlanması kolay mı?	
Cobotun hata yapma oranı yüksek mi?	
Cobotun geliştirilmesi için bir uzman desteği gerekiyor mu?	
Cobot ile çalışırken verimlilik, süreklilik ve doğru kullanım gibi konularda kaynak yönetimini etkileyen öneriler çıkabiliyor mu?	
Cobot durma, hatalı aksiyon gibi üretimi, lojistiği ya da operasyonu etkileyen durumlar yaratıyor mu?	
Operatör sistemi tasarlayan/uygulayan uzmana geri bildirimde bulunuyor mu?	
Operatör Cobot'ta yeni bir görev için programlama yapmak istese hangi sıklıkta firma yetkilisinden yardım alıyor?	
Hata ya da kaza durumunda sistemi tasarlayan/uygulayan uzman sisteme uzaktan müdahale edebiliyor mu?	
Herhangi bir konuda sistemi tasarlayan firma sorumlusuna alarm ya da bildirim gidiyor mu?	
Sistemi tasarlayan firma sorumlusu herhangi bir izleme ve kontrol aracı kullanıyor mu?	
Otomasyonun herkes için erişilebilir olmasını sağlıyor mu?	
Cobot ile iletişim yöntemleri yeterli mi?	
Cobot bir sorun durumunda operatöre ya da ilgili sorumluyla sesli ya da yazılı bir uyarıda bulunuyor mu?	
Cobot beraber çalışırken hiç hata yapıyor mu?	
Cobot ile beraber çalışırken, parça alıp verme, bir işi devam ettirme, sözlü-yazılı komut verme, geri bildirim alma gibi etkileşim ihtiyaçları oluyor mu?	
Cobot operatörlerinin eğitim, farkındalık ve doğru kullanımı için sistemden geri bildirim ya da rapor alınıyor mu?	
Cobotlarla çalışırken daha güvenli hissetmesi için operatöre önerilerde bulunuluyor mu?	
Operatör Cobot'u eğitirken görev türünü hızlı bir şekilde değiştirebilecek sisteme sahip mi?	
Cobot sesli ya da yazılı sorun bildiriyor mu?	
Firma yetkilisi sorun olduğunda yerinde müdahale mi etmek zorunda?	
Gün içinde bir sorun olduğunda sistemi tasarlayan firma sorumlusuna herhangi bir alarm ya da bildirim gidiyor mu?	
Sistemi tasarlayan firma operatör ya da yönetim ekibi ile durjın ya da performansla dair bir rapor paylaşıyor mu?	
Cobotun otomasyon seviyesini arttırmak ne kadar mümkün?	
Cobot firma yetkilisine Cobot ile etkileşim açısından önerilerde bulunmak gerekiyor mu?	
Cobot firma yetkilisine Cobot ile etkileşim açısından önerilerde bulunmak gerekiyor mu?	
Cobot ile çalışan operatörün verimliliği, bilgisi, kullanımını iyileştirecek tavsiyeler alınıyor mu?	
Cobot operatörlerinin Cobotlarla çalışırken sisteme güveninin artması için üretici firma ya da uygulayıcısı tarafından bir analiz yapılıyor mu?	
Operatör firma yetkilisi olmadan yeni bir görev tanımlayabiliyor mu?	
Firma yetkilisi sorun olduğunda hangi sıklıkta sisteme uzaktan müdahale ediyor?	

Table G16 *Answers to the Survey for the Assessment of Deployer Performance at Unilever*

QUESTIONS	ANSWERS of OPERATORS											
	Second Ordering	OP1	OP2	OP3	OP4	OP5	OP6	OP7	OPE8	OP9	OP10	OP11
Sistemden otomatik olarak ya da operatörden sistemi tasarlayan/ uygulayan uzmana alarm ya da bildirim gidiyor mu?	3	1	2	4	2	2	1	5	2	4	2	2
Gün içinde bir sorun olduğunda sistemi tasarlayan firma sorumlusuna herhangi bir alarm ya da bildirim gidiyor mu?	25	2	2	5	2	2	2	2	2	2	2	2
Herhangi bir konuda sistemi tasarlayan firma sorumlusuna alarm ya da bildirim gidiyor mu?	13	2	2	4	2	2	2	2	4	2	2	2
Sistemi tasarlayan/ uygulayan uzman sistemin durumunu, operator ile ilgili kriterleri izliyor ve raporluyor mu?	4	1	2	4	5	2	5	4	2	4	5	5
Sistemi tasarlayan firma operator ya da yönetim ekibi ile durjım ya da performansa dair bir rapor paylaşıyor mu?	26	2	2	4	4	2	4	2	2	2	4	4

QUESTIONS	ANSWERS of OPERATORS											
	Second Ordering	OP1	OP2	OP3	OP4	OP5	OP6	OP7	OPE8	OP9	OP10	OP11
Sistemi tasarlayan firma sorumlusu herhangi bir izleme ve kontrol aracı kullanıyor mu?	14	2	2	5	2	2	2	2	2	4	2	2
Cobotun programlanması kolay mı?	5	2	2	4	2	2	2	4	2	4	2	2
Cobotun otomasyon seviyesini arttırmak ne kadar mümkün?	27	4	2	3	2	2	4	4	2	4	2	2
Otomasyonun herkes için erişilebilir olmasını sağlıyor mu?	15	2	4	4	2	2	2	4	4	4	2	2
Cobot ile beraber çalışırken, parça alıp verme, bir işi devam ettirme, sözlü-yazılı komut verme, geri bildirim alma gibi iletişim ihtiyaçları oluyor mu?	19	4	2	4	4	4	4	3	5	4	2	4
Cobot firma yetkilisine Cobot ile iletişim açısından önerilerde bulunmak gerekiyor mu?	28	4	3	4	5	4	4	4	4	4	5	5
Cobot ile iletişim yöntemleri yeterli mi? Geliştirilmesi için bir uzman desteği gerekiyor mu?	16	2	4	5	2	2	2	2	2	4	2	2

QUESTIONS	ANSWERS of OPERATORS											
	Second Ordering	OP1	OP2	OP3	OP4	OP5	OP6	OP7	OPE8	OP9	OP10	OP11
Cobotun hata yapma oranı yüksek mi?	6	4	3	4	2	4	4	4	2	4	2	2
Cobot beraber çalışırken hiç hata yapıyor mu?	18	4	4	4	4	4	2	4	4	4	2	4
Cobot durma, hatalı aksiyon gibi üretimi, lojistiği ya da operasyonu etkileyen durumlar yaratıyor mu?	9	4	3	3	4	4	4	4	4	4	4	4
Cobot hata mesajı veriyor mu?	2	4	5	4	5	4	4	2	4	4	5	5
Cobot sesli ya da yazılı sorun bildiriyor mu?	23	2	2	4	4	4	2	4	2	4	4	4
Cobot bir sorun durumunda operatore ya da ilgili sorumluya sesli ya da yazılı bir uyarıda bulunuyor mu?	17	2	2	4	4	4	2	2	2	2	4	4
Cobotun Geliştirilmesi için bir uzman desteği gerekiyor mu?	7	4	2	4	5	4	4	4	4	4	5	5
Cobot firma yetkilisine Cobot ile etkileşim açısından önerilerde bulunmak gerekiyor mu?	29	4	3	4	5	4	2	4	4	4	5	5

QUESTIONS	ANSWERS of OPERATORS											
	Second Ordering	OP1	OP2	OP3	OP4	OP5	OP6	OP7	OPE8	OP9	OP10	OP11
Cobot ile beraber çalışırken, parça alıp verme, bir işi devam ettirme, sözlü-yazılı komut verme, geri bildirim alma gibi etkileşim ihtiyaçları oluyor mu?	1	5	2	4	4	4	5	5	2	3	4	4
Cobot ile çalışırken verimlilik, süreklilik ve doğru kullanım gibi konularda kaynak yönetimini etkileyen öneriler çıkabiliyor mu?	8	2	2	4	4	2	2	4	4	2	4	4
Cobot ile çalışan operatörün verimliliği, bilgisi, kullanımını iyileştirecek tavsiyeler alınıyor mu?	30	2	3	4	5	2	2	4	4	4	5	5
Cobot operatörlerinin eğitim, farkındalık ve doğru kullanımı için sistemden geri bildirim ya da rapor alınıyor mu?	20	2	2	4	4	2	2	4	4	4	4	4
Operatör sistemi tasarlayan/uygulayan uzmana geri bildirimde bulunuyor mu?	10	2	4	4	4	2	2	4	5	4	4	4
Cobot operatörlerinin Cobotlarla çalışırken sisteme güveninin artması için üretici firma ya da uygulayıcısı tarafından bir analiz yapılıyor mu?	31	2	2	4	5	2	2	4	4	4	5	5

QUESTIONS	ANSWERS of OPERATORS											
	Second Ordering	OP1	OP2	OP3	OP4	OP5	OP6	OP7	OPE8	OP9	OP10	OP11
Cobotlarla çalışırken daha güvenli hissetmesi için operatöre önerilerde bulunuluyor mu?	21	2	4	4	2	2	2	4	4	4	2	2
Operatör Cobot'ta yeni bir görev için programlama yapmak istese hangi sıklıkta firma yetkilisinden yardım alıyor?	11	2	2	3	4	2	2	5	2	4	4	4
Operatör firma yetkilisi olmadan yeni bir görev tanımlayabiliyor mu?	32	2	2	2	2	2	2	2	2	2	2	2
Operator Cobot'u eğitirken görev türünü hızlı bir şekilde değiştirebilecek sisteme sahip mi?	22	2	4	4	4	2	2	4	2	2	4	4
Hata ya da kaza durumunda sistemi tasarlayan/uygulayan uzman sisteme uzaktan müdahale edebiliyor mu?	12	2	2	1	2	2	2	2	4	2	2	2
Firma yetkilisi sorun olduğunda hangi sıklıkta sisteme uzaktan müdahale ediyor?	33	2	2	3	2	2	2	2	2	2	2	4
Firma yetkilisi sorun olduğunda yerinde müdahale mi etmek zorunda?	24	4	4	4	4	4	4	4	4	4	4	4

1	Hiç Katılmıyorum
2	Katılmıyorum
3	Az Katılıyorum
4	Katılıyorum
5	Oldukça katılıyorum

Applying FDM for the Assessment of the Deployer Performance at Unilever

Repetition 1 Analysis with the 1st Set of Questions

Table G17 Participant Scores at Unilever: Level of the Deployer Attributes $j=1,2,...,11$ for Each Participant $i=1,2,...,11$ at Unilever - Repetition 1

	Operator1	Operator2	Operator3	Operator4	Operator5	Operator6	Operator7	Operator8	Operator9	Operator10	Operator11
Attribute 1	1	2	4	2	2	1	5	2	4	2	2
Attribute 2	1	2	4	5	2	5	4	2	4	5	5
Attribute 3	2	2	4	2	2	2	4	2	4	2	2
Attribute 4	4	2	4	4	4	4	3	5	4	2	4
Attribute 5	4	3	4	2	4	4	4	2	4	2	2
Attribute 6	4	5	4	5	4	4	2	4	4	5	5
Attribute 7	4	2	4	5	4	4	4	4	4	5	5
Attribute 8	2	2	4	4	2	2	4	4	2	4	4
Attribute 9	2	4	4	4	2	2	4	5	4	4	4
Attribute 10	2	2	3	4	2	2	5	2	4	4	4
Attribute 11	2	2	1	2	2	2	2	4	2	2	2

Table G18 Fuzzification of the Level of the Deployer Attributes $j=1,2,...,11$ for Each Participant $i=1,2,...,11$ at Unilever - Repetition 1

Participant i=1	a _{ij}	b _{ij}	c _{ij}
Attribute 1	1	1	2
Attribute 2	1	1	2
Attribute 3	1	2	3
Attribute 4	3	4	5
Attribute 5	3	4	5
Attribute 6	3	4	5
Attribute 7	3	4	5
Attribute 8	1	2	3
Attribute 9	1	2	3
Attribute 10	1	2	3
Attribute 11	1	2	3

Participant i=2	a _{ij}	b _{ij}	c _{ij}
Attribute 1	1	2	3
Attribute 2	1	2	3
Attribute 3	1	2	3
Attribute 4	1	2	3
Attribute 5	2	3	4

Attribute 6	4	5	5
Attribute 7	1	2	3
Attribute 8	1	2	3
Attribute 9	3	4	5
Attribute 10	1	2	3
Attribute 11	1	2	3

Participant i=3	a _{ij}	b _{ij}	c _{ij}
Attribute 1	3	4	5
Attribute 2	3	4	5
Attribute 3	3	4	5
Attribute 4	3	4	5
Attribute 5	3	4	5
Attribute 6	3	4	5
Attribute 7	3	4	5
Attribute 8	3	4	5
Attribute 9	3	4	5
Attribute 10	2	3	4
Attribute 11	1	1	2

Participant i=4	a _{ij}	b _{ij}	c _{ij}
Attribute 1	1	2	3
Attribute 2	4	5	5
Attribute 3	1	2	3
Attribute 4	3	4	5
Attribute 5	1	2	3
Attribute 6	4	5	5
Attribute 7	4	5	5
Attribute 8	3	4	5
Attribute 9	3	4	5
Attribute 10	3	4	5
Attribute 11	1	2	3

Participant i=5	a _{ij}	b _{ij}	c _{ij}
Attribute 1	1	2	3
Attribute 2	1	2	3
Attribute 3	1	2	3
Attribute 4	3	4	5
Attribute 5	3	4	5
Attribute 6	3	4	5
Attribute 7	3	4	5
Attribute 8	1	2	3

Attribute 9	1	2	3
Attribute 10	1	2	3
Attribute 11	1	2	3

Participant i=6	a _{ij}	b _{ij}	c _{ij}
Attribute 1	1	1	2
Attribute 2	4	5	5
Attribute 3	1	2	3
Attribute 4	3	4	5
Attribute 5	3	4	5
Attribute 6	3	4	5
Attribute 7	3	4	5
Attribute 8	1	2	3
Attribute 9	1	2	3
Attribute 10	1	2	3
Attribute 11	1	2	3

Participant i=7	a _{ij}	b _{ij}	c _{ij}
Attribute 1	4	5	5
Attribute 2	3	4	5
Attribute 3	3	4	5
Attribute 4	2	3	4
Attribute 5	3	4	5
Attribute 6	1	2	3
Attribute 7	3	4	5
Attribute 8	3	4	5
Attribute 9	3	4	5
Attribute 10	4	5	5
Attribute 11	1	2	3

Participant i=8	a _{ij}	b _{ij}	c _{ij}
Attribute 1	1	2	3
Attribute 2	1	2	3
Attribute 3	1	2	3
Attribute 4	4	5	5
Attribute 5	1	2	3
Attribute 6	3	4	5
Attribute 7	3	4	5
Attribute 8	3	4	5
Attribute 9	4	5	5
Attribute 10	1	2	3
Attribute 11	3	4	5

Participant i=9	a _{ij}	b _{ij}	c _{ij}
Attribute 1	3	4	5
Attribute 2	3	4	5
Attribute 3	3	4	5
Attribute 4	3	4	5
Attribute 5	3	4	5
Attribute 6	3	4	5
Attribute 7	3	4	5
Attribute 8	1	2	3
Attribute 9	3	4	5
Attribute 10	3	4	5
Attribute 11	1	2	3

Participant i=10	a _{ij}	b _{ij}	c _{ij}
Attribute 1	1	2	3
Attribute 2	4	5	5
Attribute 3	1	2	3
Attribute 4	1	2	3
Attribute 5	1	2	3
Attribute 6	4	5	5
Attribute 7	4	5	5
Attribute 8	3	4	5
Attribute 9	3	4	5
Attribute 10	3	4	5
Attribute 11	1	2	3

Participant i=11	a _{ij}	b _{ij}	c _{ij}
Attribute 1	1	2	3
Attribute 2	4	5	5
Attribute 3	1	2	3
Attribute 4	3	4	5
Attribute 5	1	2	3
Attribute 6	4	5	5
Attribute 7	4	5	5
Attribute 8	3	4	5
Attribute 9	3	4	5
Attribute 10	3	4	5
Attribute 11	1	2	3

Table G19 *Converting the participant scores into a Single Fuzzy Membership Expression for Each Attribute – Repetition 1*

	$a_j = \min_i(a_{ij})$	$b_j = \text{Geometric mean}_i(b_{ij})$	$c_j = \max_i(c_{ij})$
Attribute 1	1	2.17	5
Attribute 2	1	3.17	5
Attribute 3	1	2.42	5
Attribute 4	1	3.51	5
Attribute 5	1	2.03	5
Attribute 6	1	4.07	5
Attribute 7	1	3.99	5
Attribute 8	1	2.92	5
Attribute 9	1	3.38	5
Attribute 10	1	2.9	5
Attribute 11	1	2	5

Table G20 *Defuzzification: The FDM Scores and the Averages of the Original Participant Scores for the Level of the Deployer Attributes at Unilever – Repetition 1*

	Average(a1,b1,c1)	Arith. Mean
Attribute 1	2,72	2,45
Attribute 2	3,06	3,55
Attribute 3	2,81	2,55
Attribute 4	3,17	3,64
Attribute 5	3,01	3,18
Attribute 6	3,36	4,18
Attribute 7	3,33	4,09
Attribute 8	2,97	3,09
Attribute 9	3,13	3,55
Attribute 10	2,97	3,09
Attribute 11	2,67	2,09

Repetition 2 Analysis with the 2nd Set of Questions

Table G21 *Participant Scores at Unilever: Level of the Deployer Attributes $j=1,2,...11$ for Each Participant $i=1,2,...,11$ at Unilever - Repetition 2*

	Operator1	Operator2	Operator3	Operator4	Operator5	Operator6	Operator7	Operator8	Operator9	Operator10	Operator11
Attribute 1	2	2	5	2	2	2	2	2	2	2	2
Attribute 2	2	2	4	4	2	4	2	2	2	4	4
Attribute 3	4	2	3	2	2	4	4	2	4	2	2
Attribute 4	4	3	4	5	4	4	4	4	4	5	5
Attribute 5	4	4	4	4	4	2	4	4	4	2	4
Attribute 6	2	2	4	4	4	2	4	2	4	4	4
Attribute 7	4	3	4	5	4	2	4	4	4	5	5
Attribute 8	2	3	4	5	2	2	4	4	4	5	5
Attribute 9	2	2	4	5	2	2	4	4	4	5	5
Attribute 10	2	2	2	2	2	2	2	2	2	2	2
Attribute 11	2	2	3	2	2	2	2	2	2	2	4

Table G22 *Fuzzification of the Level of the Deployer Attributes $j=1,2,...11$ for Each Participant $i=1,2,...,11$ - Repetition 2*

Participant $i=1$	a_{ij}	b_{ij}	c_{ij}
Attribute 1	1	2	3
Attribute 2	1	2	3
Attribute 3	3	4	5
Attribute 4	3	4	5
Attribute 5	3	4	5
Attribute 6	1	2	3
Attribute 7	3	4	5
Attribute 8	1	2	3
Attribute 9	1	2	3
Attribute 10	1	2	3
Attribute 11	1	2	3

Participant $i=2$	a_{ij}	b_{ij}	c_{ij}
Attribute 1	1	2	3
Attribute 2	1	2	3
Attribute 3	1	2	3
Attribute 4	2	3	4
Attribute 5	3	4	5
Attribute 6	1	2	3
Attribute 7	2	3	4
Attribute 8	2	3	4

Attribute 9	1	2	3
Attribute 10	1	2	3
Attribute 11	1	2	3

Participant i=3	a _{ij}	b _{ij}	c _{ij}
Attribute 1	4	5	5
Attribute 2	3	4	5
Attribute 3	2	3	4
Attribute 4	3	4	5
Attribute 5	3	4	5
Attribute 6	3	4	5
Attribute 7	3	4	5
Attribute 8	3	4	5
Attribute 9	3	4	5
Attribute 10	1	2	3
Attribute 11	2	3	4

Participant i=4	a _{ij}	b _{ij}	c _{ij}
Attribute 1	1	2	3
Attribute 2	3	4	5
Attribute 3	1	2	3
Attribute 4	4	5	5
Attribute 5	3	4	5
Attribute 6	3	4	5
Attribute 7	4	5	5
Attribute 8	4	5	5
Attribute 9	4	5	5
Attribute 10	1	2	3
Attribute 11	1	2	3

Participant i=5	a _{ij}	b _{ij}	c _{ij}
Attribute 1	1	2	3
Attribute 2	1	2	3
Attribute 3	1	2	3
Attribute 4	3	4	5
Attribute 5	3	4	5
Attribute 6	3	4	5
Attribute 7	3	4	5
Attribute 8	1	2	3
Attribute 9	1	2	3
Attribute 10	1	2	3
Attribute 11	1	2	3

Participant i=6	a_ij	b_ij	c_ij
Attribute 1	1	2	3
Attribute 2	3	4	5
Attribute 3	3	4	5
Attribute 4	3	4	5
Attribute 5	1	2	3
Attribute 6	1	2	3
Attribute 7	1	2	3
Attribute 8	1	2	3
Attribute 9	1	2	3
Attribute 10	1	2	3
Attribute 11	1	2	3

Participant i=7	a_ij	b_ij	c_ij
Attribute 1	1	2	3
Attribute 2	1	2	3
Attribute 3	3	4	5
Attribute 4	3	4	5
Attribute 5	3	4	5
Attribute 6	3	4	5
Attribute 7	3	4	5
Attribute 8	3	4	5
Attribute 9	3	4	5
Attribute 10	1	2	3
Attribute 11	1	2	3

Participant i=8	a_ij	b_ij	c_ij
Attribute 1	1	2	3
Attribute 2	1	2	3
Attribute 3	1	2	3
Attribute 4	3	4	5
Attribute 5	3	4	5
Attribute 6	1	2	3
Attribute 7	3	4	5
Attribute 8	3	4	5
Attribute 9	3	4	5
Attribute 10	1	2	3
Attribute 11	1	2	3

Participant i=9	a_ij	b_ij	c_ij
Attribute 1	1	2	3

Attribute 2	1	2	3
Attribute 3	3	4	5
Attribute 4	3	4	5
Attribute 5	3	4	5
Attribute 6	3	4	5
Attribute 7	3	4	5
Attribute 8	3	4	5
Attribute 9	3	4	5
Attribute 10	1	2	3
Attribute 11	1	2	3

Participant i=10	a _{ij}	b _{ij}	c _{ij}
Attribute 1	1	2	3
Attribute 2	3	4	5
Attribute 3	1	2	3
Attribute 4	4	5	5
Attribute 5	1	2	3
Attribute 6	3	4	5
Attribute 7	4	5	5
Attribute 8	4	5	5
Attribute 9	4	5	5
Attribute 10	1	2	3
Attribute 11	3	2	3

Participant i=11	a _{ij}	b _{ij}	c _{ij}
Attribute 1	1	2	3
Attribute 2	3	4	5
Attribute 3	1	2	3
Attribute 4	4	5	5
Attribute 5	3	4	5
Attribute 6	3	4	5
Attribute 7	4	5	5
Attribute 8	4	5	5
Attribute 9	4	5	5
Attribute 10	1	2	3
Attribute 11	3	4	5

Table G23 *Converting the Participant Scores into a Single Fuzzy Membership Expression For Each Attribute – Repetition 2*

	$a_j = \min_i(a_{ij})$	$b_j = \text{Geometric mean}_i(b_{ij})$	$c_j = \max_i(c_{ij})$
Attribute 1	1	2.17	5
Attribute 2	1	2.74	5
Attribute 3	1	2.67	5
Attribute 4	2	4.14	5
Attribute 5	1	3.53	5
Attribute 6	1	3.11	5
Attribute 7	1	3.88	5
Attribute 8	1	3.43	5
Attribute 9	1	3.3	5
Attribute 10	1	2	3
Attribute 11	1	2.21	5

Table G24 *Defuzzification: The FDM Scores and the Averages of the Original Participant Scores for the Level of the Deployer Attributes – Repetition 2*

	Average(a1,b1,c1)	Arith. Mean
Attribute 1	2.72	2.27
Attribute 2	2.91	2.91
Attribute 3	2.89	2.82
Attribute 4	3.71	4.18
Attribute 5	3.18	3.64
Attribute 6	3.04	3.27
Attribute 7	3.30	4.00
Attribute 8	3.14	3.64
Attribute 9	3.10	3.55
Attribute 10	2.00	2.00
Attribute 11	2.74	2.27

Repetition 3 Analysis with the 3rd Set of Questions

Table G25 *Participant Scores at Unilever: Level of the Deployer Attributes $j=1,2,...,11$ for Each Participant $i=1,2,...,11$ – Repetition 3*

	Operator1	Operator2	Operator3	Operator4	Operator5	Operator6	Operator7	Operator8	Operator9	Operator10	Operator11
Attribute 1	2	2	4	2	2	2	2	4	2	2	2
Attribute 2	2	2	5	2	2	2	2	2	4	2	2
Attribute 3	2	4	4	2	2	2	4	4	4	2	2
Attribute 4	2	4	5	2	2	2	2	2	4	2	2
Attribute 5	4	3	3	4	4	4	4	4	4	4	4
Attribute 6	2	2	4	4	4	2	2	2	2	4	4
Attribute 7	5	2	4	4	4	5	5	2	3	4	4
Attribute 8	2	2	4	4	2	2	4	4	4	4	4
Attribute 9	2	4	4	2	2	2	4	4	4	2	2
Attribute 10	2	4	4	4	2	2	4	2	2	4	4
Attribute 11	4	4	4	4	4	4	4	4	4	4	4

Table G26 *Fuzzification of the Level of the Deployer Attributes $j=1,2,...,11$ for Each Participant $i=1,2,...,11$ – Repetition 3*

Participant i=1	a _{ij}	b _{ij}	c _{ij}
Attribute 1	1	2	3
Attribute 2	1	2	3
Attribute 3	1	2	3
Attribute 4	1	2	3
Attribute 5	3	4	5
Attribute 6	1	2	3
Attribute 7	4	5	5
Attribute 8	1	2	3
Attribute 9	1	2	3
Attribute 10	1	2	3
Attribute 11	3	4	5

Participant i=2	a _{ij}	b _{ij}	c _{ij}
Attribute 1	1	2	3
Attribute 2	1	2	3
Attribute 3	3	4	5
Attribute 4	3	4	5
Attribute 5	2	3	4
Attribute 6	1	2	3
Attribute 7	1	2	3

Attribute 8	1	2	3
Attribute 9	3	4	5
Attribute 10	3	4	5
Attribute 11	3	4	5

Participant i=3	a _{ij}	b _{ij}	c _{ij}
Attribute 1	3	4	5
Attribute 2	4	5	5
Attribute 3	3	4	5
Attribute 4	4	5	5
Attribute 5	2	3	4
Attribute 6	3	4	5
Attribute 7	3	4	5
Attribute 8	3	4	5
Attribute 9	3	4	5
Attribute 10	3	4	5
Attribute 11	3	4	5

Participant i=4	a _{ij}	b _{ij}	c _{ij}
Attribute 1	1	2	3
Attribute 2	1	2	3
Attribute 3	1	2	3
Attribute 4	1	2	3
Attribute 5	3	4	5
Attribute 6	3	4	5
Attribute 7	3	4	5
Attribute 8	3	4	5
Attribute 9	1	2	3
Attribute 10	3	4	5
Attribute 11	3	4	5

Participant i=5	a _{ij}	b _{ij}	c _{ij}
Attribute 1	1	2	3
Attribute 2	1	2	3
Attribute 3	1	2	3
Attribute 4	1	2	3
Attribute 5	3	4	5
Attribute 6	3	4	5
Attribute 7	3	4	5
Attribute 8	1	2	3
Attribute 9	1	2	3
Attribute 10	1	2	3

Attribute 11	3	4	5
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Participant i=6	a _{ij}	b _{ij}	c _{ij}
Attribute 1	1	2	3
Attribute 2	1	2	3
Attribute 3	1	2	3
Attribute 4	1	2	3
Attribute 5	3	4	5
Attribute 6	1	2	3
Attribute 7	4	5	5
Attribute 8	1	2	3
Attribute 9	1	2	3
Attribute 10	1	2	3
Attribute 11	3	4	5

Participant i=7	a _{ij}	b _{ij}	c _{ij}
Attribute 1	1	2	3
Attribute 2	1	2	3
Attribute 3	3	4	5
Attribute 4	1	2	3
Attribute 5	3	4	5
Attribute 6	1	2	3
Attribute 7	4	5	5
Attribute 8	3	4	5
Attribute 9	3	4	5
Attribute 10	3	4	5
Attribute 11	3	4	5

Participant i=8	a _{ij}	b _{ij}	c _{ij}
Attribute 1	3	4	5
Attribute 2	1	2	3
Attribute 3	3	4	5
Attribute 4	1	2	3
Attribute 5	3	4	5
Attribute 6	1	2	3
Attribute 7	1	2	3
Attribute 8	3	4	5
Attribute 9	3	4	5
Attribute 10	1	2	3
Attribute 11	3	4	5

Participant i=9	a _{ij}	b _{ij}	c _{ij}
Attribute 1	1	2	3
Attribute 2	3	4	5
Attribute 3	3	4	5
Attribute 4	3	4	5
Attribute 5	3	4	5
Attribute 6	1	2	3
Attribute 7	2	3	4
Attribute 8	3	4	5
Attribute 9	3	4	5
Attribute 10	1	2	3
Attribute 11	3	4	5

Participant i=10	a _{ij}	b _{ij}	c _{ij}
Attribute 1	1	2	3
Attribute 2	1	2	3
Attribute 3	1	2	3
Attribute 4	1	2	3
Attribute 5	3	4	5
Attribute 6	3	4	5
Attribute 7	3	4	5
Attribute 8	3	4	5
Attribute 9	1	2	3
Attribute 10	3	4	5
Attribute 11	3	4	5

Participant i=11	a _{ij}	b _{ij}	c _{ij}
Attribute 1	1	2	3
Attribute 2	1	2	3
Attribute 3	1	2	3
Attribute 4	1	2	3
Attribute 5	3	4	5
Attribute 6	3	4	5
Attribute 7	3	4	5
Attribute 8	3	4	5
Attribute 9	1	2	3
Attribute 10	3	4	5
Attribute 11	3	4	5

Table G27 *Converting the Participant Scores into a Single Fuzzy Membership Expression for Each Attribute – Repetition 3*

	$a_j = \min_i(a_{ij})$	$b_j = \text{Geometric mean}_i(b_{ij})$	$c_j = \max_i(c_{ij})$
Attribute 1	1	2.27	5
Attribute 2	1	2.32	5
Attribute 3	1	2.74	5
Attribute 4	1	2.47	5
Attribute 5	2	3.9	5
Attribute 6	1	2.74	5
Attribute 7	1	3.65	5
Attribute 8	1	3.11	5
Attribute 9	1	2.74	5
Attribute 10	1	2.92	5
Attribute 11	3	4	5

Table G28 *Defuzzification: The FDM Scores and the Averages of the Original Participant Scores for the Level of the Deployer Attributes – Repetition 3*

	Average(a1,b1,c1)	Arith. Mean
Attribute 1	2.76	2.36
Attribute 2	2.77	2.45
Attribute 3	2.91	2.91
Attribute 4	2.82	2.64
Attribute 5	3.60	3.82
Attribute 6	2.91	2.91
Attribute 7	3.22	3.82
Attribute 8	3.04	3.27
Attribute 9	2.91	2.91
Attribute 10	2.97	3.09
Attribute 11	4.00	4.00

Applying FDM for the Assessment of the Deployer Performance at Benoplast

Repetition 1 Analysis with the 1st Set of Questions

Table G29 Participant Scores at Benoplast: Level of the Deployer Attributes $j=1,2,...,11$ for Each Participant $i=1,2,...,11$ at Benoplast - Repetition 1

	Opr 1	Opr 2	Opr 3	Opr 4	Opr 5	Opr 6	Opr 7	Opr 8	Opr 9	Opr 10	Opr 11
Attribute 1	4	3	3	2	3	3	3	4	5	1	2
Attribute 2	3	2	4	2	4	4	3	4	3	1	3
Attribute 3	3	4	2	4	5	2	1	2	5	2	4
Attribute 4	4	5	6	3	6	5	4	3	2	2	4
Attribute 5	5	5	5	5	3	4	3	5	4	1	5
Attribute 6	2	4	4	2	4	4	3	1	4	5	5
Attribute 7	4	4	4	2	3	3	3	3	1	4	4
Attribute 8	3	3	5	3	4	3	5	4	3	3	5
Attribute 9	3	3	7	2	3	4	3	3	2	3	2
Attribute 10	2	3	4	2	3	3	3	4	4	3	4
Attribute 11	2	2	3	3	4	5	4	3	7	4	3

Table G30 Fuzzification of the Level of the Deployer Attributes $j=1,2,...,11$ for Each Participant $i=1,2,...,11$ at Benoplast - Repetition 1

Participant $i=1$	a_{ij}	b_{ij}	c_{ij}
Attribute 1	3	4	5
Attribute 2	2	3	4
Attribute 3	2	3	4
Attribute 4	3	4	5
Attribute 5	4	5	6
Attribute 6	1	2	3
Attribute 7	3	4	5
Attribute 8	2	3	4
Attribute 9	2	3	4
Attribute 10	1	2	3
Attribute 11	1	2	3

Participant $i=2$	a_{ij}	b_{ij}	c_{ij}
Attribute 1	2	3	4
Attribute 2	1	2	3
Attribute 3	3	4	5
Attribute 4	4	5	6
Attribute 5	4	5	6
Attribute 6	3	4	5
Attribute 7	3	4	5

Attribute 8	2	3	4
Attribute 9	2	3	4
Attribute 10	2	3	4
Attribute 11	1	2	3

Participant i=3	a _{ij}	b _{ij}	c _{ij}
Attribute 1	2	3	4
Attribute 2	3	4	5
Attribute 3	1	2	3
Attribute 4	5	6	7
Attribute 5	4	5	6
Attribute 6	3	4	5
Attribute 7	3	4	5
Attribute 8	4	5	6
Attribute 9	6	7	7
Attribute 10	3	4	5
Attribute 11	2	3	4

Participant i=4	a _{ij}	b _{ij}	c _{ij}
Attribute 1	1	2	3
Attribute 2	1	2	3
Attribute 3	3	4	5
Attribute 4	2	3	4
Attribute 5	4	5	6
Attribute 6	1	2	3
Attribute 7	1	2	3
Attribute 8	2	3	4
Attribute 9	1	2	3
Attribute 10	1	2	3
Attribute 11	2	3	4

Participant i=5	a _{ij}	b _{ij}	c _{ij}
Attribute 1	2	3	4
Attribute 2	3	4	5
Attribute 3	4	5	6
Attribute 4	5	6	7
Attribute 5	2	3	4
Attribute 6	3	4	5
Attribute 7	2	3	4
Attribute 8	3	4	5
Attribute 9	2	3	4
Attribute 10	2	3	4

Attribute 11	3	4	5
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Participant i=6	a _{ij}	b _{ij}	c _{ij}
Attribute 1	2	3	4
Attribute 2	2	7	4
Attribute 3	1	7	2
Attribute 4	3	7	5
Attribute 5	2	3	4
Attribute 6	2	3	4
Attribute 7	2	7	4
Attribute 8	4	5	6
Attribute 9	2	3	4
Attribute 10	2	4	4
Attribute 11	3	4	5

Participant i=7	a _{ij}	b _{ij}	c _{ij}
Attribute 1	3	4	5
Attribute 2	3	7	5
Attribute 3	1	6	3
Attribute 4	2	7	4
Attribute 5	4	2	6
Attribute 6	1	2	2
Attribute 7	2	7	4
Attribute 8	3	5	5
Attribute 9	2	1	4
Attribute 10	3	1	5
Attribute 11	2	6	4

Participant i=8	a _{ij}	b _{ij}	c _{ij}
Attribute 1	4	5	6
Attribute 2	2	3	4
Attribute 3	4	5	6
Attribute 4	1	2	3
Attribute 5	3	4	5
Attribute 6	3	4	5
Attribute 7	1	1	2
Attribute 8	2	3	4
Attribute 9	1	2	3
Attribute 10	3	4	5
Attribute 11	6	7	7

Participant i=9	a _{ij}	b _{ij}	c _{ij}
Attribute 1	1	1	2
Attribute 2	1	1	2
Attribute 3	1	2	3
Attribute 4	1	2	3
Attribute 5	1	1	2
Attribute 6	4	5	6
Attribute 7	3	4	5
Attribute 8	2	3	4
Attribute 9	2	3	4
Attribute 10	2	3	4
Attribute 11	3	4	5

Participant i=10	a _{ij}	b _{ij}	c _{ij}
Attribute 1	1	2	3
Attribute 2	2	3	4
Attribute 3	3	4	5
Attribute 4	3	4	5
Attribute 5	4	5	6
Attribute 6	4	5	6
Attribute 7	3	4	5
Attribute 8	4	5	6
Attribute 9	1	2	3
Attribute 10	3	4	5
Attribute 11	2	3	4

Participant i=11	a _{ij}	b _{ij}	c _{ij}
Attribute 1	4	5	6
Attribute 2	4	5	6
Attribute 3	1	2	3
Attribute 4	2	2	3
Attribute 5	2	2	4
Attribute 6	6	7	7
Attribute 7	6	7	7
Attribute 8	4	5	6
Attribute 9	2	3	4
Attribute 10	3	4	5
Attribute 11	4	5	6

Table G31 *Converting the Participant Scores into a Single Fuzzy Membership Expression for Each Attribute – Repetition 1*

	$a_j = \min_i(a_{ij})$	$b_j = \text{Geometric mean}_i(b_{ij})$	$c_j = \max_i(c_{ij})$
Attribute 1	1	2.94	6
Attribute 2	1	3.24	6
Attribute 3	1	4.08	7
Attribute 4	1	4.31	7
Attribute 5	1	2.89	7
Attribute 6	1	3.21	7
Attribute 7	1	4.34	7
Attribute 8	2	4.30	7
Attribute 9	1	2.46	7
Attribute 10	1	2.75	7
Attribute 11	1	4.28	7

Table G32 *Defuzzification: The FDM Scores and the Averages of the Original Participant Scores for the Level of the Deployer Attributes at Benoplast – Repetition 1*

	Average(a1,b1,c1)	Arith. Mean
Attribute 1	3.31	3.00
Attribute 2	3.41	3.00
Attribute 3	4.03	3.09
Attribute 4	4.10	4.00
Attribute 5	3.63	4.09
Attribute 6	3.74	3.45
Attribute 7	4.11	3.18
Attribute 8	4.43	3.73
Attribute 9	3.49	3.18
Attribute 10	3.58	3.18
Attribute 11	4.09	3.64

Repetition 2 Analysis with the 2nd Set of Questions

Table G33 *Participant Scores at Benoplast: Level of the Deployer Attributes $j=1,2,...,11$ for Each Participant $i=1,2,...,11$ at Benoplast - Repetition 2*

	Opr1	Opr2	Opr3	Opr4	Opr5	Opr6	Opr7	Opr8	Opr9	Opr10	Opr11
Attribute 1	5	4	3	2	5	3	3	5	7	5	4
Attribute 2	5	3	5	3	3	4	4	3	3	1	3
Attribute 3	4	3	3	2	3	3	4	3	3	1	3
Attribute 4	4	4	3	3	5	4	3	4	2	5	4
Attribute 5	3	4	5	5	3	4	4	4	2	2	4
Attribute 6	3	4	2	3	4	4	5	4	3	3	5
Attribute 7	4	5	3	3	3	3	2	3	3	2	3
Attribute 8	4	4	4	2	3	4	2	4	2	1	3
Attribute 9	5	4	5	3	3	5	3	5	2	3	4
Attribute 10	4	3	6	5	4	6	3	3	6	3	4
Attribute 11	4	3	4	3	7	5	4	5	5	1	5

Table G34 *Fuzzification of the Level of the Deployer Attributes $j=1,2,...,11$ for Each Participant $i=1,2,...,11$ - Repetition 2*

Participant i=1	a _{ij}	b _{ij}	c _{ij}
Attribute 1	4	5	6
Attribute 2	4	5	6
Attribute 3	3	4	5
Attribute 4	3	4	5
Attribute 5	2	3	4
Attribute 6	2	3	4
Attribute 7	3	4	5
Attribute 8	3	4	5
Attribute 9	4	5	6
Attribute 10	3	4	5
Attribute 11	3	4	5

Participant i=2	a _{ij}	b _{ij}	c _{ij}
Attribute 1	3	4	5
Attribute 2	2	3	4
Attribute 3	2	3	4
Attribute 4	3	4	5
Attribute 5	3	4	5
Attribute 6	3	4	5
Attribute 7	4	5	6
Attribute 8	3	4	5

Attribute 9	3	4	5
Attribute 10	2	3	4
Attribute 11	2	3	4

Participant i=3	a _{ij}	b _{ij}	c _{ij}
Attribute 1	2	3	4
Attribute 2	4	5	6
Attribute 3	2	3	4
Attribute 4	2	3	4
Attribute 5	4	5	6
Attribute 6	1	2	3
Attribute 7	2	3	4
Attribute 8	3	4	5
Attribute 9	4	5	6
Attribute 10	5	6	7
Attribute 11	3	4	5

Participant i=4	a _{ij}	b _{ij}	c _{ij}
Attribute 1	1	2	3
Attribute 2	2	3	4
Attribute 3	1	2	3
Attribute 4	2	3	4
Attribute 5	4	5	6
Attribute 6	2	3	4
Attribute 7	2	3	4
Attribute 8	1	2	3
Attribute 9	2	3	4
Attribute 10	4	5	6
Attribute 11	2	3	4

Participant i=5	a _{ij}	b _{ij}	c _{ij}
Attribute 1	4	5	6
Attribute 2	2	3	4
Attribute 3	2	3	4
Attribute 4	4	5	6
Attribute 5	2	3	4
Attribute 6	3	4	5
Attribute 7	2	3	4
Attribute 8	2	3	4
Attribute 9	2	3	4
Attribute 10	3	4	5
Attribute 11	6	7	7

Participant i=6	a _{ij}	b _{ij}	c _{ij}
Attribute 1	2	3	4
Attribute 2	3	7	5
Attribute 3	3	7	5
Attribute 4	2	7	4
Attribute 5	3	3	5
Attribute 6	4	3	6
Attribute 7	1	7	3
Attribute 8	1	5	3
Attribute 9	2	3	4
Attribute 10	2	4	4
Attribute 11	3	4	5

Participant i=7	a _{ij}	b _{ij}	c _{ij}
Attribute 1	4	5	6
Attribute 2	2	7	4
Attribute 3	2	6	4
Attribute 4	3	7	5
Attribute 5	3	2	5
Attribute 6	3	2	5
Attribute 7	2	7	4
Attribute 8	3	5	5
Attribute 9	4	1	6
Attribute 10	2	1	4
Attribute 11	4	6	6

Participant i=8	a _{ij}	b _{ij}	c _{ij}
Attribute 1	6	7	7
Attribute 2	2	3	4
Attribute 3	2	3	4
Attribute 4	1	2	3
Attribute 5	1	2	3
Attribute 6	2	3	4
Attribute 7	2	3	4
Attribute 8	1	2	3
Attribute 9	1	2	3
Attribute 10	5	6	7
Attribute 11	4	5	6

Participant i=9	a _{ij}	b _{ij}	c _{ij}
Attribute 1	4	5	6
Attribute 2	1	1	2

Attribute 3	1	1	2
Attribute 4	4	5	6
Attribute 5	1	2	3
Attribute 6	2	3	4
Attribute 7	1	2	3
Attribute 8	1	1	2
Attribute 9	2	3	4
Attribute 10	2	3	4
Attribute 11	1	1	2

Participant i=10	a _{ij}	b _{ij}	c _{ij}
Attribute 1	3	4	5
Attribute 2	2	3	4
Attribute 3	2	3	4
Attribute 4	3	4	5
Attribute 5	3	4	5
Attribute 6	4	5	6
Attribute 7	2	3	4
Attribute 8	2	3	4
Attribute 9	3	4	5
Attribute 10	3	4	5
Attribute 11	4	5	6

Participant i=11	a _{ij}	b _{ij}	c _{ij}
Attribute 1	4	5	6
Attribute 2	4	5	6
Attribute 3	1	2	3
Attribute 4	1	2	3
Attribute 5	2	2	4
Attribute 6	6	7	7
Attribute 7	6	7	7
Attribute 8	4	5	6
Attribute 9	2	3	4
Attribute 10	3	4	5
Attribute 11	4	5	6

Table G35 *Converting the Participant Scores into a Single Fuzzy Membership Expression for Each Attribute – Repetition 2*

	$a_j = \min_i(a_{ij})$	$b_j = \text{Geometric mean}_i(b_{ij})$	$c_j = \max_i(c_{ij})$
Attribute 1	1	3.81	7
Attribute 2	1	3.52	6
Attribute 3	1	3.50	7
Attribute 4	1	4.26	7
Attribute 5	1	2.71	7
Attribute 6	1	3.06	7
Attribute 7	1	4.47	7
Attribute 8	1	3.68	7
Attribute 9	1	2.73	7
Attribute 10	1	3.30	7
Attribute 11	1	4.50	7

Table G36 *Defuzzification: The FDM Scores and the Averages of the Original Participant Scores for the Level of the Deployer Attributes – Repetition 2*

	Average(a1,b1,c1)	Arith. Mean
Attribute 1	3.94	4.18
Attribute 2	3.51	3.36
Attribute 3	3.83	2.91
Attribute 4	4.09	3.73
Attribute 5	3.57	3.64
Attribute 6	3.69	3.64
Attribute 7	4.16	3.09
Attribute 8	3.89	3.00
Attribute 9	3.58	3.82
Attribute 10	3.77	4.27
Attribute 11	4.17	4.18

Repetition 3 Analysis with the 3rd Set of Questions

Table G37 Participant scores at Benoplast: Levele of the Deployer Attributes $j=1,2,...11$ for Each Participant $i=1,2,...,11$ - Repetition 3

	Opr1	Opr2	Opr3	Opr4	Opr5	Opr6	Opr7	Opr8	Opr9	Opr10	Opr11
Attribute 1	6	4	5	3	4	4	4	5	7	1	4
Attribute 2	3	3	3	3	5	3	3	5	7	6	4
Attribute 3	3	3	1	2	5	5	4	5	5	5	5
Attribute 4	5	3	5	2	3	3	4	3	4	3	5
Attribute 5	3	5	4	4	3	4	3	3	2	2	4
Attribute 6	2	3	7	3	5	6	4	6	3	2	4
Attribute 7	3	4	5	2	3	4	2	2	2	6	6
Attribute 8	5	3	3	3	5	5	4	5	5	4	5
Attribute 9	4	5	3	3	3	3	2	3	2	2	3
Attribute 10	2	3	2	5	4	4	3	4	7	1	4
Attribute 11	4	3	5	3	3	3	3	3	1	3	2

Table G38 Fuzzification of the Level of the Deployer Attributes $j=1,2,...11$ for Each Participant $i=1,2,...,11$ - Repetition 3

Participant i=1	a _{ij}	b _{ij}	c _{ij}
Attribute 1	5	6	7
Attribute 2	2	3	4
Attribute 3	2	3	4
Attribute 4	4	5	6
Attribute 5	2	3	4
Attribute 6	1	2	3
Attribute 7	2	3	4
Attribute 8	4	5	6
Attribute 9	3	4	5
Attribute 10	1	2	3
Attribute 11	3	4	5

Participant i=2	a _{ij}	b _{ij}	c _{ij}
Attribute 1	3	4	5
Attribute 2	2	3	4
Attribute 3	2	3	4
Attribute 4	2	3	4
Attribute 5	4	5	6
Attribute 6	2	3	4
Attribute 7	3	4	5
Attribute 8	2	3	4

Attribute 9	4	5	6
Attribute 10	2	3	4
Attribute 11	2	3	4

Participant i=3	a _{ij}	b _{ij}	c _{ij}
Attribute 1	4	5	6
Attribute 2	2	3	4
Attribute 3	1	1	2
Attribute 4	4	5	6
Attribute 5	3	4	5
Attribute 6	6	7	7
Attribute 7	4	5	6
Attribute 8	2	3	4
Attribute 9	2	3	4
Attribute 10	1	2	3
Attribute 11	4	5	6

Participant i=4	a _{ij}	b _{ij}	c _{ij}
Attribute 1	2	3	4
Attribute 2	2	3	4
Attribute 3	1	2	3
Attribute 4	1	2	3
Attribute 5	3	4	5
Attribute 6	2	3	4
Attribute 7	1	2	3
Attribute 8	2	3	4
Attribute 9	2	3	4
Attribute 10	4	5	6
Attribute 11	2	3	4

Participant i=5	a _{ij}	b _{ij}	c _{ij}
Attribute 1	3	4	5
Attribute 2	4	5	6
Attribute 3	4	5	6
Attribute 4	2	3	4
Attribute 5	2	3	4
Attribute 6	4	5	6
Attribute 7	2	3	4
Attribute 8	4	5	6
Attribute 9	2	3	4
Attribute 10	3	4	5
Attribute 11	2	3	4

Participant i=6	a _{ij}	b _{ij}	c _{ij}
Attribute 1	3	4	5
Attribute 2	2	7	4
Attribute 3	3	7	5
Attribute 4	3	7	5
Attribute 5	2	3	4
Attribute 6	3	3	5
Attribute 7	1	7	3
Attribute 8	3	5	5
Attribute 9	1	3	3
Attribute 10	2	4	4
Attribute 11	2	4	4

Participant i=7	a _{ij}	b _{ij}	c _{ij}
Attribute 1	4	5	6
Attribute 2	4	7	6
Attribute 3	4	6	6
Attribute 4	2	7	4
Attribute 5	2	2	4
Attribute 6	5	2	7
Attribute 7	1	7	3
Attribute 8	4	5	6
Attribute 9	2	1	4
Attribute 10	3	1	5
Attribute 11	2	6	4

Participant i=8	a _{ij}	b _{ij}	c _{ij}
Attribute 1	6	7	7
Attribute 2	6	7	7
Attribute 3	4	5	6
Attribute 4	3	4	5
Attribute 5	1	2	3
Attribute 6	2	3	4
Attribute 7	1	2	3
Attribute 8	4	5	6
Attribute 9	1	2	3
Attribute 10	6	7	7
Attribute 11	1	1	2

Participant i=9	a _{ij}	b _{ij}	c _{ij}
Attribute 1	1	1	2
Attribute 2	5	6	7

Attribute 3	4	5	6
Attribute 4	2	3	4
Attribute 5	1	2	3
Attribute 6	1	2	3
Attribute 7	5	6	7
Attribute 8	3	4	5
Attribute 9	1	2	3
Attribute 10	1	1	2
Attribute 11	2	3	4

Participant i=10	a _{ij}	b _{ij}	c _{ij}
Attribute 1	3	4	5
Attribute 2	3	4	5
Attribute 3	4	5	6
Attribute 4	4	5	6
Attribute 5	3	4	5
Attribute 6	3	4	5
Attribute 7	5	6	7
Attribute 8	4	5	6
Attribute 9	2	3	4
Attribute 10	3	4	5
Attribute 11	1	2	3

Participant i=11	a _{ij}	b _{ij}	c _{ij}
Attribute 1	4	5	6
Attribute 2	4	5	6
Attribute 3	2	2	4
Attribute 4	3	2	3
Attribute 5	3	2	5
Attribute 6	6	7	7
Attribute 7	6	7	7
Attribute 8	4	5	6
Attribute 9	2	3	4
Attribute 10	3	4	5
Attribute 11	4	5	6

Table G39 *Converting The Participant Scores into q Single Fuzzy Membership**Expression for Each Attribute – Repetition 3*

	$a_j = \min_i(a_{ij})$	$b_j = \text{Geometric mean}_i(b_{ij})$	$c_j = \max_i(c_{ij})$
Attribute 1	1	3.69	7
Attribute 2	2	4.14	7
Attribute 3	1	3.94	7
Attribute 4	1	4.24	7
Attribute 5	1	2.67	7
Attribute 6	1	3.09	7
Attribute 7	1	4.77	7
Attribute 8	2	4.60	7
Attribute 9	1	2.52	7
Attribute 10	1	2.75	7
Attribute 11	1	3.92	7

Table G40 *Defuzzification: The FDM Scores and the Averages of the Original**Participant Scores for the Level of the Deployer Attributes – Repetition 3*

	Average(a1,b1,c1)	Arith. Mean
Attribute 1	3.90	4.27
Attribute 2	4.38	4.09
Attribute 3	3.98	3.91
Attribute 4	4.08	3.64
Attribute 5	3.56	3.36
Attribute 6	3.70	4.09
Attribute 7	4.26	3.55
Attribute 8	4.53	4.27
Attribute 9	3.51	3.00
Attribute 10	3.58	3.55
Attribute 11	3.97	3.00

APPENDIX H. CURRICULUM VITAE

Name-Surname: Şirin Aktaş

Education:

BA: Hacettepe University, Computer Science & Engineering, 2000

MSC: İstanbul Technical University, Computer Science & Engineering, 2004

PHD: Özyeğin University, Technology, Society, Design, Ongoing

Work Experience:

IT & Data Director, Danone Türkiye, Russia, CIS, Iran - 2024-Ongoing

CIO and Executive Committee Member, Edenred Turkey – 2021-2024

IT Director, Unilever Turkey, Central Asia, Iran – 2013-2021

Manager, Service Management and Reporting, Turkcell - 2008-2013

Senior Project Manager, Koç.net – 2005-2008

Network Specialist, Garanti Technology – 2000-2005

Awards and Scholarships:

N/A

Scientific Publications:

Aktas, S., Orhun, S.E. (2025), Exploring The Role Of Deployer In Trust Models For Human Robot Collaboration: A Case Study At Turkey FMCG Industry, New Era International Journal Of Interdisciplinary Social Researches, ISSN: 2757-5608.

<https://doi.org/10.5281/zenodo.14941526>

Scientific Presentations:

N/A