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AUTOMATION AND ROBOTICS SYSTEM (ARS) ADOPTION IN THE TRANSFORMATIONAL COMPANIES IN THE KINGDOM OF SAUDI ARABIA: A CONCEPTUAL FRAMEWORK

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ABSTRACT

The manufacturing sector indubitably holds great significance to the development of the global economy, whereby innovative methods have been brought forward to implement new technologies including robotics and automation in the sector. However, regardless of the robots' benefits to productivity and the effectiveness of management, the circumstances under which they are used as alternatives or assistance to labor, the influence on the formation of new firms, their facilitating of effective and efficient management, and their formation of the regional economies, the topic with all the related aspects still calls for extensive investigation. Researches on factors hinders the adoption of automation and robotics are still scarce. Thus, in the present work, the factors that influence intention to adopt automation and robotics system (ARS) among the Saudi transformational companies were examined, using a conceptual framework based on the Technology Acceptance Model (TAM) and Technology, Organization, Environment (TOE) Theory. Such factors were obtained from a review of literature, theory analysis and consultation of experts via interviews. The study conducted an analysis of the qualitative findings to verify the framework, with the help of thematic approach. Based on the results, the proposed conceptual framework comprehensiveness and importance were confirmed. This paper concluded the importance of such empirical studies on factors that could influence the adoption of ARS. Furthermore, the verification of the results also showed support for the results and the experts were of the consensus in their agreement of the proposed ARS adoption framework's validity and adoption. The experts affirmed that the framework is inclusive of the significant factors that lead to effective adoption and they indicated their agreement by their involvement and by the inclusion of all the factors in the framework.

Keywords: *Robotics, Automation, Adoption, Saudi Arabia, Transformational Companies.*

1. INTRODUCTION

In the present manufacturing industry, the focus is directed towards competiveness improvement through ICT technologies integration in order to shift to a new growth direction. This is best exemplified by the fourth manufacturing revolution, Smart Manufacturing, which is still considered a new paradigm. Smart Manufacturing refers to a set of current technologies that facilitate effective and on point engineering decision-making in real-time, using ICT technologies integrations with the current manufacturing technologies. Modern organizations have been directed towards the adoption of such technologies in order to keep abreast of and thrive in the continuous changes that IT has brought on. This explains why today's world is what science fiction envisioned it to be ten years ago. The reality is such that there is a notable increased smart innovations development, and the continuous attempts by scientists and engineers to develop novel innovative ideas, homes, factories and even cities. Notwithstanding the dynamic progress in the field, the significant concepts used remain visions of a future that call for the realization of considerable efforts [2].

What appears certain is the role of new robotics in boosting of economies around the world, albeit its potential advantages are still undocumented, making it a feat to determine its advantages and

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limitations, particularly in the first implementation phases in order to ensure overall economic development and mitigation of limitations [3].

Prior to delving into the robotics and automation topic, it is important to clarify what the term 'robot' means – a robot is described as a system consisting of sensors, control systems, power supply, manipulators and software working in combination to complete a given task [3]. Therefore, robotics refers to a specific innovation consisting of a sensor, actuator, microcomputer and transceiver. In relation to this, the term, 'smart' is frequently employed when describing an object that has additional features introducing multi-platform communications and improved computational abilities. Intelligent devices formed are relayed through a connection of networks of other smart devices, with the ability to review system updates and reach the course of action to adopt – such a connection of networks is known as smart network [2].

In the industries, the development and growth of robots started back in 1947, with further developments urged on by developments in technology. In the current times, industrial robots have become mainstream as alternatives to human workforce in different industries. In this background, the continuous robotic technology development has led to several challenges like the adverse influence of robotics on employment, cost reductions and production enhancements, the latter two of which have led to industrial nations to opt for robots over human work force, particularly in the production lines [4]. However, robotics systems may be used in industries in a way that ensures their adoption and mitigates their negative influence and results.

In addition to the above, global robotics market make use of computer-controlled robots for the completion of manual tasks and robots generally need innovative and creative methods towards technology usage in order so that the company using them are differentiated from its rivals for sustainable competitive advantage. Such scenario calls for the joint function of re-configuration of human resources and machines, which may involve new and innovative business models creation. The top barrier to this is the way the initial step begins, and the business model development requires knowledge in order for firms to progress to a future that holds promising outcomes [5].

In the present paper, the primary focus is laid on the adoption of robotics and automation in the transformational industry of a developing nation, Saudi Arabia. The study focuses on the robotics role in productivity improvement, and on the importance of the framework in directing the adoption and use of technology in an efficient and effective way. The study conducts a discussion of various issues that are robotics and automation-related in various scenarios, underlying the key role that they play in productivity improvement. In this regard, robotics and automation should be viewed as significant assets in transformative industry, its productivity, using a guiding framework.

Finally, the present work lays bare the limited studies conducted on the topic of robotics and automation, with regards to their role in productivity enhancement and the development of a framework for successful adoption. The paper highlights the needs to develop and propose a framework for the robotic and automation adoption success as the lack of framework could result in issues and challenges when it comes to the implementation of the system. Based on the reviewed prior studies, robotics and automation implementation success is tightly linked with the proper framework for guidance.

2. THE NEED FOR ADOPTING ROBOTICS AND AUTOMATION

The organizations in today's era are faced with the challenge of handling increased labor costs and lack of workforce, urging them to take their recourse in the form of robots – entities that demand no raises and work around the clock, performing tasks that humans are not capable of doing, in trying conditions that need accuracy [3, 6]. Nevertheless, a firm that is up to facing challenging conditions should have technology and human resources on its side, particularly as robots' influence employment and employee motivation [7, 8]. On the basis of the specialists obtained evidence, majority of the tasks (60%) may be automated through robots, with the prediction of increasing to further increasing (80%) by the year 2050. Stated clearly, by 2050, 80% of the industrial tasks in the petrochemical, oil, coal, plastic, and metal products, shoes and textiles industries will be run by robots, and in the food and beverage industry, this figure is expected to increase to 60% [4].

Studies dedicated to technology, primarily laid focus on technology adoption benefits, while steering clear of the adoption determinants and the needed technological tools as evidenced by Xu, Thong [9]. Several of the merits mentioned in technology promotion are high labor intensity, local skills and technology dependence, development of

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entrepreneurship, ingenuity and enhanced industrial connections, making it more accessing to the developing countries [10, 11]. Despite the high potential for adopting robots, such adoption is still lagging and so to enhance it, the determinants of adoption decisions need an in-depth study [12]. In the present study, the author calls for the need to identify the factors that affect behavioral intention towards adopting and using robotics and automation in the transformational companies in Saudi Arabia.

Academic research dedicated to worldwide robotics indicated that robotics may have contributed to the 1/10th increase in productivity for the years 1993-2007 [13]. Also, based on the Economic Report of the President 2016, the world's demand of robotics almost doubled from 2010 to 2014, along with several robotic-oriented patents (CEA 2016), which is indicative of the role that robots play in increasing productivity.

Moving on to the framework of ARS in literature, Seamans and Raj [14] highlighted the limited firm-level data concerning the use of robotics and automation, and such data is required to answer the relevant questions and to help the establishment of policies concerning the topic in light of economic and societal processes [15]. It is pertinent for studies to investigate the relationship between robotics and automation adoption and the productivity of industries, and the way robotics can be adopted in the Saudi transformational companies for enhancement.

In a related study, Cowan [16] related the current world is rife with ongoing technological changes, and this has made a small village of the world owing to globalization, communication revolution as well as IT [17]. Before the advent of automation, traditional management practices were not conducive to facilitating the organization's sustainable survival [18]. In the context of the Arab countries, particularly in Saudi Arabia, businesses make use of Western practices but fail to consider the characteristics of the country. In this regard, it is notable that the Saudi transformational firms' administrative and managerial practices lack adoption and use frameworks when it comes to robotics and innovative automation to enhance management effectiveness and efficiency and productivity.

Therefore, in this paper, a robotics and automation adoption framework is proposed for Saudi transformational firms' productivity enhancement.

3. RELATED WORKS ON ROBOTICS AND AUTOMATION ADOPTION

In literature dedicated to the adoption of robotics and automation, the developed and proposed frameworks used in examining the developing nations' contexts were mostly adopted from their Western counterparts [19, 20]. The West presents important lessons through their experiences but their developed frameworks are not sufficient to be utilized to developing nations, owing to the distinct factors and characteristics in each. More specifically, IS studies adoption frameworks encapsulates factors that promote the technological adoption implementation.

IT and IS proposed models in prior literature have been extensively utilized to examine the acceptance and adoption of technology, with majority of them carried out focusing on a distinct environment [21]. This section is dedicated to reviewing studies on the acceptance of robotics and automation and the relevant and related variables.

To begin with, De Graaf and Allouch [22] contended that social robotics introduction success requires the understanding of the underpinning reasons upon which the users may accept such tools into their abode. Literature reviewed by the authors examined the variables influencing social robots' acceptance involving utilitarian variables, hedonic variables, user characteristics, social normative beliefs and control beliefs. The study also had 60 participants interacting with a social robot, from which their experience was obtained and documented. On the basis of the study findings, the important variables to accepting social robots included usefulness, adaptability, sociability, companionship, adaptability, and perceived behavioral control. The authors expected the study to extend literature on human-robot interaction as it determined the variables promoting such robots' acceptance. The study may also be benchmarked by future studies in terms of the development of an integral model that encapsulates the determinants of social robot acceptance.

Moreover, along the same line of studies, different political reviews were cited concerning social robotics for the autistic children's skill augmentation as well as for those that have brain disabilities. Studies to this effect included Hashim and Yussof [23], who conducted an analysis of article publications in peer-reviewed journals and proceedings from conferences, after which, they noted emerging themes from the review namely influence, acceptance and adoption. Based on their obtained findings, social skills of brain-impaired

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children may be affected although they are absent from the robot development and design processes, as a result of which human skills were integrated into the general robot capabilities. This indicates that social robots' necessity is consistent with the changes in society, the heightening demographics and the healthcare demands. Also, the brain-impaired children conceptualization is that they are handicapped through mental and physical disabilities, requiring 24/7 care and robotic assistance. Based on the national status, the social robotics influence, acceptance and adoption form political and successful societal science that highlights the need to re-examine and re-define such conceptualization in order to reap maximum advantages from return on investment on manufacturing robots.

Aside from a few notable studies, works on robotics and automation adoption are still lacking, marking he need to further and extensively study technology so that a suitable framework can be developed to assist in the usage of robots and to enhance the industrial firms' productivity.

In addition, studies dedicated to ICT also underlined various factors that have a significant influence on robotics and automation adoption and acceptance and these are ease of use, infrastructure, perceived usefulness, subjective norm, support from top management, training, readiness, financial support, anxiety, security reliability as well as efficacy.

4. DEVELOPMENT OF THE TAXONOMIC FRAMEWORK

This study develops and proposes a robotics and automation conceptual framework based on the Technology Acceptance Model (TAM) by Venkatesh and Bala [24], and the Technology, Organization and Environment (TOE) model by Depietro, Wiarda [25]. Additionally, the study presents the detailed method of the conceptual framework development in an attempt to identify the factors affecting industrial automation and robotics acceptance and adoption, along with its influence on the productivity of transformational firms.

Figure 1 depicts the phases of followed methodology by the study, where three major phases stand out. First, the factors that have the potential to influence robotics and automation adoption are extracted; second, the construction of the development framework is conducted along with the classification of factors and third, the required steps to verify the framework are carried out and presented.

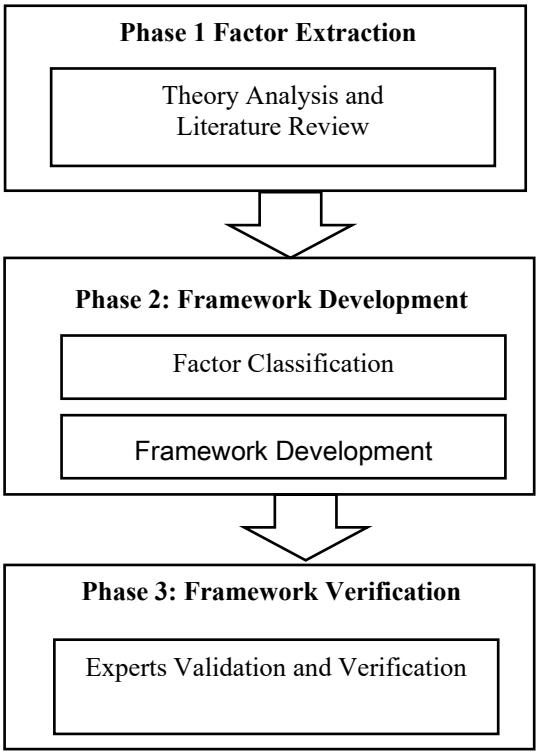

Figure 1 Methodology Of The Taxonomic Framework For Robotics And Automation Adoption Adopted From Mukred, Yusof [1]

Various methods have been used by prior studies to identify the factors of technology adoption and implementation, majority of which are tabulated in Table 1. With every method, the strengths and weaknesses are also listed as well as the techniques clarification as enumerated in Khandewal and Miller [26] and Khandelwal and Ferguson [27] studies.

Table 1 Literature Approaches

Research method	Authors
Action-research	[28]
Case studies	[29]
Structured interviewing	[30]
Scenario analysis	[31]
Multivariate analysis	[32]
Literature review	[33]
Group interviewing	[26]
Focus groups	[34]
Delphi technique	[35, 36]
Combination of methods	[27, 37]

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The paper conducts review of literature method to identify and highlight the factors affecting robotics and automation adoption.

4.1 Factor Extraction

The first phase, as introduced in the prior sub-section is the extraction of factors, and this process requires the use of theories and review of literature that examined the adoption of technology and robotics. Such review made use of various key terms, such as, 'robotics and automation factors', 'factors influencing robotics and automation adoption', 'robotics and automaton adoption', 'framework for robotics and automation', and 'robotics and automation and productivity'.

Following the extraction of factors phase, the highest number of factors cited in literature were found to be perceived ease of use, perceived usefulness, IT infrastructure, subjective norm, top management support, financial support, training, readiness, efficacy, reliability, security and lastly, anxiety.

4.2 Framework Development

Moving on to the next phase, which is the development of the framework, this requires the understanding of the related theories/models that underpin the study in order to produce a logical platform to develop the relationship among the constructs. The developed and proposed robotics and automation adoption framework includes five variables namely organizational variables, technological variables, trust variables, behavioral intention towards adopting robotics and automation and organizational productivity (refer to Figure 4). The developed framework was employed for the gathering and analysis of the variables and their integration within a specific adoption factors system. The formulated relationships were examined among the constructs for their significance as suggested by Sekaran and Bougie [38].

To reiterate the Technology Acceptance Model 3 (TAM3) was adopted in this study to investigate the intention towards the adoption of automation and robotics on the basis of technological, organizational and trust variables. Through an automation and robotics taxonomic framework, this study proposes a study framework based on TOE theory that supports Saudi transformational firms' productivity. The framework is useful in identifying the effects of automation and robotics adoption on the productivity of firms. This study contributes to the field of robotics adoption research, with the development of taxonomy framework encapsulating the relevant information. Also, this study is useful for research circles that long to determine and classify the relevant factors and relationships among categories of factors.

In past empirical works, the authors revealed several sub-important factors that affect the intention to adopt automation and robotics that are connected to the dimension of trust. A study framework is proposed in this study extending and integration TAM3 with the TOE framework, considering intention towards adoption as a determinant of robotics and automation adoption success/failure.

The integration of both models, necessitated the consideration of TOEs technology, organization and trust dimensions as determinants of robotics and automation technology adoption success. Specifically, the study included the trust dimension as a direct determinant of behavioral intention towards technology adoption, following past studies in literature [39, 40]. In particular, Alharbi [39] established trust as a determinant of users' technology adoption. Along a similar line of study, trust was considered as a main element in the field of e-commerce and e-government [41], and a must for robotics and automation technology [2, 14, 42, 43].

Figure 2 presents the study framework with the adopted theories.

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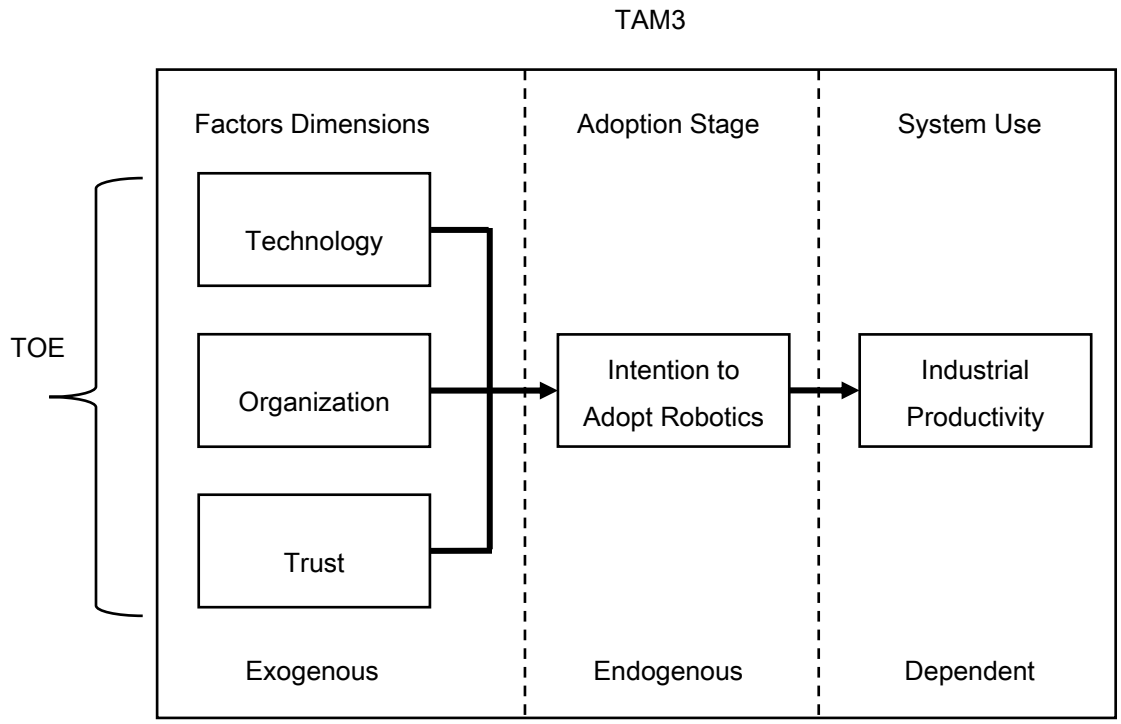

Figure 2 Framework Construction

Information on individual intention technology use determinants can help management in managing and putting the right strategies in place, enhancing use of technology and in accepting innovation [44]. Such information is required for the diffusion, adoption and usage of various innovations, with the success related to the productivity of the firm [15].

The reviewed literature gathered technological dimensions, organizational dimensions and trust dimensions relevant in determining adoption of technology with the following factors under each dimension; technological dimension includes perceived ease of use, perceived usefulness, infrastructure and subjective norms, organizational dimension includes top management support, financial support, training and readiness, and lastly, trust dimension includes efficacy, security, reliability and anxiety.

Figure 5 displays the first framework level involving technology, organizational and trust dimensions. The factors are representatives of the exogenous variables that have a direct effect on the robotics and automation technology adoption, which is the endogenous variable. In the second framework level (adoption stage), intention towards robotics and automation technology is considered as the endogenous variable that has a direct effect on the productivity of firms, and on the third framework level (system use), organizational productivity is the dependent variable, which Davis [45] also referred to as the outcome construct. The framework details and the classification of factors of the framework development is furnished in the third level, with both TAM3 and TOE adopted to develop it-the latter is specifically adopted for the purpose of classification. The study framework is depicted in Figure 2.

Majority of studies dedicated to technology adoption theories and models were conducted primarily in the developed nations of the West [19], in relation to this which, the models applications may vary on the basis of the cultural and economic variables that may matter in one context but not another [46]. Also, robotics and automation adoption studies have revealed inconstant findings in both nation groups (developing and developed nations). Thus, it becomes necessary to examine and validate the theories in the developing countries, which may have differentiated and unique outcomes.

Hence, the present study investigates the factors affecting intention towards robotics and automation adoption in Saudi transformational firms. The paper develops a research framework which integrates main IS adoption of robotics and automation factors highlighted in literature. The development of the

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framework consisted of two phases namely the theoretical phase and the design of the model phase.

4.2.1 Theoretical Phase

The first development phase, which is the theoretical phase, involved the review of studies on robotics and automation adoption to pinpoint the influence of significant factors on the adoption of technology. The adoption factors were further categorized into contexts (technological and organizational), following prior literature [47, 48], with trust as an additional context. The factors were considered to facilitate or prevent the adoption of robotics and automation and they are discussed in the next paragraphs.

A) Technological Context

Under this context, technological attributes are covered (Straub, 2009), which affect usage behavior [1, 49], including perceived ease of use, perceived usefulness, IT infrastructure and subjective norms. The above factors were obtained from the reviewed literature and from the feedback of experts.

The study proposes the following proposition with regards to the factors;

P1: Technological factors have a positive influence on the adoption of robotics and automation in Saudi transformational firms.

i. Perceived Ease of Use

Perceived ease of use is posited by Davis [45]' TAM as the belief of the individual that using a specific system will be effort-free. In addition, ease of use in TAM is, in effect, represented by effort expectancy in UTAUT. This study conceptualized perceived ease of use as the perception of the managers and employees that robotics and automation use will be free of effort. According to Venkatesh, Morris [50], indicated that perceived ease of use affects intentions towards technology adoption and use.

Additionally, in a related study, [51], examined intention towards using IT among academic circles and revealed both perceived usefulness and perceived ease of use to directly impact the variable. The findings also supported the mediating role of perceived ease of use on intention towards IT use-perceived usefulness relationship.

In other studies, like Venkatesh and Bala [24], both perceived usefulness and ease of use were found to be major determinants of adoption. Nevertheless, in other studies, no significant relationship was found between perceived ease of use and intention towards system adoption and usage (e.g., Bröhl, Nelles [48]; De Graaf, Allouch [52]; Teo, Luan [53]; Xu, Thong [9]), and as such, this study proposition is as follows;

P1a: Perceived ease of use has a positive influence on robotics and automation adoption among Saudi transformational firms.

ii. Perceived Usefulness

Perceived usefulness is described as the user's belief that using the system will be useful in their work. UTAUT posits that perceived expectancy is linked to the effectiveness on the job, work productivity (time and cost incurred) and relative motivation for specific technology usage [54].

In human robotics field, the positive influence of perceived usefulness on intentions towards robotics use was supported by Bröhl, Nelles [48]. In relation to this, TAM was examined by De Graaf and Allouch [22] in the way it is used to determine social robot acceptance. They revealed a significant effect of perceived usefulness on the intention of users. Meanwhile, Venkatesh, Morris [50] indicated that perceived usefulness (performance expectancy) and perceived ease of use (effort expectancy) determine the behavioral intention of individuals towards using IS.

In this study, the author conceptualized perceived usefulness as the belief among managers and employees that robotics and automation is useful to their work. Accordingly, usefulness is investigated in terms of the ability of the system to maximize work performance, effectiveness and productivity. Prior empirical findings reported by Bröhl, Nelles [48], De Graaf, Allouch [52], Teo, Luan [53] and Xu, Thong [9] revealed perceived usefulness to be a main determinant of intention towards using and adopting systems and thus, this study proposes that;

P1b: Perceived usefulness has a positive influence on the robotics and automation adoption among Saudi transformational firms.

iii. IT Infrastructure

Duncan [55] revealed the presence of several components in IT infrastructure and they are shared and tangible IT resources, and such resources according to Broadbent and Weill [56], facilitate the business applications functions platform. They consist of computer hardware and software, including operating systems, network and telecommunication technologies, key data, core data-processing applications and shared IT services. Other prior studies [1, 55] stated that IT infrastructure represents the alignment between IT

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plans, business objectives, IT architecture and the IT employees' skills. Moreover, Broadbent and Weill [56] explained that IT infrastructure capabilities facilitate different IT applications, support business objectives (present and future) and ultimately leads to the firm's competitive advantage.

Based on the proposed definitions, IT infrastructure can be referred to as consisting of technical IT infrastructure and human IT infrastructure, the former of which comprises of application, data and technology, whereas the latter comprises of IT personnel knowledge and capabilities for managing the resources of the firm. A successful IT infrastructure allows tasks performance of employees using technology and technological skills.

IT infrastructure-dedicated studies advocate technology usage [57], and related services serve a key role in successful e-learning as empirically found by Alsabawy, Cater-Steel [58]. Their findings indicated that IT infrastructure services are valid and reliable as an empirical construct used for gauging successful e-learning system and in identifying the intention towards system adoption and usage. This indicates that IT infrastructure is a must in adopting robotics [59], which brings us to propose that;

P1c: IT infrastructure has a positive influence on robotics and automation adoption among Saudi transformational firms.

iv. Subjective Norms

This factor refers to the perceptions of the individual concerning the view of others on his/her performance or lack thereof of a specific behavior. Subjective norms have been shown to have a significant relationship with IT use among individuals in Won, Lee [60] study.

Subjective norms, in the present study, are referred to as the belief of the employee that his colleagues and those who are important to him at work that have prior encounters with him think about the technology and its potential use. This holds true for industrial firms as they require robotics and automation use, which is the reason behind the likelihood of subjective norms influence at work. In addition, subjective norms have a key role in the early phase of technology adoption owing to the limited experience of the user. Early adopters have not yet developed attitudes towards the adoption and use of technology [60].

Majority of studies of this caliber indicated the significant effects of security on the intention towards technology adoption [48], and thus, subjective norms are posited to significantly influence the adoption of robotics and automation. Hence, this study proposes the following;

P1d: Subjective norms have a positive influence on the adoption of robotics and automation in Saudi transformational firms.

B) Organizational Context

Organizational context refers to the environment of the workplace within which the adoption and acceptance of technology occurs [49]. It is the environment surrounding the individual in his adoption process and it is, more often than not, a work-based firm, despite the fact that individuals may function as change promoters [61]. For the maximization of IS acceptance among users, organizations need to an acceptance-supporting environment [1, 49]. The factors under the organizational context that were examined in the present study are top management, financial support, training and readiness, which were all highlighted in the literature review and obtained from the feedback of experts.

Furthermore, studies on the emerging IS adoption and use in the IS field have increased since the introduction of the field. Majority of studies in this line focused on the phenomenon using various settings at different levels (individual and organizational), taking the help from different theoretical models [62].

Organizations need to adopt robotics and automation and the organization's role can guarantee that their implementation is quick and efficient. In this study, four organizational factors were examined and they are management support, financial support, training and readiness – all these are mandatory for the successful adoption of robotics and automation. Accordingly, this study proposes that;

P2: Organizational factors have a positive influence on the adoption of robotics and automation in Saudi transformational firms.

i. Top Management Support

The understanding of top management of the crucial role of IS in system activities is known as top management support Mukred, Yusof [1]. Venkatesh, Morris [50] described it as the level to which an individual believes that the infrastructure of the organization supports the use of the system.

Studies along this line include Elysee [63], who investigated the relationship between top management support and information system and revealed IS as a strategy used to develop the organization and to obtain its competitive

advantage. Based on the study's findings issues pertaining to development, planning and technology use are related to the failure of top management to support and manage the use of technology.

Studies in literature [63, 64], evidenced the influence of top management support on intention towards the adoption of technology. Prior studies in robotics and automation revealed a positive relationship between top management and adoption of technology [65], and as such, this study proposes the following statement for testing;

P2a: Top management support has a positive influence on the adoption of robotics and automation in Saudi transformational firms.

ii. Financial Support

Financial support is another significant factor covered in IS adoption and it was identified by Chizmar and Williams [66] as among the factors that affect such adoption. Majority of the study's respondents indicated that lack of financial supports may be one of the factors that relate to the failure of technology adoption.

Additionally, lack of enough financial support is one of the factors that hinder the facilitation of sufficient time for system training and adoption as related by Al-Senaidi, Lin [67]. Similarly, DesRoches, Charles [68] concluded that increased adoption of technology in terms of positive/negative financial incentives turned out based on expectations, and thus, financial support has to be taken into account as an organizational factor.

Also, incurred financial costs had a negative effect on the behavioral intention towards system use and adoption [69], and thus, financial support is a significant antecedent of behavioral intentions towards use, implementation and adoption of technology [70]. Following the proposition tested by Lorenzi, Kouroubali [71] and Mukred, Yusof [1], that financial support is a significant factor related to technology adoption intention, this study proposes the following for testing;

P2b: Financial support has a positive influence on the adoption of robotics and automation in Saudi transformational firms.

iii. Training

Past studies on training shows that majority of the examined firms focus on training employees in terms of new technology use, specifically the use of microcomputers [72]. In other studies, such as Gross, Holsinger [73] and [74]training was reported to have a significant effect on the adoption and use of the system. On the basis of the above discussion, this study proposes that;

P2c: Training has a positive influence on the adoption of robotics and automation in Saudi transformational firms.

iv. Readiness

Readiness has been described in different ways in literature as evident from the reviewed studies, but researchers generally agree that the tools utilized for e-readiness assessment can be divided into tools assessing fundamental infrastructure readiness/the country's readiness to embark on business activities/readiness of the country for economic growth, and tools assessing the country's ability to make use of ICTs [75].

Generally defined, readiness is the inclination of the country to participate in a connected world via evaluating the adoption aspects of ICT. In particular, adopting robotics and automation readiness is the capability of the organizations to develop and maintain institutions, legal frameworks and ICT infrastructure.

In the case of a developing country, Mahbub [76] described readiness as the automation and robotics adoption in the construction industry via leveraging the perceptions of the industry, best practices and barriers to implementation. The findings were based on data collected from questionnaire survey and semi-structured interviews conducted among construction firms in Malaysia (particularly contractors, specialist sub-contractors, developers and consultants). The findings showed that Malaysian construction industry were ready to implement technology in certain pre-fabrication and assembly areas along within the phases of design, planning and costing.

Some other empirical works found that in developing countries readiness positively and significantly influenced the adoption of technology [77]. Thus, readiness can be logically stated as having a significant effect on intention towards the adoption of robotics and automation and thus, this study proposes that;

P2d: Readiness has a positive influence on the adoption of robotics and automation in Saudi transformational firms.

C) Trust Context

Presently, robotics technologies use has highlighted issues pertaining to ethics, law and society, and even some to IS of robotic systems. Moreover, social issues related to privacy, informed consent, cyber security, hacking and data ownership have had a major role in robotics field, with the open

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source feature of robotics enabling ease for terrorist organizations to take advantage of it [78]. This underlines the significance of trust in the relationship between the human and the machine described by Coeckelbergh, Pop [79].

When it comes to new technologies, trust has been investigated in several case studies and different nations; for instance, Sambasivan, Patrick Wemyss [80], examined intention towards e-procurement systems use in Malaysia, and Weiss, Bernhaupt [81] focused on the interaction between human and robot acceptance in terms of trust. In the present study, the considered trust variables are efficacy, reliability, security and anxiety.

In the relationship between human and machine, a critical variable required is trust, with trust in new technology being a topic examined in various contexts and countries throughout literature. This may be exemplified by the Malaysian study by Sambasivan, Patrick Wemyss [80] that focused on intentions to e-procurement systems use, and in the study of Weiss, Bernhaupt [81] that focused on the human-robot interactions acceptance in terms of trust.

More importantly, in the field of robotics, new robotics brought with them issues relating to ethics, legal and social aspects, and the premise that robotic systems form a portion of IS. Stated clearly, social issues in the form of privacy, informed consent, cyber security, data ownership and hacking arose. In this regard, robotics technology is characterized by open source features that make it susceptible to hackers and terrorists [78].

For the maintenance of competitiveness in the globalized market, it becomes a challenge for manufacturing firms to make constant changes to their production systems to meet the demands in the market [82], and in this background, trust plays a key role [83]. Based on the above discussion, this study proposes that;

P3: Trust factors have a positive influence on the adoption of robotics and automation in Saudi transformational firms.

i. Efficacy

The first exogenous latent variable in the dimension of trust proposed in the conceptual framework is efficacy. In this regard, self-efficacy refers to the employee's ability to use the computer or any technology to train, manage training materials and interact with other trainees and trainers. A highly self-efficacious individual is one that is able to tackle computer systems/software issues with the least support or no support at all. On the contrary, a lowly self-efficacious individual may experience frustration when using technology that he/she is not familiar with, specifically when there with no support or only with minimal support [84].

Efficacy in the robotics and automation field is gauged using the ability of the individual to using and dealing with robotics and based on the above, this study's proposition is as follows;

P3a: Efficacy has a positive influence on the adoption of robotics and automation in the Saudi transformational firms.

ii. Reliability

A robot is described as a system that has innate issues although they are meant to be reliable. Trust is a feature of robot performance coupled with the fluency of motion [40]. Reliability of robots influences trust on them [85], and hence, it is crucial for robots to have reliability. The related question that arises is relates to the characteristics of a framework that would enable reliability of robots to tackle uncertainty and ever-changing tasks of production, while layman is intuitively using and re-programming them.

In the present study, the aim is to identify the variables that link to the owners'/managers' perceptions of internal barriers and inherent external barrier [86-88] of robotics and automation adoption. Thus, reliability is one of the main factors that influence user's trust towards robotics and as such, this study proposes that;

P3b: Reliability has a positive influence on the adoption of robotics and automation in the Saudi transformational firms.

iii. Security

New technology security is frequently given the least importance when compared to top design objective, and this may result in issues in security. Additionally, environmental security in robotics is the furnishing of core security services and this according to Higgins, Tomlinson [89], is considered as one of the top robotics and automation features.

Literature supports a significant relationship between security and intention towards technologies adoption [90-92]. Thus, security issues in robotics are evidently similar to those of other related technologies where some solutions may be applied. Hence, security is a top factor that influences intentions towards robotics and automation adoption in firms and therefore, the study proposes that;

P3c: Security has a positive influence on the adoption of robotics and automation in Saudi transformational firms.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

iv. Anxiety

Anxiety arises when the individual falls short of experiencing satisfaction, in the face of lack of clarity of such deprivation [93]. Anxious individuals hold high concern over the potential barriers that could face them – in the form of imagined or actual concern, and this may negatively affect their performance.

This highlights the influence of anxiety on the behavioral intentions towards systems use and adoption [94], making it a significant factor in the intention towards adoption of robotics [48]. Therefore, this study's proposition is as follows;

P3d: Anxiety has a positive influence on the adoption of robotics and automation in Saudi transformational firms.

D) Intention to Use/Adopt

Intention to use or to adopt refers to the user's intention towards using or adopting new technology [95]. A user will have a tendency to use a particular system when he intends to do so, making intention towards technology use a determinant of the possible adoption.

This study describes intention to adopt as the inclination of the individual towards performing a certain act [96]. In their identification of additional technology acceptance determinant factors, Hanheide, Lohse [97], noted that attitude is not the only factor influencing intention to use but there are direct and indirect significant effects stemming from perceived usefulness to intention towards using system, even stronger than the effect of attitude.

According to Casas [98], in his examination of intentions towards adopting Internet-based health applications among physicians using TAM2, perceived usefulness was found to have a significant influence on intentions towards use. The findings also indicated that the use intentions of physicians were clarified by usefulness and output quality, and that a significant relationship exists between perceived usefulness and use intention.

In Venkatesh, Thong [99] and Zhou, Yuen [94], the authors' studies on successful integration or new technologies adoption in organizations are highly dependent on the acceptance of users. In the light of robotics and automation adoption within developing nations, empirical works [3, 76, 100, 101], revealed that intentions to adopt, user acceptance, satisfaction, attitudes, expected beliefs, reluctance, perceptions and new technology adoption resistance all had a significant effect on the adoption of technology within industrial firms. This highlights the significance of examining and identifying the determinants of attitudes towards IS acceptance in order to overcome the barriers against it [11, 102, 103].

Furthermore, the intention to adopt technology determinants in different contexts and environments, based on technology, organizations and trust need in-depth examination to enhance productivity [104]. Rantanen, Lehto [101] study on healthcare examined the care robots acceptance and adoption, with personal behavioral intentions connected to the introduction of robot applications in homecare. Such intentions were influenced by the appreciation of the users of the usefulness of robots, their colleagues and supervisors' expectations and their perceptions of the learning needed for care robots' usage. The authors revealed that new technology adoption and investment aids that brought about investments were needed in areas characterized by low-productivity, wherein which the investment in technology could enhance productivity, competitive edge and profitability in the long-run.

Based on past studies, automation technology and robotics application is an increasing trend in the livestock sector [105], playing a major role in the productivity of the sector [14, 104, 106]. Hence, the proposition brought by this study is as follows;

P4: Robotic and automation adoption has a significant relationship with the productivity of the Saudi transformational firms.

4.2.2 Model Design Phase

The second phase of developing a study framework is the model design phase and it is divided into three major categories namely technological factors, organizational factors and trust factors. based on the reviewed literature in the second section, IS theory and model development entails the improvement and extension of the extant theories and models in literature. Accordingly, this study adopts TAM3 and TOE to shed light on the relationships to generate a new theoretical and practical knowledge.

Organizational employees are generally not inclined to using newly introduced technologies in their firms Schaper and Pervan [95] and this has enhanced the IS researchers focus on specific factors contributing to usage prevention or delay. The study model proposed by this study was employed to investigate the factors that affect the use of IS, specifically in the form of robotics and automation.

To reiterate, organizations have to acknowledge that lack of new system acceptance among the

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workers have been largely attributed to the systems' inability to furnish the expected outcomes in daily work, and this has a negative effect on the workers' attitudes towards adopting the system. Stated clearly, technology usefulness and ease of use have to be established and confirmed.

In addition, IT infrastructure also plays a role in the adoption and use of the system and the same holds true for subjective norms, which have been evidenced to influence new system use and adoption. Thus, this study considered perceived ease of use, perceived usefulness IT infrastructure and subjective norms under the technological context as factors that affect intentions towards robotics and automation technology adoption in Saudi transformational firms. To clarify, Figure 3 depicts the relationships among the technological factors and behavioral intention towards use/adoption.

Moving on to the technological factors, as the second category of factors in the proposed framework design, these factors consist of top management support, financial support, training and readiness. Organizational factors dedicated studies supported their significance and thus, researchers have to take them into consideration when examining intention towards using/adopting the system. Figure 4 displays the relationship of organizational context factors with the intention towards adopting robotics and automation in Saudi transformational firms.

The proposed framework's third category comprises of trust factors and the reviewed literature shows that trust is an important issue in the individual's technology adoption and acceptance phenomenon [107].

Therefore, the present study included trust factors in the examination, including efficacy, reliability, security and anxiety – these factors can influence the intentions of employees towards adopting robotics and automation in Saudi transformational firms. Figure 5 presents the relationships among trust factors and behavioral intention towards robotics and automation adoption.

The study also aims to investigate the factors that affect robotics and automation adoption through behavioral intention towards use. Prior relevant studies played a part in establishing relationships among the technological, organizational and trust factors and intention towards adoption/use (refer to Figure 6).

On the basis of the underpinning theory TAM, perceived ease of use and perceived usefulness affect behavioral intentions towards the use of IS [24]. The reviewed literature dedicated to the phenomenon of technology adoption and the model justification resulted in the development of a study framework for the adoption of robotics and automation displayed in Figure 6.

According to Heikkilä, Myyrä [104], Raj and Seamans [15], Seamans and Raj [14] and [106], robotics and automation adoption is a key player in the productivity and performance of organizations and thus, this study aimed to examine the level of adoption of robotics and automation and its enhancement of the Saudi transformational firms' productivity. The relationship between robotics and automation adoption and productivity is depicted in Figure 7.

This study's proposed framework along with the formulated propositions is presented in Figure 8.

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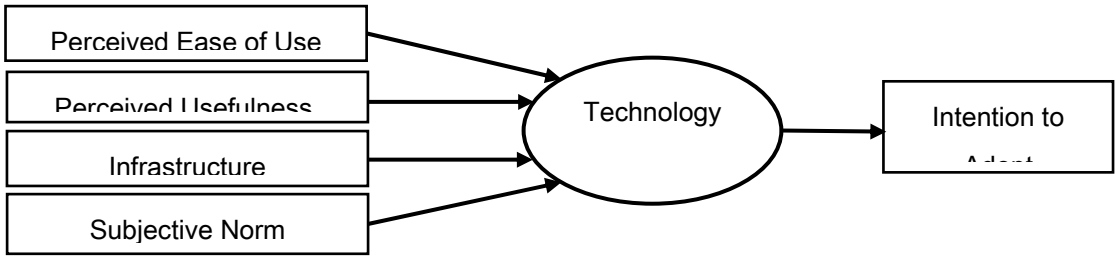

Figure 3 Technological Factors That Influence Behavioral Intentions To Adopt Robotics And Automation

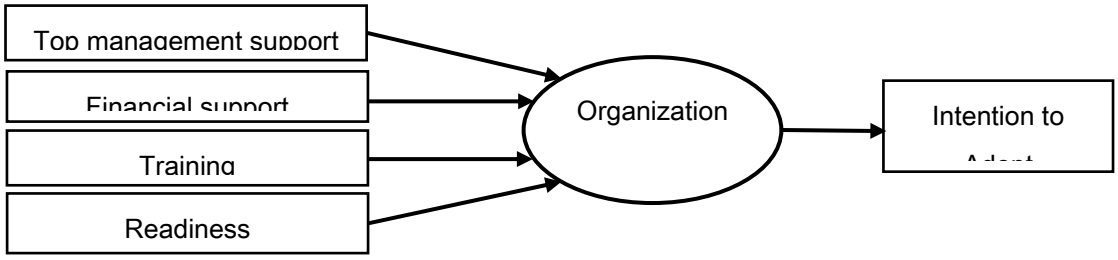

Figure 4 Organizational Factors That Influence Behavioral Intention To Adopt Robotics And Automation

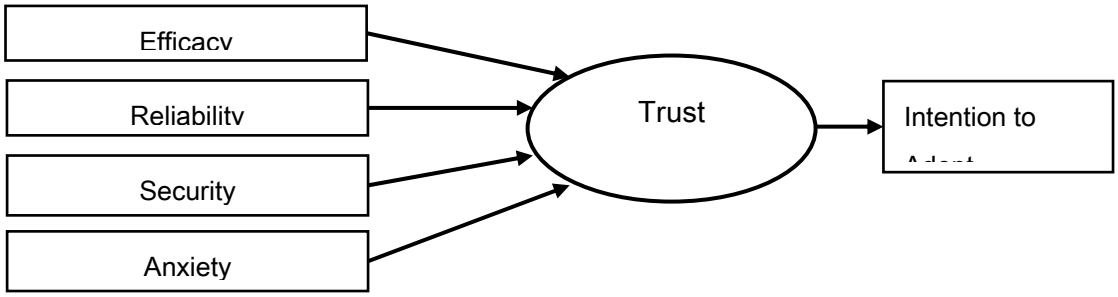

Figure 5 Trust Factors That Influence Behavioral Intention To Adopt Robotics And Automation

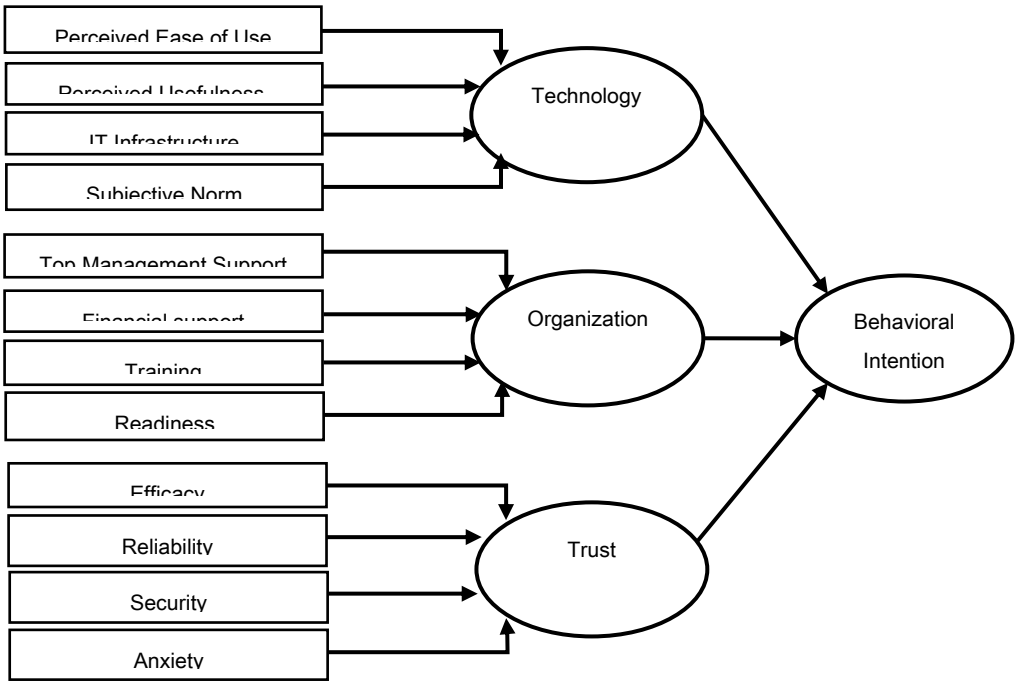

Figure 6 The Conceptual Model For Factors Influencing The Adoption Of Robotics And Automation

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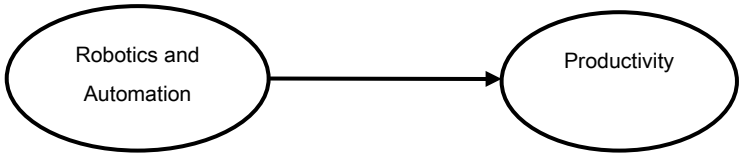

Figure 7 The Conceptual Model For Robotics And Automation Adoption Withproductivity

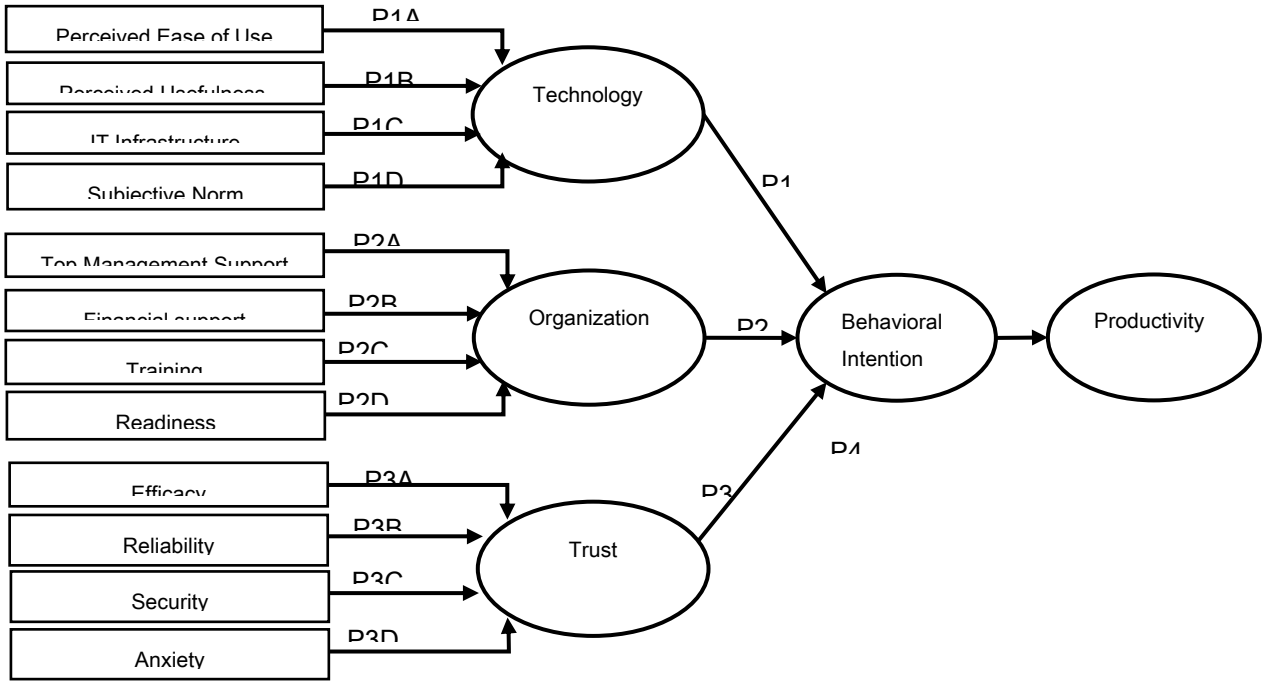

Figure 8 Conceptual Framework

Throughout studies in literature, TAM is the most extensively used theory to examine and tackle individual technology acceptance [108]. TAM has been adopted by majority of studies to examine different technologies in different situations and countries, focusing primarily in the context of the organization [109]. TAM has also been compared to its counterpart theories like TRA and TPB to establish its predictive ability and validity.

TAM studies such as, Li, Hess [110], indicated the capability of the model to obtain at least 40% variance in intentions to use and 30% variance in actual use. The model was also found to be efficient in the context of the Middle Eastern nations, where it explained 40% of the variance of use. TAM has been utilized in various fields including tourism, e-shopping, technology, psychology and marketing [111].

TAM's posited relationships were validated by Park and Kwon [112] who examined the perceptions of users towards Teaching Assistant (TA) robots and the possible motivators that affect intention towards robotics use in daily tasks. The authors employed SEM and CFA for analysis and revealed perceived usefulness to be the top determinant of intention towards using TA. They also found significant relationships from perceived enjoyment and service quality to intention towards use.

However, according to Lewellen [113], TAM and UTAUT are deemed to be incomplete models as they are incapable of covering the entire structures surrounding the user's operations. Based on the study's findings, perceived usefulness in TAM, and performance expectancy in UTAUT may serve as a narrow definition of specific situations. Nevertheless, regardless of these drawbacks, the models are starting points for gathering information

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that facilitate variables examination, which is significant to the industrial robots' acceptance.
Thus, the present study examines the behavioral intentions of employees towards adopting robotics and automation through the use of extended TAM proposed by Venkatesh and Bala [24].

4.3 Framework Verification

The next step involves the validation of the developed study framework to ensure that it explains the aims of and the purpose behind the study. For this step, the author approached 15 experts in technology adoption and implementation in the firms to peruse the framework and provide their feedback and opinions of its completeness, the relationships among the variables and their correlations and strengths. A face-to-face interview was conducted with them, through a semi-structured interview.

4.3.1 Qualitative Data Collection

In qualitative data collection, data is gathered from a small group of respondents or interviewees [114], and the methods adopted should be aligned with the research questions [115]. The study adopted the qualitative data collection method to allow direct examination of the framework.

Thus, the author conducted interviews with the 15 experts for their opinions and feedback on the robotics and automation adoption framework. The experts came from specific disciplinary backgrounds to avoid potential bias if they hailed from just a single discipline. They consisted of integration managers, planning and coordination department managers and business analysts in transformational firms that had experience in technology and IS adoption.

The interview questions were drawn up based on the themes focused on the robotics and automation framework validation and data obtained was used to establish the framework's validity and credibility. The questions were open-ended to allow free opinions of experts, with 12 factors categorized into three dimensions based on their effects on the robotics and automation adoption and their support to the productivity of the firms. Moreover, the questions in the interviews were drawn up from a review of literature in order to emphasize on the experts' perceptions and experiences concerning the studied phenomenon.

Added to the above, the author conducted a semi-structured interviews with the experts to achieve specific objectives, among which are, to verify the framework in terms of its completeness and credibility, to examine the framework adoption level in the transformational firms, to explore the effective adoption of robotics and automation to reinforce and improve productivity, and to explore the key role of robotics and automation in enhancing the firms' productivity.
Each interview session carried out with the experts spanned 30-50 minutes, with each session initiated with an introduction to the topic of research and explanation of its scope and purpose, while making sure that the experts were aware that their confidentiality and privacy would not be breached, and their right to withdraw existed at any time they opted to do so. The interview sessions were recorded, after which, they were transcribed, and a second person was requested to confirm the accuracy of the transcriptions and to highlight inconsistencies for later rectification.

The interview questions were translated through a discussion with an academic professor who was also an expert in IS, and a comparison of the English and Arabic versions. This was conducted to ensure that the translated questions had completeness and credibility and its reflection of the robotics and automation adoption framework. This also confirmed if there are other additional factors missing.

For the validation of the interview data, Brenner, Green [116], recommendation that this step is dependent on the collection of data and the data collection instrument was considered. Several methods have been utilized for qualitative data validation including triangulation, member-checking and peer-debriefing [114, 116]. In this regard, majority of the reviewers contended that participant validation serves as a good indicator of quality [117]. Thus, this study used to member-check to validate the data in a two-step process; first, the researcher reviewed the transcript to identify translation mistakes, and second, every participant reviewed the Arabic and English transcripts.

4.3.2 Qualitative Data Analysis and Results

The interview sessions-obtained data were analyzed using qualitative analysis, wherein which a decision was reached as to the use of manual methods or computer methods. According to Creswell [114], data gathered that constitute less than 500 pages may be manually analyzed and as such, this study conducted manual analysis. Also, qualitative data analysis describes a story/theme that comes from the story. Generally speaking a qualitative data analysis provides a description and a summary of the statements, following which, thematic analysis was conducted on the data by applying numerical

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and textual codes to identify top and matching themes [117]. Procedures used in such an analysis are appropriate for qualitative data analysis [118].

According to Braun and Clarke [119], thematic analysis has been used widely to conduct qualitative analysis on study data and is deemed to be one of the top methods that researchers utilize in various study fields [119]. Such analysis method produces data inferences based on their replicable and validated context, identifying, analyzing and reporting the patterns/themes of data through six steps. The first one being familiarization of data, followed by the second one, which entails initial codes generation. The third one involves themes searching, and the fourth one themes revision. The fifth phase involves the definition and labeling of themes and lastly, the sixth one involves the generation of reports [119].

The detailed steps are provided under this sub-section. In the first step, the author conducts a familiarization of the gathered data, via their transcription, review, re-reading, while documenting the main ideas from them. In the second step, initial codes are created on the basis of prior works in literature or on certain themes (codes) referred commonly as theory-driven codes or data-driven codes. In such codes, data is based on certain research questions. In the third step, the categorization of data into themes is conducted, followed by the fourth step that involves the generation of thematic analysis map. The fifth step defines and clarifies each theme through labeling, after which, in the sixth step, the report of findings from the extracted raw data from the interview connecting them to the research questions and to past findings is drawn up. According to Braun and Clarke [119], thematic analysis encapsulates different aspects of research topics based on their connections to the corresponding research questions [119].

The interview sessions provided the data, after which, such data was exposed to thematic analysis, whereby three major themes were identified. The themes and the details related to them are tabulated in Table 2.

T*able 2 The Qualitative Themes And Sub-Themes*

Theme	Sub-theme	Source
Technological	perceived ease of use, perceived usefulness, IT infrastructure, subjective norm	TAM + Literature
Organizational	top management support, financial support, training, readiness	TAM + Literature
Trust	efficacy, reliability, security and anxiety	TAM + Literature

The research main themes along with the details of each theme were analyzed and on the basis of the analysis, the experts seemed to support the robotics and automation adoption framework's completeness and credibility, establishing the framework's ability to support the productivity of the Saudi transformational industries. In other words, the experts confirmed the framework comprehensiveness in covering the factors that promote the adoption of system among users.

Specifically, the importance of technological dimensions of the adoption of robotics and automation was confirmed by the interviewed experts in terms of the following factors; perceived ease of use, perceived usefulness, IT infrastructure and subjective norms and their significant effects on the intention of the employees towards the adoption of robotics and automation.

Also, based on the findings of the qualitative data analysis, organizational dimension factors were also confirmed in their importance through their significant effects on the adoption of robotics and automation, based on the experts' consensus. The factors include top management support, financial support, training and readiness.

Along a similar line of experts' support, the trust dimension factors of efficacy, reliability, security and anxiety were confirmed in their significant influence on the adoption of robotics and automation. The proposed hypotheses findings are presented in Table 3.

On the whole, the experts agreed on the framework validity and on the basis of their statements, the variables along with their relationships were clear, with the relationships strength and direction confirmed in the proposed framework.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Table 3 The Results Of Preposition Testing

No.	Preposition	Result
P1	Technological factors have a positive influence on the adoption of robotics and automation.	Supported
P1a	Perceived ease of use has a positive influence on the adoption of robotics and automation.	Supported
P1b	Perceived usefulness has a positive influence on the adoption of robotics and automation.	Supported
P1c	IT infrastructure has a positive influence on the adoption of robotics and automation.	Supported
P1d	Subjective norm has a positive influence on the adoption of robotics and automation.	Supported
P2	Organizational factors have a positive influence on the adoption of robotics and automation.	Supported
P2a	Top management support has a positive influence on the adoption of robotics and automation.	Supported
P2b	Financial support has a positive influence on the adoption of robotics and automation.	Supported
P2c	Training has a positive influence on the adoption of robotics and automation.	Supported
P2d	Readiness has a positive influence on the adoption of robotics and automation.	Supported
P3	Trust factors have a positive influence on the adoption of robotics and automation.	Supported
P3a	Efficacy has a positive influence on the adoption of robotics and automation.	Supported
P3b	Reliability has a positive influence on the adoption of robotics and automation.	Supported
P3c	Security has a positive influence on the adoption of robotics and automation.	Supported
P3d	Anxiety has a positive influence on the adoption of robotics and automation.	Supported
P4	Robotics and automation adoption has a positive impact on productivity	Supported

5. DISCUSSION

The ARS adoption framework proposed in this study was confirmed by the interviewed experts by virtue of its completeness and credibility. The framework is extensive in that it covers areas that promote the system implementation in organizations. To begin with, the first interviewed expert supported the importance of the framework and the issues that it encapsulates, and the need to motivate staff towards its implementation. According to his statement,

"I believe that your framework is comprehensive in its combination of factors, and as such, it is crucial that we motivate our staff towards system implementation".

Experts 2, 3 and 7 were supportive of the above statement, and provided their full agreement to it in their statement that reads,

"I fully agree with the components of the framework as it encapsulates the technological aspect and it is comprehensive enough to cover other aspects relating to organizational

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

requirements and trust requirements – aspects that can be used to promote the adoption of the system".
Experts 11, 12, 13, 14 and 15, summarily also stated their support through the following statement,
"The framework's comprehensiveness is evidenced by its coverage of the required aspects and as such, it can be promoted with ease for implementation and acceptance among the users".
Meanwhile, Experts 1 and 7 related that suitability of the framework for the Saudi transformational firms as it contains the important factors relevant to such firms with the characteristics of the system. They stated,
"I opined that the framework is complete and comprehensive in its inclusion of the significant factors for the transformational firms, specifically, when it comes to ARS adoption. It is acknowledged that the ARS adoption would lead to overall productivity enhancement, and thus, the process of implementation needs the factors for success".
Added to the above statements, experts 3, 4, 6 and 8 believed that the adoption of the ARS framework is crucial for transformational firms as the users can boost their performance and productivity from its potential.
A similar opinion was provided by Experts 2, 4 and 11 who stated,
"ARS is capable of enhancing industrial and transformational firms' productivity although there is still lack of awareness and knowledge among the users in the way it can be successful adopted and leveraged for maximum advantages. The framework factors can help in clarifying how the system implementation can be benefited from".
The experts were of the consensus that the included technological factors (i.e., perceived ease of use, perceived usefulness, IT infrastructure and subjective norms) are all significant for ARS adoption success and thus, the framework is successful in clarifying the implementation requirements, which could eventually lead to optimum productivity. This was true for the statements provided by Experts 3 and 8.
According to Experts 2, 4, 7 and 14,
"We believe that it is a great idea to integrate the trust dimension factors in the ARS framework, as they have key role in proper ARS adoption. The success of such adoption requires the trust factors of efficacy, reliability, security and anxiety, which are all covered in the framework".
Furthermore, based on the statements issued by the interviewees, for ARS implementation success, it is important that management supports staff training of the system – top management has to support ARS function. The statements relating to this factor from the experts are as follows;
"In ARS, transformational firms' management should use its executive authority to participate in managing and running the system functions" (Expert 2).
"The importance of top management's inclination towards system implementation and training enhancement for system successful use cannot be over-emphasized" (Expert 3).
The experts were convinced of the need for management to be well aware of the value of ARS and the return of investments of the system. Top management's inclination towards the adoption and implementation of ARS is one of the main factors needed for implementation success, as without such interest, ARS implementation will only lead to failure.
"Organizational readiness should be ensured through provision of sufficient raining to staff" (Experts 7, 9 and 12).
In successful transformational companies, ARS is crucial in light of management activities as stated by Expert 1;
"ARS is important for the purpose of productivity enhancement, with the implementation of the system working towards cost, time and effort-saving. The administration's perceptions are such that the system facilitates processes based on the production of the relevant information by the system".
Added to the above, Expert 1 also stated,
"ARS implementation factors are significant to implementation success, whereby they are categorized into three major groups and their factors; technological factors ensure control and provision of the requirements of implementation, while organizational factors ensure system implementation requirements, and trust factors ensure proper implementation of the system. Without the above factors, implementation will fail".
On the whole, the experts were of the consensus that the framework is valid and complete in light of the included variables and their relationships, relationships strength and direction in the framework. They agreed that the focus of the framework is on the successful ARS implementation for enhanced firm performance.
This novel study identified the significant factors that will lead to the successful adoption of ARS from the experts' point of views. The study will shape the direction in the adoption of ARS, since there is a lack of researches in this regard. In fact, ARS is an urgent demand for transformation

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companies and will improve the productivity with less effort. Thus, taking into account such factors will definitely guide in the fast and successful adoption.

6. IMPLICATIONS OF THE STUDY

The study findings carry implications for practice and theory. Practically, the findings are useful for Saudi authorities who are open to adopting robotics and automation technologies for productivity enhancement of transformational industries.

Theoretically, studies have constantly called for developing technology adoption frameworks, especially in the case of transformational firms and this research answered the call by adopting a distinctive approach from past studies to bring forward a new adoption framework.

In the present dynamic technological developments in robotics and automation field, society has managed to leverage and reap the fruits by handling several challenges through them. Such technologies can be leveraged through the clear understanding of the influence of robotics and automation on growth, productivity, labor and equality. This necessitates systematically obtained data concerning robotics and automation adoption and usage, in the level of business, to highlight the role of technology in the economic and societal progress. Such datasets development through census, public and private firms' surveys and internal data obtained from individual firms, would be invaluable to researchers and policymakers to empirically examine the robotics and automation effects to create appropriate responses to the issues arising from the phenomenon.

In this study, the findings provide accurate data required for promoting national competitiveness, particularly for developing policies. Lack of information on robotics and automation could result in under-preparedness when facing technological advancements, which could ultimately bring about failure and missed opportunities. For example, decisions related to taxing or subsidizing robots and automation hinge on knowing if the technology should be used as a substitute or a complement to work and decisions to this effect can affect the adoption patterns. With haphazard adoption taken because of lack of information, economic growth may decrease along with employment levels and wages. Data also has to be effectively utilized so that the technology adoption outcomes can be responded to.

In the present study, the study variables were empirically tested based on their influence on the robotics and automation adoption in transformational firms in Saudi Arabia. The study thus provides a deeper insight into how productivity can be enhanced in such firms. Studies dedicated to examining automation and robotics in developing nations, particularly Saudi Arabia's industrial firms are still few and far between and thus, this study provides crucial information that can guide towards robotics and automation implementation success.

7. CONCLUSION

The proposed theories in literature appear to serve as tools to examine the determinants of IT acceptance, with TAM being the top of those theories. Other models can be utilized for such investigation to motivate the IT usage among employees and managers in transformational firms. In this study, the determinants of robotics and automation acceptance in Saudi transformational firms are identified and they are perceived ease of use, perceived usefulness, IT infrastructure, subjective norm, top management support, financial support, training, readiness, efficacy, reliability, security and anxiety, and behavioral intention to use. The role of robotics in industrial firms and in the whole economic development is indubitable, with robotics and automation holding the core of the development of such firms. Enhancement of firms requires technologies adoption as this brings about increased productivity. Thus, new technologies adoption needs the investigation into the factors promoting the technologies adoption and usage. The present study clarified specific issues connected to such factors, specifically in the adoption of robotics and automation in transformational firms in Saudi Arabia.

In particular, the main focus of the study is laid on TAM's technological factors and those the factors obtained from the literature review (i.e., perceived ease of use, perceived usefulness, infrastructure and subjective norms), organizational factors obtained from past models and reviewed literature (i.e., top management support, financial support, training and readiness), and trust factors adopted from prior literature (efficacy, reliability, anxiety and security). These were all found to be vital in the robotics and automation adoption in Saudi transformational firms. The study underlined the lack of empirical studies conducted on robotics and automation, with specific focus on their roles in productivity enhancement and the lack of a relevant framework to guide successful system adoption. Moreover, the study enumerated the limitations in prior robotics works and the need to develop and

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

propose a framework for the adoption of robotic and automation as the lack of the same could lead to system implementation failure.

This study contributed to the both theory and practice in the field of RAS adoption. IN the theory, it will add some new factors to be included to TAM and a new dimension to TOE. While in practice it will give an overview to the transformational companies to understand the importance of the factors to adopt ARS successfully and properly.

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