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THE USE OF AUTOMATION AND ROBOTIC INNOVATIONS IN THE TRANSFORMATIONAL COMPANIES: SYSTEMATIC LITERATURE REVIEW

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ABSTRACT

Without a doubt, robotics has a crucial role to play in industrial firms, and in turn, in the overall economic development. Robotics and automation can hold the key to industrial companies' progress and as such, for the industry to be enhanced, new technologies have to be adopted for increased productivity. In effect, the adoption of new technologies calls for the examination of the factors that could facilitate their proper and effective adoption and use. Robots call for the determination of innovative and creative ways to make use of technology in the hopes of differentiating the company from its rivals in order to ultimately achieve sustainable advantage. This paper aims to identify the factors influencing the behavioral intention to adopt robotics and automation among transformational companies in the kingdom of Saudi Arabia (KSA). This identification is based on systematic literature review that lead to construct a conceptual framework for the proposed adoption of robotics and automation. The results show that there are main factors to guarantee the successful use and adoption for robotics and automation. These are perceived ease of use, perceived usefulness, it infrastructure, subjective norm, top management support, financial support, training, readiness, efficacy, reliability, security and anxiety.

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

1. INTRODUCTION

There is no doubt of the importance of manufacturing to the global economy and its significant contributions to it. In the prior decade, the national manufacturing sector lost almost 30% of its resources and investments as a result of which, the quality of domestic goods, global share and manufacturing capabilities have decreased. In answer to this, innovative ways have been proposed for the optimization of new technologies use, like robotics and automation, in the new manufacturing era [1].

In the current manufacturing industry, the aim is focused on enhancing competitiveness via the integration of ICT technologies to establish a new growth direction. The fourth revolution of the manufacturing industry, namely Smart Manufacturing, is also considered as a new paradigm, and it refers to a collection of current technologies supporting the effective and accurate engineering decision-making done in real-time via the use of ICT technologies in combination with existing manufacturing technologies. Current organizations are urged to adopt such technologies and adapt to the ongoing changes brought on by IT [2].

In recent years, technological innovation has generated sophisticated computers, robots and software that are now being launched in the realm that has long been exclusive to humans, namely, the cognition realm. In other words, today's computers have the capability of recognizing patterns and generating insights into fraud detection, medical diagnosis, legal research and auditing, as well as other capabilities. In the same line of argument, artificial intelligence algorithms are able to process multiple documents, in thousands, they can act expediently compared to any human, and are devoid of human biases. Such expedient generation of outcomes does not require interrupted breaks of concentration lapses. Thus, new technological revolution is expected to lead to the provision of considerable benefits to society in the form of the creation of novel goods, services markets, jobs, and greater productivity, among others

Today's world is characterized by the science fiction features found in literature a decade ago. In fact, there is an increasing development of smart innovations, with scientist and engineer circles attempting to develop new and innovative devices, and also homes, factories and cities. Regardless of the ongoing progress in this field, the concepts are just vision of the future that needs significant efforts for their realization [3].

More importantly, the economy is boosted by the new robotics concept although the potential benefits remain ambiguous. Therefore, it is crucial to determine such benefits along with the limitations in the robotics at the early stages in order to leverage the former and establish and develop additional employment for the purpose of overall economic development. With regards to the limitations, it can be examined and minimized [4].

Specifically speaking, a robot refers to a system comprising sensors, control systems, manipulators power supplies and software that works in combination to achieve a task [4]. Added to this, robotics, in some instances, is described as an independent innovation that comprises of a sensor, an actuator, a microcomputer and a transceiver. In relation to this, adjective smart is often utilized to describe an object fitted with additional features that introduces multi-platform communication and enhances computational abilities. Such device intelligence can be displayed through the crisscrossing network of other smart devices that are able to check the updates of the system and decide on carrying out the action or refusing to do so – such a network is commonly referred to as a smart network [3].

The world standard organization, an international organization, referred to an industrial robot as a multi-objective and programmable robotic arm that can move/stand in multiple directors (three directions) and it can be controlled or reprogrammed automatically.

The industrial robots development and growth can be traced back to 1947, after which the impetus of the process and development was directed by technology development. In the current times, industrial robots are widely applied, mostly as substitutes for human resources in various industries. The ongoing robotic technology growth and development in the industry always posed challenges, with one being the negative effect of robotics on the employment scale. Because of cost reduction and production improvement, industrial nations have been urged to use robots to replace human force in lines of production [5]. Nevertheless, the extensive utilization of robotic systems in the field of industry can be directed by a framework to ensure their successful adoption and to steer clear of obtaining adverse outcomes.

In relation to the above, the Survey of Manufacturing Technology (SMT), carried out by the Census Bureau with the assistance of the Department of Defense in 1988, 1991 and 1993 measured the diffusion, use and the long-term use of new technologies in the U.S. manufacturing industry. The SMT involved 10,000 establishments in their survey to determine the plant characteristics and their adoption of 17 established technologies categorized into five namely, design and engineering, fabricated machining and assembly, automated material handling, automated sensors, and communication and control. The survey was employed by the SMT obtained data was easily integrated with firm-level data obtained from the BLS or Census Bureau itself. Such survey also enabled panel analysis, as a group of firms within which the sample comprised of respondents in multiple groups. After the 1993 SMT, the Bureau had to discontinue the survey owing to limited funds [6].

In relevant literature, marketing and information system works have examined different factors affecting automation technology adoption (e.g., robotics and smart automations) [7]. Literature evidences the requirement to examine the factors that could result in the successful robotics and automation adoption. Therefore, in the present study, the author determines the factors influencing behavioral intention of adoption and use of robotics and automation among Saudi transformational companies for more effective and efficient management of establishments.

The focus of this paper is one the robotics and automation adoption in the transformative industry in Saudi Arabia, as a developing nation. It lays stress on the role of robotics in enhancing productivity, and on the framework importance in guiding effective and efficient technology adoption and use. The paper also provided a discussion of the different issues that are linked with robotics and automation in different contexts, and it revealed that robotics and automation play a key role in enhancing productivity. On this basis, robotics and automation should be considered as crucial assets of transformative industry and its productivity, with the frameworks used as guidance.

Lastly, this paper highlighted the lack of studies dedicated to robotics and automation, particularly in their role of enhancing productivity and the developed framework for adoption success. The paper touched upon the limitations of prior studies

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when it comes to robotics. There is thus a need to develop and put forward a framework for proper robotic and automation adoption as the lack of such framework could lead to major challenges in successful system implementation. On the basis of the literature reviewed, successful implementation of robotics and automation is related to the proper framework to guide it.

2. PROBLEM BACKGROUND

According to the report of the World Bank GROUP (2017), Saudi Arabia is among the richest countries in the world based on per capita but its robust economy is mostly attributed to its major share in the world oil resources that dominate the country's exports. More specifically, the Kingdom's oil produces up to 80% of the country's revenues, representing 45% of the GDP (GROUP 2016). Nevertheless, throughout the 1980s and 1990s, the Kingdom underwent a dynamic modernization process based on the purchasing power that oil revenues could produce. This was coupled by the efforts towards industrialization [8]that led to higher diversity, where the manufactured goods production was enabled to obtain competitive advantage and tackle challenges and issues in the markets [9].

In relation to the above, the government of Saudi Arabia advocates a competitive free market economy although it is still lagging in global competitive markets, requiring the reconsideration of national competitive advantages. This is because the Kingdom's strong economy provides high opportunities for investors that can contribute to its promotion through economic diversification, economic reform, liberalization of market, and the development of the private sector, in a country that is weaning from its dependence on oil and gas [10]. Evidently, there are opportunities at all levels in the country that include oil, gas and petrochemicals, power, water, financial services, education, transportation, environmental technology and services, ICT, consumer and luxury goods, defense and security, healthcare and life sciences, mining and others [11].

In the current times, the Saudi industrial products constitute over 90% of non-oil exports in the country's exports petrochemicals, plastics, metal goods, building materials and electrical appliances to over 90 nations. On the other hand, there is increasing focus on economic development reflected by the construction of industrial cities and technology areas.

In relation to this, the body that holds the responsibility of developing industrial land is the Saudi Industrial Property Authority (MODON). Its primary objective is to promote and regulate industrial and technology zones and to boost private sector's participation in its development and processes. Coupled with this is one of the aims established by the Saudi Vision 2030, which is to expansive use the continuous digital transformation of manufacturing industries. Such transformation realizes reduced downtime, increased productivity, cutting costs and producing new revenue channels, which majority of transformational companies has only begun to realize [12].

Evidently, the increasing labor costs and the attempt to increase productivity in Saudi Arabia and several other developing countries have driven them towards automation of processes. A survey involving over 2500 executives, throughout 36 economies, showed that 56% of firms have followed the automation trend. The scenario is such that even with the labor costs stable, the attempt and requirement to increase productivity makes automation a very tempting option. This is because digital transformation enables firms to make use of artificial intelligence (AI) to enhance their performance and work in an efficient manner, so much so that robots are making considerable changes in the global marketplace.

In the context of the global robotics market, using computer-controlled robots to complete manual tasks are picking up more than ever before. Robots call for the determination of innovative and creative ways to make use of technology in the hopes of differentiating the company from its rivals in order to ultimately achieve sustainable advantage. This may need the combination of re-configuration of the human factor and the machine, which may entail the creation of a new and innovative business model. The biggest obstacle in this attempt is determining where and how to begin, and the development of such business model calls for experience and knowledge to eventually assist firms to move forward to a brighter and more dynamic future [13].

From the industries, the industrial and military sectors were the pioneering sectors when it comes to robotics adoption. Robots are suitable for dirty, routine tasks requiring little or no precision and owing to lower prices, more efficient CPUs, security and safety guarantees and easier programming, robots have now permeated every sector [14]. Robots are able to function in combination with humans and this has opened up various new applications. Many industries, including retail trade, healthcare, food processing, mining, transportation and agriculture are expected to go through changes brought on by robots in the near future [15]. This could result in competitive markets that call for effective automation and robots usage strategy. Many researchers found technology strategy as a way to enhance competitive advantage, with failure to develop and integrate technology and business strategy contributing to the firm's declined competitiveness. Majority of studies also revealed the significant role of technology strategy in identifying firm performance in technology-centered industries like industrial automation firms [16].

Nevertheless, despite the benefits of digital transformation to businesses competitive advantage, it also has its drawbacks and challenges, with one of them being job cuts, making lower-skilled employees obsolete, and leading to the growing divide in income and opportunities between service-based and knowledge-based economies and professions – in this context, automation assume considerable responsibilities [17].

More importantly, automation transforms work, businesses and even economies. But as a developing and emerging economy having a younger population demographic, KSA necessities a combination of automation and additional productivity-raising measures to sustain its economic development, and achieve its high growth aspirations and global competitiveness [18]. In this case, the National Productivity Program (NPP) in KSA was established as a comprehensive national program, aiming to increase the country's productivity in the coming decade. It concentrates on the top sectors of the Kingdom, sets up sectoral initiatives and renews the business model through the adoption of automation and innovation technologies in order to sustain the development of the private sector.

In countries all over the globe, automation has transformed work, businesses and economies [18]. For instance, China is the largest market for robots worldwide, on the basis of production volume while Brazil, Germany, India and Saudi Arabia among other economies, can stand to leverage from the monumental boosts brought about by robotics and artificial intelligence. The extent and pace robotics adoption varies from one country to the next and are dependent on several factors such as, the levels of wages but every country will be affected by it. Thus, this study assesses the factors influencing the adoption of automated technology and robots and their impact on the productivity of Saudi transformational companies in light of their efficiency and effectiveness.

Based on the above research problem, the research question of this paper is; what are the factors influencing the behavioral intention to adopt automation and robotic technologies among employees in Saudi transformational companies?

3. ROBOTICS AND AUTOMATION TECHNOLOGY

This section is categorized into four sub-sections for effective organization and ease of understanding. The first sub-section is dedicated to the description of robotic and automation technology in general, the second one discusses industrial robotics, while the third one presents the objectives behind robotic and automation in industrial productivity. In the fourth sub-section, the author provides an overview of the use of robotics and automation in the context of Saudi Arabia. Before discussing robotics and automation concepts, a description of this type of technology has to be provided and this section provides detailed information on it as well as its important role.

3.1 General Robotics and Automation

The field of robots has received scarce empirical examination, with studies dedicated more to examine robots because of their physical nature that is easier to keep track of as time passes and their location. Prior studies dedicated to the effect of robots on industrial productivity provided mixed findings. To begin with, Graetz and Michaels [19] who used robot shipment data at the level of country, industry and year level from the International Federation of Robotics (IFR) and found significant effects on the growth of productivity. Viewed from the national-level, data on robot shipments throughout 17 countries indicated that robots may have constituted around 1/10th of the increases in the gross domestic product of the countries for the years from 1993 to 2007, and they may have contributed to the increased productivity by over 15%. According to the authors, this is a significant effect in comparison to the effect of the adoption of steam engines on the productivity of British labor back in the 19th century. The authors also showed that increased wages with robot use, on average, corresponded to minimized hours for low-skilled and middle-skilled employees.

Meanwhile, Mann and Püttmann [20]

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adopted information obtained from granted patents in analyzing the effects of automation on employment. The authors employed a machine learning algorithm to all U.S. patients granted for the years 1976 to 2014 in their attempt to determine patents linked with automation, where an automation patent refers to a device operating independently from human intervention and achieves the reasonable completion of the task. The authors then related the automation patents to the industries they are potentially utilized in and determined the areas in the U.S. where the industries are related to. Their examination of the economic indicators compared to the density of automation patents used in the area led to the outcome that although automation leads to manufacturing employment to fall, it maximizes the employment in the service sector, which has an overall effect on employment.

In Pedersen, Nalpantidis [21] study, they provided a simplified illustration of the situation (see Figure 1). It is evident that traditional manufacturing systems are automated to a specific level but their configuration is challenging. Traditional manual labor is versatile but the economic viability for large-scale production, particularly in high wage countries is negligible. It is expected that in the future, mass customization will necessitate the combination of high configurability with high-levels of automation. This is achievable in two distinct ways; workers can be equipped with optimum automation tools (intuitive on the fly programming of robots) so that the productivity is increased, or the configurability of traditional automated products online can be enhanced using multi-purpose robots. In this regard, robots are expected be one of the major enablers of this transition and in order to achieve the required level of flexibility of robots, they need to autonomously move, cope with risky interactions with humans and environments, tackle various tasks, and reprogram expediently even by non-robot experts, when a new factory task arises. Therefore, the question that begs to be answers is “what should be the characteristics of a framework that would allow robots to be flexible enough to handle uncertainty and changing production tasks, while being intuitive enough to be used and reprogrammed by non-robot experts?” The study contended that the answer can be found in the integration of sensing and action in a small modular and parmetrizable robot skills.

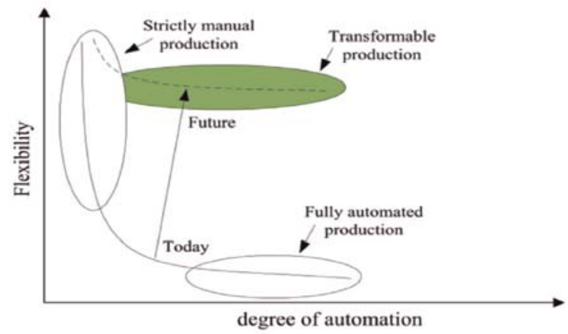

Figure 1: A clear requirement for the factories of tomorrow is that of transformable production system, showing a high degree of flexibility, while still applying a high degree of automation (Pedersen et al. 2016)

3.2 Industrial Robots

Industrial robots are described as a radical technology and they are automatically controllable, reprogrammable, multipurpose manipulators, programmable based on three or more than three axes that can be fixed or mobile (ISO8373, IFR.org).

In addition, the industrial robot market constituted over four billion dollars with a rate of growth of 4% per annum in 2005 alone, and is currently valued at more than U.S.$29 billion in the U.S. [22]. Majority of the industrial applications are confined to material handling or welding but industrial robots can also be used to assemble, palletize and paint.

Moreover, industrial robots are generally confined to the workplace, programmed to do repetitive tasks, which when compared to personal robots, need minimal human-robot social interaction. Despite the fact that much of the work in the human-robot interaction (HRI) field has been carried out within the personal robots scope, HRI still plays a key role in industrial robotics as such robots have become advanced in many ways and they have the potential to collaborate with operators and people Guizzo and Ackerman [23] and this underlies the importance to understand HRI in industrial application.

In HRI, there are five major components namely, the robot, the human, the interaction between the two, the environment within which the interaction happens, and the specific tasks to be done. Among these components, environment is of specific interest because it forms a part of the culture of the organization and the physical space within which a robot-human interaction takes place [23].

In relation to culture, it has been evidenced to be a boundary condition to robot acceptance, particularly in the case of stagnant cultures or that

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which is rife with change resistance [24]. A boundary refers to the obstacle or challenge to be addressed and resolved. Along a similar line explanation, facilitating condition promotes the acceptance or the object.

Studies dedicated to personal robots lay stress on the human-robot interaction and their high social interaction. Nevertheless, industrial robots generally have minimal social interaction but the human and robot existence in an environment can affect the robots acceptance because of the culture of the environment/workplace. Hence, various factors including trust factors have to be taken into consideration in order to boost acceptance.

3.3 Aim of Robotics and Automation in Industrial Productivity

Responding to the challenges brought about by globalization, current manufacturing firms face the necessity of flexible and agile manufacturing tools and in this regard, robotics and automation is important for the industry as evidenced by its direct impact on the industrial companies' productivity [17].

In a related study, Acemoglu and Restrepo [25] examined the influence of the increased robot use on regional U.S. labor markets for the years 1990 to 2007. The employed the distribution of robots at the industry level in other advanced countries and found that industrial robot adoption in the U.S. has a negative relationship with employment and wages for the years examined. The authors revealed that an estimation of each additional robot reduced employment by six employees and that one new robot for every thousand workers minimized wages by 0.50%. They revealed that the effects are higher in manufacturing, specifically in routine manual and blue collar professions, and for workers with no college degrees. They also found no positive effects on employment as a result of robotics adoption in any industry.

Moreover, the European Commission Report on Robotics and Employment (2016) investigated the industrial robots use in Europe, depending on robotics data obtained from the European Manufacturing Survey. The report based its survey on a sample of 3000 manufacturing firms in seven European nations that has been periodically surveyed since 2001, with the recent of which was in 2012. The data was used to determine the use of industrial robots and the findings showed that this is more likely in large-sized firms, firms using batch production, and firms that export. No evidence was found revealing that the use of industrial robots directly impacts employment despite the fact that firms using robotics displayed higher labor productivity levels.

Generally speaking, work dedicated to automation and employment revealed that automation is a substitute or a complement for labor. In Frey and Osborne [26] study, they indicated that almost 50% of the total U.S. employment is facing risk of being automated in the next twenty years. Along a similar line of study, Brynjolfsson and McAfee [27] explained that because of cognitive tasks automation, new technologies may function as substitutes as opposed to complements. However, other authors indicated that positive technology has historically often led to heightened job opportunities and overall employment [28].

Notwithstanding the effect of automation on employment in the directly affected industry, technology adoption may have positive effects (upstream and downstream) on labor. Also, Autor and Salomons [29] revealed that with the increase of industry-specific productivity, employment appears to fall, but positive spillovers permeate to other sectors more than counter the negative own-industry effect of employment. Furthermore, new technologies should positive affect employment if they enhance market productivity, where a large amount of demand is unmet [30]. In the case of robotics and automation, new computer technology is related with employment declines in manufacturing, where while demands are met, it is related with the growth in employment in non-manufacturing industries, which are not as saturated [30]. Meanwhile, Dauth, Findeisen [31] integrated German labor market data with IFR robot shipment data and found that each additional industrial robot resulted in the loss of two manufacturing positions, but sufficient jobs are developed in the service industry to counter it and in some contexts, it over-compensates for the effect of the negative employment in the manufacturing sector.

A report article by Gudun [32] revealed that increased productivity enables firms like Whirlpool, Caterpillar and Ford Motor Company in the U.S. and Adidas in Germany to conduct restructuring of their supply chains, and to bring back parts of manufacturing process to the original country. Robot density and slow good production fragmentation, particularly in Citigroup and Oxford Martin School point, are major drivers of the process. Surveying 238 Citigroup clients, the study found 70% to be convinced that automation encouraged companies to shift their manufacturing closer to home and consolidate production (Citi and Oxford Martin School 2016).

In addition to the above, the Reshoring Initiative in

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the U.S. made an estimation that 250,000 jobs have been retrieved to the country via reshoring and inward-bound foreign direct investment from 2010 (Reshoring Initiative 2015). Automation enables reshoring, enabling companies deploying robots to be less likely to relocate or go offshore based on the report by the European Commission by the Fraunhofer Institute for Systems and Innovation Research (European Commission 2015). Reshoring also provides benefits at the national level, with the potential for spillovers of demand to other sectors and the gathering of specialist manufacturing knowledge on attracting and expanding skills and talent for competitiveness at the national level.
According to the Oxford Martin School and Citigroup report, firms may not have adjusted their structures to leverage the advantages of automated technologies. The report enumerates limitations in the measurement of productivity, and stated that 81% of respondents comprising of Citigroup clients revealed that technological developments were insufficiently displayed in the statistics of productivity (Citi and Oxford Martin School 2016).

Prior studies evidenced that robots do enhance productivity in the context of tasks performed efficiency and consistently by them compared to humans [33, 34]. In a study of the same caliber, Graetz and Michaels [19] focused on robotics for the Center of Economic Performance at the London School of Economics and reached to the conclusion that robot densification heightened the GDP annual growth and labor productivity for the years 1993 to 2007 by around 0.37 and 0.36% respectively throughout the examined 17 countries, which represents 10% of the total GDP growth over the time period, in comparison to the 0.35% point estimated total contribution of steam technology to the historic British annual labor productivity growth for the years 1850 to 1910. In a more current study, robots investment constituted 10% of GDP per capita growth in OECD countries for the years 1993 to 2016. The study indicated that a one-unit increase in the density of robotics (the number of robots per million hours worked) is related with a 0.04% increase in labor productivity (Center for Economics and Business Research 2017). In their prediction, the Mc Kinsey Global Instituted related that up to half of the total productivity growth required to guarantee 2.8% GDP growth over the next 5 decades will be brought about by automation (Mc Kinsey Global Institute 2017).

On the basis of the report published by Accenture and Frontier Economics collaboration, it was forecasted that automation can potentially double Gross Value Added (GVA) throughout 12 developed economies by 2035, with improvements in labor productivity increasing up to 40% (Accenture 2016). Similarly, as forecasted by the Boston Consulting Group, productivity enhancements of 30% over the next decade via the SMEs uptake of robots (with their affordability), will lead to adaptable and easier to program robotics (Boston Consulting Group 2015).

In this line of argument, some firms are enabled by increased productivity to restructure their supply chains, retrieving parts of the manufacturing process to the original country and this holds true in the case of Whirlpool, Caterpillar and Ford Motor Company in the U.S. and Adidas in Germany. Meanwhile, Citigroup and Oxford Martin School indicated slowdown indications in goods production fragmentation and robot density as the major drivers of this process. Surveying 238 Citigroup clients, they found that 70% of them are convinced that automation would boost the move of companies of manufacturing closer to the country of origin and their production consolidation (Citi and Oxford Martin School 2016). On the basis of the Reshoring Initiative in the U.S., 250,000 jobs were estimated to be brought back to the country via reshoring and inward-bound foreign direct investment from 2010 (Reshoring Initiative 2015). In other words, automation enables reshoring, with companies deploying robots now less likely to relocate based on the European Commission report by the Fraunhofer Institute for Systems and Innovation Research (European Commission 2015). Reshoring also provides benefits at the national level in the form of demand spillovers to other sectors and the gathering of specialist manufacturing knowledge that is significant for the attraction and expansion of talent and skills and for competitiveness at the national level.

More importantly, productivity benefits owing to robotics and automation are crucial at the company level, the industry level and the competitiveness at the national level [35]. A steady rise in the U.S. manufacturing and industrial productivity has been noted since the financial crisis and the Barclays report made an estimation that an accelerated investment level in robots would lead to heightened GVA in manufacturing in the U.K. by 21% for over a decade [36]. In this regard, the estimates made by BCG indicated that South Korea, a country with the highest robot density is projected to enhance its manufacturing cost competitiveness by 6% points in relation to that in the U.S. by 2025, with the assumption that the other cost factors remain as they are (Boston Consulting Group 2015).

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Lastly, a relationship exists between productivity, company competitiveness and increased demand as evidenced by Graetz and Michaels [19] and if production increase leads to increase in wages or overall employment, then increased demand spillovers permeate other economic sectors [37]. This leads to the creation of cycle of increased productivity, increased demand, increased wages and spending power, which in turn, would lead to increased demand for other products/services.

Moreover, automation is also bringing changes in the demand nature, particularly when it comes to allowing increased personalization and mass customization; this may be exemplified by robots used in one factor to decrease customized flip-flops based on the 3D laser scan of the feet of customers (International Federation of Robotics 2016). Such personalization level would not have been possible without developments in automation technologies.

In sum, the effective use of robotics and automation would allow firms to gain and maintain their competitiveness, and this is specifically important for SMEs, which form the backbone of developed and developing nations. It allows large-sized firms to obtain high competitiveness via expedient product development and delivery. The increasing robot use also allows firms in high cost countries to restore or retrieve their domestic base parts of the supply chain, that were previously outsourced for cheaper labor purposes.

3.4 KSA Transformative Industry and the Need to Adopt Robotics and Automation

The successful adoption of IT by an enterprise could assist the enterprise to mitigate ineffective organizational and economic performance via reduced costs, while enhancing production and quality. Certain aspects like security and reduced risk, increased productivity, efficiency and improved working conditions have enabled the progressive increase of the companies' automation and introduction of robots in the workplace environment [38].

According to Rigby [36], an expedited level of investment in robots would lead to enhanced GVA in manufacturing in the U.K> by 21% in over a decade. In other words, robots and automation will form the way work is done in the future, with considerable potential for enhancements in productivity, national competitiveness, quality and work remuneration [39]. It is crucial for governments and organizations to collaborate to bring about an environment enabling workers, organizations and countries to leverage such enhancements benefits and rewards. This indicates that supporting investments in R&D in robotics field and providing educational and skills re-training for employees (both current and future) are a must.

The International Federation of Robotics stated that robots are increasingly being used but such use is still confined to a few industries in advanced countries – with the exception of China. In 2016, out of the sold industrial robots numbering 294,312, 74% were supplied to only five countries namely China, South Korea, Japan, the U.S. and Germany. While China constituted 87,000 of the robots sold in the same year, India only accounted for 2627. In the latter, robots assist in manufacturing automobile but only a few in labor-intensive manufacturing industries like the garment sector.

Compared to the industrial revolution, technology shows signs of being adopted much expediently all over the globe although diffusion in the countries remains influenced by several limitations. Smaller businesses in developing countries are operated away from the technology frontier and are limited in their access to new technologies because of limited credit and access to information, among others. The World Bank Enterprise Survey in 2014, indicated that only 3.8% of small Indian firms (5-19 employees) held licenses to foreign technology in comparison to 20.5% for large-sized firms (100+ employees).

Eventually, developing nations like the Middle East countries have to steer clear of being swayed by doomsday predictions of the ultimate eradication of jobs via automation. In relation to this, smaller businesses require optimum access to technology to increase their productivity and competitiveness and to enhance occupational safety at work. As opposed to being apprehensive about technology, developing countries policymakers should concentrate on the general factors that boost growth and job creation, with technology constituting only a single dimension.

More importantly, the global impact of technology will arise differently in different areas and nations [40]. For instance, in developed nations, manufacturing contributes only a small portion of employment and thus, the most significant impact is going to stem from the service sector's robotic industry and in white collar professions. With regards to developing nations, factor robots are expected to have a significant effect.

In the Kingdom of Saudi Arabia, the

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industrial robots market was predicted to grow at 15% by 2015, achieving a total of 11000 robots by that time as shown in Figure 1.

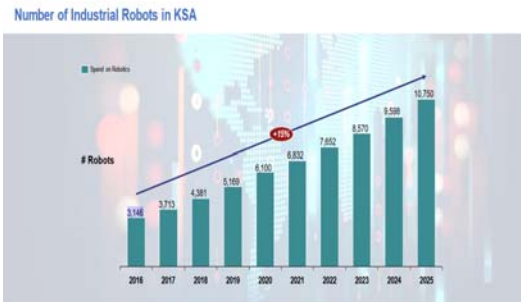

Figure 2: Industrial Robotics in KSA

It is pertinent for the KSA to utilize robotics and automation in its industrial companies for many reasons, the first being that the technical frontier of activities is that machines can perform effectively compared to humans and they are rapidly proliferating, and beginning to influence workplace environment. Majority of tasks that were automated by robots and computers in the current times, were considered as simple and routine a few years ago. Meanwhile, complex cognitive and challenging tasks are still considered to need human coordination and intelligence. Nevertheless, with the advent of artificial intelligence, humanoid robotics, quantum computing and similar advances, technology is increasingly evolving to perform simple repetitive work and they are taking over more complex work activities that majority of employees would deem to be interesting tasks in their work description.

Another reason for the new age development is the accelerated pace of automation brought about by the nature of the underlying technologies. In majority of cases, the proliferation of one type of automation technology leads to the increased benefits from the next one as well as the speed of its adoption. Such positive, evolutionary feedback loops were identified as a key feature of Ray Kurzweil's law of accelerating returns. He reached to the conclusion that if the technological progress pace continues on its acceleration and once it becomes out of control, the singularity could be near within a century, leading to a shift of paradigm in the interaction of humans and machines [41].

The third reason is that the economic and societal disruptions and adjustment challenges have manifested in visible and prominent outcomes and eventually to the rise of automation anxiety that is polarizing the public debate among technology advocates [42].

Prior related studies by Morgenstern [41] and aus dem Moore and Chandran [42] concentrated on 6 Middle Eastern countries namely, Bahrain, Egypt, Kuwait, Oman, Saudi Arabia and the UAE. The six countries together have a total population of 147 million people, with GDP of over 1.5 trillion USD in 2016 alone. Prior work dedicated to the status and potential of the digital economy pinpointed the main proliferation within the countries in relation to their first steps in new technologies adoption on the basis of their 2015 scores in the Mc Kinsey Country Digitization Index. From the countries, the UAE leads in the sample scoring 50% points higher compared to Egypt, which is the least digitally advanced country in the region as of 2015. In the business sector, digitalization is relevant for the viewpoint of automation of workforce, with the proliferation clear in the UAE, achieving over four times greater digitization index compared to Egypt (Refere to Figure 3).

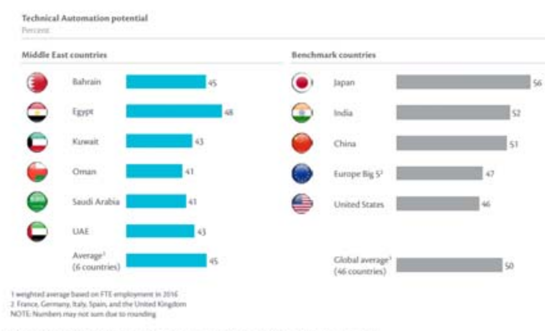

Figure 3: Potential impact due to automation based on adoption of currently demonstrated technology

On the whole, experts in the industrial companies' field in the KSA indicated that the use and adoption of automation and robotics is still in its infancy phase, with evident resistance. For the influence of such adoption and use, it is pertinent to clarify and to promote awareness concerning the factors that influence adoption and use success.

4. SYSTEMATIC LITERATURE REVIEW

Many research texts refer to doing a review of the literature in order to demonstrate a need for the research study. This need is articulated in the problem statement that uses the literature to support assertions and make the case that the purpose of the

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paper is important. The literature following the purpose is used to build a foundation for the important ideas in the problem statement and purpose.

Using literature reviews to connect the problem, purpose, and discussion sections “is a precondition for doing substantive, thorough, sophisticated research” (Boote & Beile, 2005).

For the extraction of robotics and automation factors, this study was carried out a systematic literature review. Investigating factors associated with robotics and automation adoption requires an indefinite amount of reading. Hence, good literature reviews are an inevitably needed part of providing the modern scientists with a broad spectrum of knowledge. In order to extract the factors, there should be a literature reviews to explain a specific methodological approach towards writing one, known as the systematic literature review.

The systematic literature review is a method in which a body of literature is aggregated, reviewed and assessed while utilizing pre-specified and standardized techniques. In other words, to reduce bias, the rationale, the hypothesis, and the methods of data collection are prepared before the review and are used as a guide for performing the process. Just like it is for the traditional literature reviews, the goal is to identify, critically appraise, and summarize the existing evidence concerning a clearly defined problem [43, 44].

Systematic literature reviews allow to examine conflicting and/or coincident findings, as well as to identify themes that require further investigation. Furthermore, they include the possibility of evaluating consistency and generalization of the evidence regarding specific scientific questions and are, therefore, also of great practical value within the technology field. The method is particularly useful to integrate the information of a group of studies investigating the same phenomena and it typically focuses on a very specific empirical question, such as ‘what are the factors influencing the adoption of robotics and automation?’

Systematic literature reviews include all (or most) of the following characteristics:

1. Objectives clearly defined a priori;
2. Explicit pre-defined criteria for inclusion/exclusion of the literature;
3. Predetermined search strategy in the collection of the information and systematic following of the process;
4. Predefined characteristic criteria applied to all the sources utilized and clearly presented in the review;
5. Systematic evaluation of the quality of the studies included in the review;
6. Identification of the excluded sources of literature and justification for excluding them;
7. Analysis/synthesis of the information (i.e., comparison of the results, qualitative synthesis of the results, meta-analysis);
8. References to the incoherences and the errors found in the selected material.

A systematic review is a review of the literature that addresses a clearly formulated question and uses systematic and explicit methods to: identify publications, select publications relevant to the question critically appraise the publications analyse the data reported in the relevant publications report the combined results from relevant publications.

These are the checklist that guide on HOW to develop a systematic review protocol and WHAT to include when writing up your review. In the protocol there should be a clear method including:

- **i.** Databases to be searched; additional sources used e.g. scanning bibliographies of relevant articles
- **ii.** Terms or key words to be used in the search strategy
- **iii.** Limits applied e.g. published between 2004 and 2013; English language; children < 18 years; etc.
- **iv.** Screening process e.g. scanning titles and abstracts for relevance according to inclusion and exclusion criteria
- **v.** Data to be extracted from the relevant articles identified
- **vi.** Summary data to be reported –this must be closely linked with the initial aims or “questions” of the literature review

All systematic reviews should include a Flow Diagram to demonstrate how many publications were identified and screened for eligibility, how many publications were excluded and why as seen in Figure 4.

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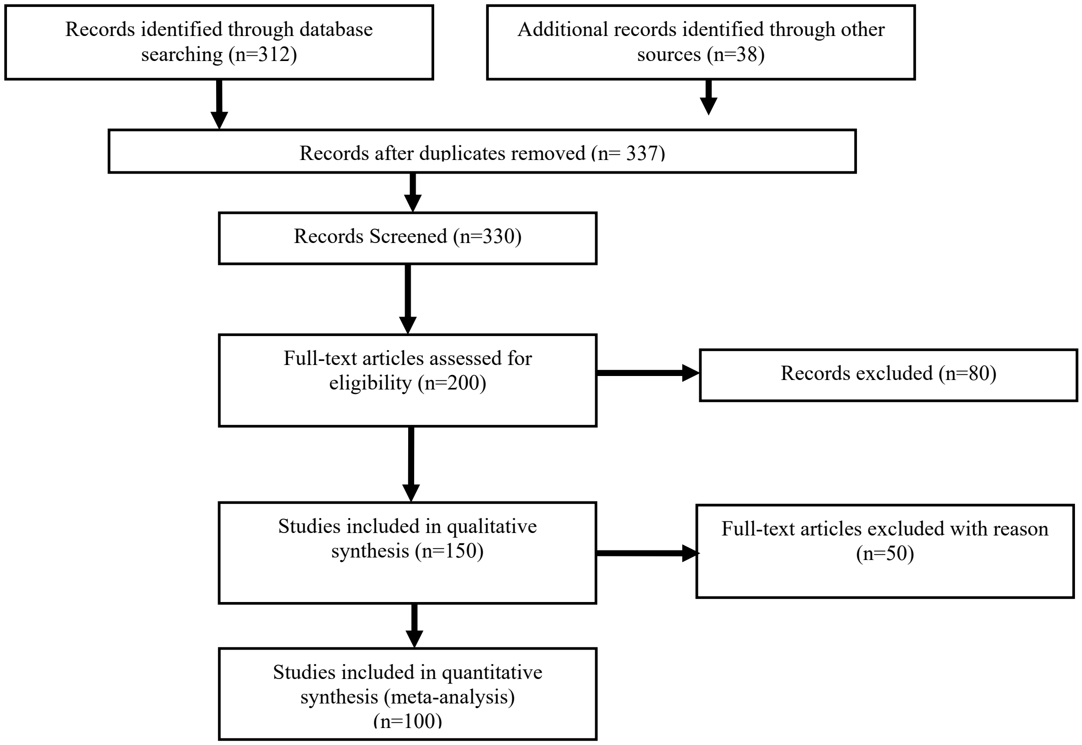

Figure 4: Systematic Literature Review Framework

The next subsections summarize the outcomes into: the research questions, the search process, inclusion and exclusion criteria, bibliography management and document retrieval, and data extraction and analysis.

The Research Questions

The research questions is one of the key factor to conduct any systematic literature review [45]. For the purpose of this research, the following research questions is defined: What are the factors that influence the adoption of robotics and automation?

The Search Process

Essentially, the research was started by implementing the literature search on related studies, and a number of research studies/papers have found using UKM Online Library and Internet services. However, the search process would be continued until the end of our study. This process has been conducted by using the search engines on several digital libraries, such as: IEEE Xplore, ACM Digital Library, Scopus, Science Direct, Springer Link, and Google Scholar.

Key terms that closely related to this research project are: "robotics adoption", "robotics Factors", "robotics and automation factors", "robotics frameworks", and "robotics and productivity".

Inclusion and Exclusion Criteria

For the purpose of conducting this review, criteria have been defined to specify those studies to be included and those ignored/excluded studies. The following inclusion criteria have been applied:

Research studies published between 2013 and 2019 that related to robotics and automation, and those researches on techniques/tools related to this field.

On the other hand, certain studies have excluded that: Informal published (no-defined or unknown journal or conference), Papers that irrelevant to the above research questions, and if there are duplicate versions of the same study (research), then the old version has been excluded.

However, if the research paper has been published in more than one journal or conference, then the most complete version was chosen.

Bibliography Management and Document Retrieval

Endnote software V.X7.8 has been used to manage all citations and bibliography in-order to formulate the report. The key terms defined above have been used for searching on the mentioned search engines. These selected studies appeared on journals/conferences have been scanned using their title and abstract. All relevant papers downloaded for further assessment and for data extraction. Table 1 presents these research studies found while conducting searching and scanning on the mentioned digital libraries.

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Table ***Error! No text of specified style in document.*** *Number Of The Articles*

Digital Library	Total number of found papers		
	Based on the defined key terms	Based on the title	Based on the abstracts
IEEE Xplore	130	64	42
ACM Digital Library	15	17	12
Scopus	70	25	11
Science Direct	20	10	13
Springer Link	29	19	9
Google Scholar	120	25	33
Total	384	160	120

However, there are a number of researches that gathered from digital libraries are duplicated, so the old version have been neglected according to the exclusion criteria (mentioned above). Also, we have applied scanning and skimming techniques on these 108 papers in-order to capture the closely related studies. Accordingly, the total number of collected studies which have been under consideration for further review is about 100 researches. After reviewing these studies, we have summarized certain information from 25 papers which have been considered as the main selected studies.

Thereafter, factors were extracted from the selected articles and the most cited factors were identified. The identified factors were categorized into technological, organizational and trust dimensions. Following the experts' perusal and their ranking of such factors, only 12 factors were taken into account. In this type of categorization, the stakeholders of robotics and automation are enabled to highlight the area within which issues may arise and to evaluate successful adoption from the viewpoint of the whole. The next sub-sections present details on each of the dimensions and the related factors.

In Table 2, the factors contributing to successful adoption are tabulated. The table contains the number of literature supporting the factors and the factors are divided into three dimensions. The outcome of the final in-depth analysis of studies carried out by authors in many fields regarding the robotics and automation usage.

Table 2 Summary of Underlying Factors

No.	Underlying factors	Demission
1	Perceived Ease of Use	Technology
2	Perceived Usefulness	
3	Infrastructure	
4	Subjective Norm	Organizational
5	Top Management Support	
6	Financial support	
7	Training	
8	Readiness	
9	Security	Trust
10	Anxiety	
11	Reliability	
12	Efficacy	

Furthermore, the table summarizes the statistical details of the major underlying factors for robotics and automation. Under this section, three main categories are focused on and they are technological factors, organizational factors and trust factors.

5. RELATED WORK ON ROBOTICS AND AUTOMATION FACTORS

This section is allocated for the past related works on the factors that influence the adoption of robotics and automation based on the proposed dimensions.

5.1 Technological Factors

The use of technology in a sector functions as a possible enhancement of service quality supported by efficient and effective employees, and mitigation of organizational costs [46]. The technology adoption significance in institutions has often been stressed as a major issue [47]. Although the studies have evidenced a positive effect of technology adoption on organizational performance [48], some studies indicated limitations and challenges relating to IS adoption, specifically in the industry and therefore, there is a need to investigate factors that affect technology adoption for the success of such adoption.

An ideal way to shed light on the current situation of robotics and automation adoption in the industrial firms is to determine the content and context of dimensions and to provide insight into the shift of legacy shared drive systems towards robotics and automation system.

Empirical studies have been conducted on technology, with each study having different objectives and outcomes, but with the major trend being that technological factors affect the adoption of the system. The next paragraphs shed light on the factors and their significance to robotics and automation adoption and technology.

a. Perceived Ease of Use

According to Davis [49], perceived ease of use refers to the level to which an individual is convinced that using a specific system would be effort-free. The factor was revealed to have a positive effect on behavioral intention towards system use [50]. In the context of robotics and automation, ease of use of technology is the easy understanding of its contents and terms and the availability of the technology review and appropriate usage [51].

Moreover, the factor of ease of use in the robotics case is deemed to determine the technology acceptance and adoption [52], with willingness towards new technology adoption hinging on factors like awareness of the way new technology works and the ease of its usage.

In Venkatesh and Bala [53]'s study, effort expectancy was referred to as the level of ease related with the system use that directly influences behavioral intention. This factor in the UTAUT model has its basis on many variables from prior acceptance models including perceived ease of use in TAM, complexity in MPCU and ease of use in IDT. The ease of new technology has been examined in several technology cases and nations by various researchers [54].

In their examination of the acceptance of mobile internet use, the influence of ease of use on behavior intention was focused on by Venkatesh, Thong [55] and they found perceived ease of use to influence intention to use. Similarly findings were found by Heerink, Kröse [56] in their study of acceptance of assistive social robots among elderly users.

Technology acceptance models generally offer explanations on the variables influencing robot acceptance and with an understanding of such variables, robot developers can design robots that have higher possibility of being adopted. According to Beer, Prakash [57], there are several potential factors predicting user acceptance of robots, and literature evidenced that perceived ease of use influences robot acceptance and adoption.

b. Perceived Usefulness

Empirical studies dedicated to the adoption of technology primarily adopted the Davis [49] technology acceptance model to shed light on the way adoption addresses barriers. The model posits that technology adoption in different fields significantly hinges on the perception of such field regarding the technology's ease of use and usefulness. In this study, perceived usefulness is also considered as a technological factor.

Organizations have to use robotics and automation in order to increase their productivity and thus, the promotion of technology usefulness is significant. Shin and Choo [58] examined theoretical models, particularly TAM through path analysis and multiple linear regression analysis to identify the major determinants of intentions towards robotics. The top determinants were found to be perceived ease of use and perceived usefulness.

However, only a few studies have conducted an assessment of perceived usefulness of robots [59] although the design and use of robots in the future is expected to hinge on their acceptance and ability to meet the demands of the aging population. Robots acceptance is influenced by perceived usefulness in varied domestic and healthcare work tasks. For example, Broadbent, Stafford [60] conducted an assessment of the perceived usefulness of robots among staff in performing different tasks ranging from assistance with cleaning to overseeing vital signs. The most highly ranked tasks in terms of robot usefulness were noted to be daily activities and health/safety monitoring, whereas personal care provision, medical advice and assessment of sadness were the lowly ranked ones.

With regards to the increasing development of and attempts at providing insight into the interactions of social robots, Park and Kwon [61] used the structural equation modeling and confirmatory analysis. They found perceived usefulness to be the topmost determinant of intention towards robots use, and in the process, they confirmed the relationships of the original technology acceptance model.

Thus, this study includes usefulness factor as one of the important determinants of the robotics and automation use.

c. Infrastructure

Developing nations often have poor infrastructure [62, 63] and as a consequence, IT infrastructure is expected to influence robotics and automation adoption in developing countries. Infrastructure is considered as a technological factor in this study because in prior studies, IT infrastructure has been deemed as one of the top factors that has a key role in successful system implementation [64].

In a related study, infrastructure was found to be one of the major challenges facing technology implementation in Africa by [65]. This holds true in adoption of robotics in developing nations. For instance, Willcocks, Lacity [66] examined IT function and its role in robotics, using casework and interview approaches and indicated misunderstanding of robotics attitudes and their mismatch with corporate IT infrastructures.

Meanwhile, in Byrd and Turner [67] study, the authors defined IT infrastructure as the shared IT resources that comprise of technical basis of hardware, software, communication technologies, data and core applications and human component (skills, expertise, competencies, commitments, values, norms, and knowledge), combined together to develop IT services that are distinct to an organization. Such IT services forms the platform upon which communications are made possible throughout the entire organization and of business applications in short- and long-term development and implementation.

d. Subjective Norm

Subjective norm is the individual's judgment of what society or societal rules think about his actions. It is the individual understands of acceptable/unacceptable behavior by others who are important to him [68]. This construct influences his decision to conduct or refrain from conducting the behavior in a specific circumstance. Subjective norm reflects the societal expectations of a specific behavior [69].

Majority of studies on subjective norm shows its positive effect on consumer's intentions and based on the reviewed literature, subjective norm influences the behavioral intentions of the individual [70].

The above result was supported by Piçarra, Giger [71] that examined the effects of factors on work intention with social robots in the future. Accordingly, the theoretical framework of the study was underpinned by the theory of planned behavior (TPB) and subjective norm was among the primary predictors of work intention with social robots in the future. Subjective norm is considered in the present study as one of the major factors that could influence behavioral intention towards robotics and automation usage.

5.2 Organizational Factors

The adoption of technology can only be successful if the whole organization takes part in such process. In this regard, senior a management has to be proactive in his involvement in new technology adoption [72]. New technological approaches to adoption and use vary but it is important to possess an integrated records management system rather than an isolated version. According to Aldosari [73], organizational support is a top factor for IS adoption and use success.

In relation to the above, industrial organizations commitment have largely been overlooked when it comes to robot acceptance, with prior studies focusing on managerial influence on workplace culture and attitudes in a standard business environment in order to earn a competitive edge. Majority of the used frameworks also tended to overlook task or organization when investigating robot aspects like its design and usability [74].

In addition, organizational factors were evidenced to be one of the top barriers to the use of robots and automation and these cover top management support, financial support, training and readiness. The overview of the factors is detailed in coming paragraphs.

a. Top Management Support

The level to which top management believes the importance of technology function and the content of its contribution to the technology activities is encapsulated in the factor of top management support [75].

On the basis of Chae, Yoo [76]'s study, top management support may have a positive/negative influence on technology adoption, with most studies supporting that lack of management support on the use of technology could lead to failure of its adoption [77]. Stated clearly, lack of organizational support could prevent user form using the technology [78].

In contrast, the presence of management support in accepting technology guarantees its use in the organization as evidenced by [79]. The author integrated management support into the model and used it to investigate the determinants of adoption of adverse event reporting systems by professional users. The study findings showed that management support is a significant adoption factor.

Similarly, Rouibah, Hamdy [80] revealed that top management support positively influences IT acceptance and adoption, with top management support categorized into two (direct and indirect). The authors described the former as the IS staff positioning in planning and developing stages, while the latter to the use of vendors and consultants to help in adopting the system within the organization. Generally speaking, studies support the positive effect of top management support on the effective technology functioning and performance.

Therefore, in the present study, top management support is considered as a factor that may influence robotics and automation adoption and use, and lack of such support could lead to challenges in the technology development, planning and usage.

b. Financial Support

Although robotics have been used in some countries increasingly, it is important to cautiously interpret the findings Frey and Osborne [26] that are based on the feasibilities of technology. The study failed to consider actual economic factors and other factors like relative costs, which could confine automation use. In this context, financial support is important for robotics technology use [81, 82].

Generally speaking financial factors have been overlooked in studies although Payr, Werner [83] showed that financial reasons may be one of the determinants of robotics. Along a similar line of study, Yoon, Chang [84] investigated the existence of technology in the Korean context and showed that financial support is a top factor that prevents/facilitates adoption of technology. This highlights the need for Korean organizations to provide financial support for technology implementation and eventually, system adoption.

Moreover, Chan [85] laid stress on the importance for organizations to appropriate human, financial and technical resources to manage their system activities. Successful implementation of systems requires significant resources and costs, including those that are related with the setting up, maintaining and improving the system. Stated clearly, costs to be incurred are a significant barrier to system implementation [86].

Evidently, financial support has a positive and significant influence on the successful adoption of technology and as such, this study examines financial support and its role in influencing robotics and automation adoption in the Saudi industrial companies and transformational sector.

c. Training

Literature evidences that successful technology adoption calls for sufficient training of employees via in-service programs, conferences, seminars and workshops so that they may address technological functions and thus, training is a factor that is examined in the present study.

In the context of healthcare, training and credentialing for robotic surgery in otolaryngology (head and neck surgery) has yet to be standardized [87] and it still dependent on industry guidance. It is important for organizations to adopt guidelines for training and credentialing of robotics as it is significant for the use or implementation of any technology.

Also, Terry, Brown [88] conducted an examination of the experiences among healthcare providers and staff that are faced with implemented system and had experience in its daily use. The findings showed that several factors prevented the use of the system and they are related to IT challenges namely learning how to use the technology and computer use. Two factors were also highlighted to motivate daily use and they are efficiency of patient care and confidence with computers and software. The system rate of use can be boosted by assessing and enhancing computer skills, promoting data entry consistency and its use, which are all encapsulated in training, confirming that need for training in the adoption and use of technology.

Lastly, training staff ensures the overcoming of risks that may prevent system adoption and implementation success. The lack of technical training and support could bar the adoption of systems among doctors [86]. Additionally, lack of training could lead to unfamiliarity with the system and computers, which would eventually lead to implementation failure [89].

Thus, training factor is vital for adoption therefore this study include it as one of the proposed framework components.

d. Readiness

Readiness was examined by Mahbub [90] in light of a developing country, Malaysia, in accepting construction automation and robotics. The study explored industry viewpoints, suggested practices and barriers to implementation using a questionnaire survey and semi-structured interviews among Malaysian construction firms' contractors, specialist sub-contractors, developers and consultants. The study found that Malaysian construction industry has readiness to a specific level, to implement technologies in areas of prefabrication and assembly and in design, planning and costing stages.

The general scenario in industries is such that employees are encouraged to work alongside robots and the similarity between humans and robots is a significant facilitator of the positive attitudes towards the latter, with readiness having a hand in addressing the issue.

Moreover, readiness functions as a means of measuring progress as opposed to the academic measures of progress (number of publications/number of citations) and the industrial measure of success (monetary profit) [91]. Considering the readiness factor in overseeing successful transfer may result in enhanced process of transfer.

Hence, in the present study, readiness is considered as a factor that could influence intention towards robotics and automation usage that is expected to enhance the overall organizational productivity.

5.3 Trust Factors

In developing effective relationships like interpersonal relationships and human-technology relationships, trust is a major component. Trust is an all encapsulating concern that influences the effectiveness of the system, particularly in relation to safety, performance and rate of use [92]. Taking this into consideration, trust has become a focal issue in the development and integration of automated systems. It is increasingly important to have trust in the synergistic human-machine relationship [93].

Trust refers to the inclination of a party to be vulnerable to another party's actions based on the former's expectation that the latter will perform a specific action that is important to him, regardless of the monitoring or controlling ability [94]. Trust is the inclination towards taking risks. In Morgan and Hunt [95] study, the authors stated that commitment and trust are important in relationship marketing, as it develops a cooperative behavior that will result in success. Trust is a top determinant of relationship commitment, and therefore, the inclination of the party to rely on another.

Trust on new technology has been examined in several contexts and nations. To begin with, Sambasivan, Patrick Wemyss [96] examined intention towards using e-procurement systems in Malaysia and Weiss, Bernhaupt [97] explored the acceptance of human-robot interaction, with trust as an important variable.

In a study of the same caliber, AbuShanab, Pearson [54] revealed the effects of trust on behavioral intention in light of the acceptance of internet banking in Jordan. The authors revealed that the findings hinged on potential risk of losing access to the funds of the respondents. Also, Foon and Fah [98] researched the Internet banking adoption in Malaysia and revealed trust to be related to and influenced behavioral intention.

The result was supported by Heerink, Kröse [56] in their study that examined acceptance of assistive social robots by older adults. They found a correlation between trust and intention towards using robots. Meanwhile, De Graaf and Allouch [99] stated that acceptance of social robots, specifically, owing robots in the home environment could contribute to the feeling of trust among the participants if they have the skills to interact with robots.

Lastly, the elderly were willing to trust a small socially assistive robot in Torta, Werner [100] study, especially when the elderly understood the use benefits. Trust may have therefore depended on the perception that the robot is nice and safe owing to its size.

a. Efficacy

Several researchers, including Agarwal, Sambamurthy [101] referred to computer self-efficacy as the individual's ability to use the computer or IT. Self-efficacy has been divided into two sub-constructs namely, general computer self-efficacy (GCSE), which is described as the individual's ability to use a computer, and task specific computer self-efficacy (TSCSE), which is described as the individual's ability to use computer to achieve a certain tasks [102, 103]. Hence, an individual with self-efficacy and is desirous of participating is able to use technology and have control over it.

Moreover, computer self-efficacy was used by prior studies for the prediction of computer use behavior and they found the construct to significantly predict user intention towards using ICT [103, 104]. In Agarwal, Sambamurthy [101] study, computer self-efficacy was found to indirectly influence the adoption of software packages via ease of use and usefulness. Meanwhile, Jaipal-Jamani and Angeli [105] revealed that majority of studies supported the indirect and significant influence of self-efficacy on user's intention towards robotics usage.

In the present study, computer self-efficacy is defined as the ability of the employee to use the computer for training, management of training materials and interaction with trainees and trainers.

b. Reliability

Reliability refers to the level to which an instrument, devoid of bias, provides consistent measurement throughout time and items. Robotics is generally a field within which uncertainties are rife and thus, for many application the safety and reliability of the robot is quite important.

Moreover, a robot is a system that is vulnerable to uncertainties despite the need for its high reliability. It is basically a mechanical system who is responsible to move an object or itself based on the high-level motion planner's decision. These robot types possess a base that is attacked to the ground as well as an end-effector that is responsible for grasping and moving the objects that need moving – the end-effector motion has to be controlled.

In the context of robotics, [106] referred to reliability as the potential of a specific system to deliver the right services without failure throughout time. Varying measures of reliability can be appropriated for robotics; for instance, an individual component, individual robot, or MRS can be gauged – MRS should ensure success and prevent failure. The system has to be distributed and have the ability to work singly and owing to the large number of individual robots, the MRS could be fault tolerant in a new environment. MRS is also referred to as swarm robots that can effectively address a single robot failure. In this regard, MRS and swarm were differentiated in Mohan and Ponnambalam [107] study. According to them, swarm robots are a novel method to coordinate multi-robot system, comprising of large simple robots that are akin to social insects.

While a large proportion of literature has been dedicated to the robotics field, only a limited part addressed robotics reliability [108]. Also, there is a lack of studies exploring the reasons behind the failure of robots [109]. In relation to this, centralized methods to online MRS diagnosis do not effective scale because of two reasons; complex solutions and the need of communicating the individual to a central diagnosis [110].

With regards to reliability in of robots, modern robots often have the same e-components and devices as those found in computers and in the latter, unreliable components are often used, which is why reliability is enhanced through error control codes, duplication with comparison, triplication with voting, diagnostics to located failed components, among others. These reliability techniques can also be found in robotics and one of the primary reasons of robotic failure is that real environment cannot be mapped owing to its dynamic aspect.

Owing to the dynamic environment, systems that are fault tolerant affixed on mobile robots have to be consistent in handling and learning from new situations. Owing to this complexity, several methods have been proposed for robotics reliability implementation. Hence, the reliability factor is an important one that can influence the robotics and automation use in industrial firms.

c. Security

Information security can be defined as the preservation of the confidentiality, integrity and availability of information and information sources as assets [111, 112]. In majority of firms, employees and departments bring on a flood of consumer technology into the work environment and this heightens the legal compliance and security concerns for the organization. Such issues can be addressed through the use of technology, where the firm would contract one service that every employee can use [113].

In a related study, Denning, Matuszek [114] supported the above statement and revealed that robots provide several advantages but they may also bring on security issues into the workplace. McClean, Stull [115] assured that one of the primary issues that prevent increased robotics use is the issue of security aspect.

Security issues have yet to be clearly understood and in the current times, there are only a few instances of cyber-physical security exploitation, but the few that exist are considerable, as is detailed in the next sub-section. For the adequate tackling of the cyber-physical security challenges, there is a need to gather data encapsulating the nature of the threats for further elaboration [115].

Finally, security is crucial for robotics and should be considered as the top determinant when it comes to robots [116] and therefore, in this study, the security factor is considered to influence the intention towards using robotics and automation.

d. Anxiety

When it comes to computers, anxiety refers to the feeling of apprehension experienced by the user when he uses a computer [117]. Literature indicates the indirect influence of anxiety on user behavioral intention to use technology [118, 119]. This study considers computer anxiety as the employee's feeling of fear when using computer-based distance training system. It is the level of apprehension of the employee when faced with the possibility of technology use.

Anxiety stems from the fear of being deprived of satisfaction despite no clear evidence of such a thing to happen [120]. People who are anxious are concerned with the potential obstacles that they may face in the future and this worry can be real or imagined, either way this can negatively affect their performance.

Carlsson, Carlsson [121] examined the acceptance level of mobile devices and services in Finland, and found anxiety to influence performance expectancy. Heerink, Kröse [122] mimics the finding when he found the acceptance of assistive social agents among elderly users to be correlated with anxiety and perceived usefulness.

Meanwhile, in Bröhl, Nelles [123] study, the authors examined the acceptance level of the cooperation between robots and humans, using a research model developed based on literature and collaborating with people working in the robotic industry. Their model was developed in a workshop with the involvement of robot manufacturers, industrial robots users and employers using robots. They found anxiety to influence perceived ease of use (TAM model), which in effect, also influence expectancy (UTAUT model).

5.4 Intention To Adopt/Use Robotics And Automation

Behavioral intention is described as the end-user's intention to adopt new technology [124]. It is the level to which an individual user has developed conscious plans to conduct or refrain from conducting specified future behavior [49]. Behavioral intention was also described as an indication of the user's readiness towards performing a specific behavior and it is assumed to be a top behavior antecedent [125].

In this study, intention refers to the willingness of people to try and how much effort they plan to exert for the behavioral performance.

In the perspective of the technology acceptance model (TAM) proposed by [49], behavioral intention to use or adopt technology is one fundamental factor that leads to actual new system use. Hence, behavior intention to use technology or adopt determines the actual use of the system. Aside from this, based on the latest studies, behavioral intention to use technology is a mediating factor.

Prior works of Fishbein and Ajzen [125], Casaló, Flavián [69], and Solbraa Bay [51] indicated that TAM comprises of four primary factors as major determinants of acceptance of technology and they are perceived ease of use, perceived usefulness, attitudes towards use, and behavioral intention to use. According to Chang, Tseng [126] study, a significant positive correlation exists among the factors of perceived ease of use, perceived usefulness, and user's attitudes towards using technology. Moreover, attitude was correlated with user's intention towards using the technology and intention to use was correlated with actual use, which confirms the positive significant relationship of TAM constructs and the predication of user's technology acceptance.

Furthermore, behavioral intention towards technology use determines actual behavior as revealed by [112]. The author found three predictors of intention to use and they are attitude, subjective norm and perceived behavioral control. Similarly, Mun and Hwang [127] examined the effect of intrinsic motivation and computer self-efficacy on the web-based information system use, with the help of TAM. Their findings indicated that behavioral intention and self-efficacy significantly impacted actual use. Woods, Dautenhahn [128] also revealed similar results.

Majority of technology acceptance models have been developed and proposed throughout the years, with some used by researchers to investigate technology acceptance [129-131]. For instance, the unified theory of acceptance and use of technology (UTAUT) proposed by Venkatesh, Morris [132] identifies major factors in ICT acceptance as gauged by behavioral intention to use technology and actual use of such technology. The determinants are four in number and they are performance expectancy, effort expectancy, social influence and facilitating conditions. The UTAUT is used in this study owing to several advantages. While TAM is capable of only predicting technology adoption success at a rate of 30%, and TAM2 at 40%, UTAUT combined all 32 variables found in the prior existing eight models (i.e., TRA, TPB, TAM, MM, C-TPB-TAM, MPCU, IDT and SCT) and summarized them into four major effects and four moderating effects. Compared to UTAUT, TAM has been used for organizational level and behavioral intention assessment in developing nations. Notably, there is a necessity to examine intention based on the influence of different technological and organizational settings and trust in robotics and automation on the basis of the TAM model.

5.5 Organization's Productivity

Improving productivity is a notable national challenge and with the increase in competition in the global economy, new ways have to determine to enhance organizational productivity all over the world. Researchers need to provide insight into the inhibitors and facilitators of organizational productivity as new development in this knowledge area will enable relating innovativeness, technologies, organizational structures and capital in an attempt to ultimately improve the productivity of organizations [133].

Prior productivity studies in organizations were done by researchers aiming to determine the interaction among environment, technology, organization and people and their influence on the productivity of organizations [29].

Among the studies of this caliber, MacDuffie and Krafcik [134] attempted to shed light on the productivity differences in a global sample of automobile assembly plants. The study findings showed that the plants having the highest automation level were not the top productive plants. Rather the productive ones are those that introduced congruent organizational changes and technological changes. Generally speaking, congruency is defined as the match between the technology type, specified by the interdependence levels and the organizational arrangements, specified by their flexibility. Better match indicates higher productivity/effectiveness scores.

Previous work dedicated to the robotics and automation use and productivity revealed that high productivity in organizations is related with congruency among technology innovation, organizational arrangements and people factors. Studies have however failed to examine the level to which automation and robotics influence industrial productivity and to pinpoint the factors influencing the robotics and automation usage and adoption in order to ultimately improve productivity.

Hence, in this study, the factors that are needed for the successful adoption of robotics and automation are extracted. These factors are vital for the framework that should be developed and proposed for robotics and automation use in the Saudi industrial firms for productivity enhancement.

6. STUDIES ON FRAMEWORK FOR ROBOTICS AND AUTOMATION ADOPTION AND USE

Majority of the developed frameworks for the adoption and implementation process in the context of developing nations have been adapted from the Western countries' experiences [54, 135]. Important lessons can be culled from the experiences of the West but the applications of the frameworks developed therein are limited when juxtaposed to the developing nations owing to the differences in factors. In the field of IS studies, the adoption framework covers factors assisting proper adoption of technology.

Studies in literature have adapted acceptance of IT/IS models from other studies in their examination of e-learning system acceptance. Added to this, a majority of these studies were conducted in a specific environment [136]. In this section, the studies dedicated to acceptance of robotics and automation and the relevant variables are presented and discussed.

A clear explanation of social robot acceptance and use calls for the understanding of the determinants of the major acceptance variables. And in this regard, Conti, Cattani [137] and Conti, Di Nuovo [138] studies relate the way cultural backgrounds can affect the perception and intention to use a robot as a system of instrument in the near future. The study sample comprised of 37 Italian students and 37 U.K. students as future psychology professionals, experienced in actual capabilities of a humanoid robot via a live demo. The study determined the major factors of UTAUT in an attempt to determine cultural differences, using UTAUT questionnaire. The questionnaire was designed and validated for the examination of the acceptance and use of the robot. The findings from the discriminant analysis indicated a high degree of separation between the two student groups, evidencing the differences in approaches when using robotics in the two countries. The study factors included anxiety, attitude, facilitating conditions, intention to use, perceived adaptability, perceived enjoyment, perceived sociability, perceived usefulness, social influence, social presence and trust.

In a study of the same caliber, De Graaf and Allouch [99] revealed that for the successful introduction of social robots, it is important to understand the underlying reasons upon which potential users accept them in their homes. An extensive literature review was conducted by the study to determine the variables that affect acceptance of social robots, which were categorized into utilitarian variables, hedonic variables, user characteristics, social normative beliefs and control beliefs. Sixty participants interacted with a social robot, with the robot itself and the interaction experience of users evaluated to obtain results. Based on the findings, usefulness, adaptability, enjoyment, sociability, companionship and perceived behavioral control are important for social robots acceptance. As such, the current study is expected to contribute to the human-robot interaction literature with its determination of variables that could facilitate the acceptance of social robot. This study is also expected to be a benchmark for developing an integral model that includes the relevant social robot acceptance determinants.

Moreover, in a review of the different held views in politics regarding social robotics for skill augmentation of children with autism and brain disabilities, Hashim and Yussof [139] analyzed article publications of peer-reviewed journals and conference proceedings. Three emerging themes were highlighted from the review and they are influence, acceptance and adoption. The findings of their study revealed that social skilling of brain-impaired children may be implicated but they are not present in developing and designing the robot's process. Rather human social skills were appropriated to the capability and general features of the robots. Thus, the necessity for social robots is aligned with the societal changes and the increased demographics and the demands from the healthcare. More importantly, the brain-impaired children conceptualization with general views of being mentally and physically handicapped, helpless, needing 24/7 care and robotic assistance arise when humans fail. According to the status of the nation, the influence, acceptance and adoption of social robotics are political and successful societal science calls for the re-examination and redefinition of the concept to leverage the return on investment of the manufacturing of robots.

Studies in literature dedicated to adopting robotics and automation are still few and far between and a dire need exists to examine the technology in order to develop an appropriate framework that could assist in the proper use and enhancement of productivity among industrial firms.

ICT studies have highlighted different factors that significantly affect the robotics and automation acceptance and the top factors include perceived ease of use, perceived usefulness, infrastructure, subjective norm, top management support, financial support, training, readiness, security, anxiety, efficacy and reliability.

The above mentioned factors can be categorized into three dimensions namely, technological, organizational and trust dimensions. Technological dimension covers the sub-factors relating to robotics technology, which are perceived ease of use, perceived usefulness and infrastructure, organizational dimension covers sub-factors relating to the organization, which are top management support, financial support, training and readiness, and lastly, trust dimension includes all sub-factors that are trust-related, which are security, anxiety, reliability and efficacy.

With regards to TAM, it managed to encapsulate two factors out of the above, which are perceived ease of use and perceived usefulness, and as such, the rest of the factors were adopted from other theories in literature. The factors determination was recommended by experts who confirmed their importance in influencing the use of robotics and automation.

Although the above factors are used in IS, they have also been tested using TAM and as such, TAM is suitable to be used in this study, with extensions to include all sub-critical variables.

7. SIGNIFICANCE OF THE STUDY

This study is expected to practically contribute recommendations to the Saudi authorities when it comes to adopting robotics and automation technologies to increase the productivity of the transformational industries. In addition to this practice contribution, this study aims to contribute to literature as well.

Literature calls for the development of frameworks in adopting technology, particularly in the context of transformational companies. This research answers the call by adopting a distinct approach from existing studies in proposing a new framework.

In the face of the recent dynamic developments in technological capabilities in the field of robotics and automation, society is handed with the potential to leverage them and along with it, several challenges to tackle. For the effective leveraging of such technologies, an in-depth understanding of the influence of robotics and automation on growth, productivity, labor, and equality has to be achieved. In this regard, there is a need for systematic data regarding the robots and automation adoption and use, specifically in the business level to provide insight into the technologies role in the economy and society. The development and aggregation of such datasets, via census, surveys of public and private organizations, and gathering of internal data from individual firms, would provide the tools required by researcher and policymaker circles to conduct empirical investigation to the effect of robotics and automation and develop suitable responses to the ongoing phenomenon.

Lastly, this study contributes by meeting the need for accurate data in this area that can assist in boosting national competitiveness, especially when developing suitable policies. The minimal amount of information concerning robotics and automation could lead to the inability to prepare for the technology advancement advent, which could eventually lead to missed opportunities and in turn, disastrous outcomes. For instance, decisions on taxing or subsidizing robots and automation depend on the understanding of whether or not technology should be used as substitute or as a complement. Such decisions can influence the patterns of adoption and if such adoptions are made haphazardly without the right information, this could result to lower economic growth, lower hiring levels and lower wages. Additionally, data has to be properly used in response to the outcomes of adopting technology.

Thus, this study would empirically test the variables that influence the adoption of robotics and automation in the context of transformational industry which would provide further insight in regard to their ability in increase the productivity. Although there is lack in existing studies on automation and robotics in developing countries and as well as in Saudi Arabia region at the time of the current research, this study will enrich the industry sector with valuable information and can be used as a guidance for implementing robotics and automation.

8. DIFFERENCE FROM PRIOR WORK

Prior studies in literature primarily focused on the advantages of technology adoption, while largely ignoring the determinants of adoption and the required technological tools [140]. The important merits that include high labor intensity, dependence on local skills and technology, entrepreneurship development, ingenuity and increasing industrial networks that are consistent with promotion are more accessible to developing nations [141]. Although the potential for this technology's adoption is high, the current adoption is still lagging behind and therefore, in order to enhance it, it is required to understand the determinants of adoption decisions [142]. This urgently calls for the identification of factors influencing behavioral intention towards adopting and using robotics and automation in the Saudi transformational companies.

On the basis of academic research conducted on worldwide robotics, robotics may be the reason behind the 1/10th increase in productivity in the years from 1993 to 2007 [19]. On the basis of the paper published by the 2016 Economic Report of the President, the demand for robotics all over the world has almost doubled in the years from 2010 to 2014 and this is accompanied by the number of robotics-oriented patents (CEA 2016), indicating the increasing contribution of robots to productivity more than ever.

Therefore, this study is considered to be important and different since it aims to identify the significant factors that will promote successful adoption for robotics in developing countries. This will help in enhancing the productivity of transformational companies of developing countries including KSA.

9. CONCLUSION

The IT importance for both employee and manager circles alike in the public sector is what propels the policy makers to consider the importance of factors affecting the IT acceptance to enhance public organizations productivity and technology acceptance.

This paper provided some of the factors that can influence robotics and automation acceptance in Saudi industrial firms and they are anxiety, attitude, facilitating conditions, intention to use, perceived adaptability, perceived enjoyment, perceived sociability, perceived usefulness, social influence, social presence, trust and behavioral intention to use.

In this paper, the author is convinced that addressing the major issues related with the factors is significant to the adoption of robotics and automation in the transformative industry of Saudi Arabia, as a developing nation. Accordingly, this study focuses on the level to which technological factors from the literature review (perceived ease of use, perceived usefulness, infrastructure and subjective norm) are crucial for the adoption. Aside from technological factors, organizational factors were culled from past models and literature (top management support, financial support, training and readiness) for their influence on robotics adoption in developing countries public firms. Along with the above factors are trust factors that were adopted from prior literature and they include efficacy, reliability, anxiety and security for their influence in robotics and automation adoption.

It is evident from the literature review that studies categorized factors influencing the robotics and automation adoption into groups namely, technological factors, organizational factors, environmental factors and individual factors, while this study categorized them into technological, organizational and trust factors. This study argues that the categorization should be

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included in a comprehensive framework based on the findings from literature. In addition, the future researches should explore more factors that could contribute to the successful adoption of such technology. The researches should come up with empirical data about the identified factors.

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