Journal of Innovation & Knowledge 5 (2020) 59–67

Journal of Innovation & Knowledge

https://www.journals.elsevier.com/journal-of-innovation-and-knowledge

Understanding the robotization landscape transformation: A centering resonance analysis

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ARTICLE INFO

Article history:
Received 20 January 2019
Accepted 28 January 2019
Available online 14 March 2019

JEL classification:
M15
O31
Q55

Keywords:
Automation
Robotization
Text-mining
Centering resonance analysis
Empirical study

ABSTRACT

The ever-increasing worldwide demand for automation has augmented the adoption of technologies such as artificial intelligence and machine learning for industrial developments. Among the recent technological advancements, intelligent robots are increasingly becoming an integral part of several firms. The study focuses on the impact of intelligent robots on productivity, competitiveness and how firms are leveraging automation. This study uses centering resonance analysis (CRA) to develop an empirically grounded understanding of the rationale for robotization, through secondary archived data. Through the content analysis of over 261 online published articles, we decipher the derived themes through the following theoretical frameworks: behavioral, economic, and operations management perspectives. The findings suggest that firms are leveraging the concept of robotization to increase performance, efficiency, and profit. The deployment of robots in various firm domains focuses on public welfare, consumer orientation, and a sustainable environment and agriculture.

Introduction

Rapid technological innovations and advancements have played a significant role in reinventing and reframing society. Digital revolutions have had a substantial impact on practically all aspects of our society, life, firms, and employment. As per the World Economic Forum (WEF), while the continuous technological advancement is leading the world to the threshold of the Fourth Industrial Revolution, it would cause the loss of five million jobs in the majority of the developed and emerging economies (Cann, 2016). According to WEF estimates, redundancy, automation, or disintermediation could be the possible explanatory causes behind the loss of 7.1 million jobs (Brinded, 2016). Rapid advances in a host of technologies such as artificial intelligence, big data, robotics, blockchain technology, 3-D printing, medical imaging, and computer vision are regarded as the possible reasons behind mass unemployment. However, some recent studies view the above notion as groundless fear and foresee the creation of specialized and high-skilled jobs related to computers, mathematics, and architecture (Thompson, 2016). While the previous "industrial revolutions" were all about manufacturing and automation of redundant, repetitive tasks, the recent shift involves the transformation of professions and possibly additional disruption and dislocation. The exponential rate of technological development and advancement will revolutionize almost every single industry. The jobs that fell under the exclusive domain of human cognitive ability and competence are now being done by software, algorithms, artificial intelligence, and big data analytics. Such a trend of technological advancement may lead to massive economic growth and global development (Grothaus, 2017). The advent of rapid technological advances leads toward the dissolution of the distinction between the physical and digital world.

Artificial intelligence is evolving continuously and has carved a niche for itself from the lab into the mainstream industrial developments. Recent research shows that artificial intelligence (AI) technologies are being increasingly deployed or planned for deployment by most large companies (Infosys, 2017). The devices and appliances utilized in everyday life are increasingly becoming "smart." Internet connectivity has exponentially multiplied the capabilities and performance of phones, watches, eyeglasses, and cars. Among the recent advancements in artificial intelligence, artificially intelligent robots have gained a special status and a prominent existence in our lives with their considerable potential to transform our lives.

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https://doi.org/10.1016/j.jik.2019.01.005

Robot integration within firms and across industries, expect these technologies to bring disruption followed by growth and opportunity, thus profiting and proliferating benefits for employees, customers, and other stakeholders. However, the potential for disruptive change also brings fear and uncertainty. Amongst the various concerns raised due to the rapid introduction of automation and AI are the issues of job loss, unemployment, inequality, singularity, security, and artificial stupidity. AI raises the primary concern of how machines will impact human behavior and interaction. The ability of AI bots to model human conversations and relationship is becoming increasingly better (Maruti Techlabs, 2018). A bot named Eugene Goostman won the Turing test in 2015, tricking 33% of panel members into believing that it was a real human boy during a five-minute long conversation (Aamoth, 2014). The report authored by the economist Daron Acemoglu of MIT and Pascual Restrepo of Boston University in 2017 found that the introduction of robots in the US economy results in the decline of wages of workers. The average salary decline was considered to be between 0.25 percent and 0.50 percent per 1000 employees, in the light of every single robot introduced (Acemoglu & Pascual, 2017).

Robots are one of the latest technological progress that is being used in businesses recently to boost productivity and performance at an augmented rate and impact. Robots come in many forms, such as self-driving cars, automated military drones, elder-care robots in our homes, in operation theaters, and many more spheres (Kelly, 2014). The continued decreasing cost of developing robots with escalated capabilities, and with a relatively low density of robots in most industries, the International Federation of Robotics (IFR) anticipates that yearly robot installations will continue to grow to double-digit rates for the time being (IFR, 2017). According to World Robotics Reports (IFR, 2016), by 2018, almost one-third of the robotic deployment will be smarter. Robots with increased efficiencies will work in collaboration with other robots safely alongside humans. However, while the world is being overwhelmed by penetration of AI in the form of robots into the economy, various socio-economic concerns are raised such as job loss, inequality, moral and ethics of machines as they get more sophisticated and smarter (West, 2015). The empirical literature on the impact of robots is still in its early stage. However, the recent studies on robots have started to support the idea that robot integration in firms accelerates productivity, improves quality and reliability, reduces costs, lifts wages and even total labor demand, but are most beneficial to high-skilled workers (Smith & Anderson, 2014). Economists are worried about "polarization of jobs," causing the decline of middle-skilled jobs, but the expansion of low, high and skilled jobs (Canon & Marifiyan, 2013). In effect, the workforce division is into two distinct groups: low-paid, unskilled workers and highly-paid, skilled workers. Shewan (2017) suggests a 60% increment in average salaries in the robotics department by 2020, however more than a third of the available jobs in robotics will remain unfilled due to a shortage of skilled professionals. AI researchers advocate the creation of an educable robot with the cognitive capabilities of performing tasks currently done by humans. Leslie Willcocks, an eminent researcher in field of effect of technology on work, provides insights in Huffington Post: "Contrary to today's worst fears, robotics could facilitate the rise, not the demise, of the human "Knowledge worker", but managers need to prepare staff for the unavoidable changes to their current jobs, enabling them to upskill specialize and re-train where necessary" (Willcocks, 2016).

With the advanced use of artificial intelligence in the form of robots, computers and other machines, the advent of the recent technological advancement is mostly at the expense of middle and low skilled workers (Hajkowicz et al., 2016). Extant studies compare the productivity impact of robots on the contribution of steam engines (Mark & Scott, 2015). Productivity gains from robot densification are often shared with employees in the form of increased wages. Income inequality is a prominent issue in the 21st century, and as robotization impacts different income and skill groups differently, it will drive a significant focus on the issues related to income inequality and consequences. Against this background, we attempt to understand the various ways through which firms are leveraging the concept of robotization and the potential payoffs.

The present study focuses on the impact of robots and how the companies are leveraging the concept of artificial intelligence in the context of robots in the workplace. Through this study, we aim to create an understanding of the introduction of robots in the various sectors of the workplace and their impact. Robots are gaining an integral status in society and will impact every facet of work and home. They have the potential to transform lives, and hence studies on robotization look into the different ways robots can impact the various strata of society. This study is essential in the current socio-economic situations as this study aims to explore the various dimensions of robot deployment and its impact on society, and how they perceive it. We conduct this study by analyzing secondary data in the form of published online articles and coding them to draw specific themes. Online articles provide and cover the current trend of news and happenings, and hence have the potential to create a clear vision and understanding of any particular phenomenon. Since robotization is an emerging issue with indirect impacts, we rely on recent articles and text-mining techniques to develop a nuanced understanding of robotization.

Background and literature review

Robots are expanding in magnitude and impact, all around the developed world with an increasing number of industrial robots in operation (IFR, 2016). According to the International Federation of Robotics (IFR, 2017), the overall estimates of installation of new industrial robots worldwide would be 1.7 million by 2020. The early 21st century witnessed the first wave of companionable social robots such as AIBO and Paro. Traditional robots were deployed in factories and were involved in manufacturing and transportation jobs. With the advent of technological progression, the robots have gained more sophistication and advancement in the form of service robots, humanoids, Pepper, Jimmy, and Sophie, to name a few. In a survey, the United Nations (UN) has categorized robotics into three major domains: industrial, professional and personal service robotics (UN, 2002). While the industrial robots are deployed, the professional and personal service robots assist humans (Fong, Nourbakhsh, & Dautenhahn, 2003; Thrun, 2004). The current day social robots possess the remarkable trait of being social through their advanced capability to receive and respond to human speech and to comprehend the underlying emotions and complexities (Hall, 2017). Studies have been conducted on human-robot interaction in the stream of psychology. Such machines are capable of creative actions and response, paving the way toward better and proficient interaction between humans and machines. The increasing capabilities of robots accelerate their possibilities of high-level functions as team members. However, the assumption that the introduction of robots in human groups will lead to improved performance, compared to when the groups or robots operate autonomously, may not be always true. The addition of robots may result into improved team competences, but it may also create challenges that need to be addressed for the efficient performance of such hybrid partnerships (Adams, Bruyn, Houde, & Angelopoulos, 2003). The prior research on human-robot interactions has highlighted the crucial role of robot design on the level of interaction between the two (Chen, Haas, & Barnes, 2007; Chen, Barnes, & Harper-Sciarini, 2010; Keyes, Micire, Drury, & Yanco, 2010). The relationship between humans and robots also impact their interaction (Evers, Maldanado, Brodecki, & Hinds, 2008).

Method

This study employs content analysis to assess the information from the selected online articles. Content analysis is a research technique used for the systematic assessment of the theme of recorded communications (Kolbe & Burnett, 1991). The content analysis technique facilitates the creation of smaller categories through the synthesis of texts with a large number of words (Stemler, 2001; Weber, 1990). This technique provides valid inferences and understanding of the aim of the written texts (Weber, 1990) and provides an empirical starting point for the generation of new research evidence (Kolbe & Burnett, 1991).

We utilize centering resonance analysis (CRA) technique, a particular type of content analysis tool as described in the next section. Keywords such as automation in firms, artificially intelligent robots, and companies, robotization and performance were searched, and about 308 online articles selected for the study were thoroughly examined, and the search was limited to 261 online articles. We included articles that focused on the introduction and impacts of robotization and excluded the general articles on robots. The articles search was done from May 2018 until August 2018, to get the latest updates on the robotization. We included general web articles, firm reports, and other anecdotal articles through a web search. The Internet is an active and accessible platform. The data set was focused on online articles as they provide with the latest information and the views on specific phenomena. We focused on online articles to gain a direction for the deployment of robotization and impacts. The anecdotal articles, practitioners' reports and research articles, news articles were reviewed to identify discernible patterns based on the text to draw coding categories. The initial manual coding results were further analyzed through content analysis utilizing CRA software.

Centering resonance analysis

Centering resonance analysis (CRA) is a sophisticated technique of content analysis methodology (Corman, Kuhn, McPhee, & Dooley, 2002). CRA was utilized to analyze reports as it interprets the meaning of specific texts (Holsti, 1969) and hence, appropriate for studying formal written communications (Corman et al., 2002). This technique analyzes words and phrases together in significant ways to form a network, depicting their influence and inter-relationship (Corman et al., 2002; McPhee, Corman, & Dooley, 2002). Compared to other methodology tools that rely on frequency counts of words and phrases with scant significance to the interrelationship between words, CRA creates maps, representing conceptual relationships visually. Unlike other techniques, CRA relies on the utilization of linguistic centering theory to determine an important word. CRA does not consider words in isolation but determines their influence building on their betweenness centrality in the network of words. In sum, CRA utilizes a network perspective. CRA facilitates identification of key terms and hence key practices subsequently. According to CRA analysis, a word in a text is considered to be more influential if it draws other words together in the text network that reflect some meaning (Canary & Jennings, 2008). Accordingly, an influence value is assigned. Corman et al. (2002) validated Crawdad as a useful tool for utilizing CRA. Crawdad allows enhanced retrieval of information, network visualization and enables secondary analysis and hence exceeds earlier text analysis tools (Lee & James, 2007). The use of Crawdad to perform CRA has been reported in various scholarly and research articles (Corman et al., 2002; Dooley, Corman, McPhee, & Khun, 2003; Lichtenstein, Dooley, & Lumpkin, 2006; McPhee et al., 2002). The acceptance of Crawdad and CRA is increasing across various fields and prestigious journals (Tate, Ellram, & Kirchoff, 2010). Crawdad version 1.2 text analysis system was utilized to perform CRA in this study.

Text analysis

The online articles were converted into readable text documents. The available online articles in this study averaged 500 words for each article. Hence, content analysis was the appropriate methodology to assess over 130,000 words to determine the existing pattern in the articles. Each sample was processed individually in the CRA software system (here Crawdad). The Crawdad Text-analysis program highlights the presence, influence, and resonance of code words (Augustin-Behravesh & Dooley, 2018). The CRA creates network maps of the words for every sampled article and influence values between 0 and 1 are assigned to words based on the principles of CRA, as explained above. Influence value of 0.01 is considered to be important, while a value above 0.05 is considered to be very important (Corman & Dooley, 2006; Dooley, 2007). To illustrate this concept better, a CRA network map and its top influential words are shown in Fig. 1. The highlighted words are the most prominent words amongst the pool of 261 articles. Below we present the top influential words with their influence value in the table format to provide a clear picture of the map. The Crawdad system parameters were set to identify the 300 most influential and important words that were common in the online articles. The goal was to determine the highly significant words across the pool of 261 articles.

Theme development

To assess the thematic structure of the online articles, we conducted exploratory factor analysis (EFA) utilizing principal component analysis with varimax rotation. The nine themes that emerged revealed coherent groups of words which provided the foundation for naming the themes and latent coding. Latent coding facilitates the analysis of underlying implicit meaning in the text (Neuman, 2000). The secondary latent coding allowed the logical connection of words to themes and further strengthened the face validity of the theme. About 34.6% (104 words approximately) of the initial (300) influential words were removed due to low loadings in EFA. Words were recoded from the original EFA loadings to a different theme, based on better suitability and interpretability. The final developed themes and the associated words are illustrated in Table 1

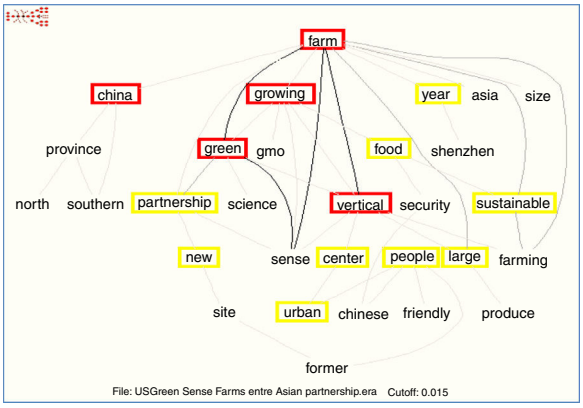
Findings

The thorough examination of the selected articles using CRA suggests specific themes that can be viewed from behavioral, economic, and operational perspectives explaining the impact of the introduction and deployment of robots on the various sectors of firms and their environment. The summary of the various themes and their relationship with robotization is summarized in Table 2.

Productivity

Firms boost productivity and performance through the exploration of the collaborative interaction between humans and machines. Machine intelligence facilitates accuracy and decision-making processes leading to increased production and firm performance. Machines can bear intensive work hours and workdays and are ideal for labor-intensive manufacturing sectors.

[1] Indicate the influential word derived from CRA analysis of a specific article.



Words	Influence Value
Farm	0.49673
China	0.16517
Growing	0.14614
Green	0.10856
Vertical	0.1015
Partnership	0.08987
Food	0.08547
Sustainable	0.07436
Center	0.07214
People	0.06411
New	0.06235
Year	0.0622
Urban	0.05587
Larg	0.05131

Fig. 1. Illustration of word network generated through CRA and important words.[1]

Table 1
An illustrative list of themes and associated words.

Productivity	Sustainable agriculture	Incentives	Public orientation	Value addition/creativity	Consumer satisfaction	Entertainment leisure	Healthcare	Human and robot interaction
Speed Factory	Farm	Driver	Parking	Job	Game	Composition	Child	Moral
Accuracy	Phenotyping	Communication	Car	Fortune	Hotel	Artist	Autism	Novel
Decision	Plant	Performance	Garage	Wage	Kiosk	Song	Therapist	Over-reliance
Proportion	Water	Official	Removal	Trade	Holiday	Painter	Interaction	Intelligent
Engineering	Crop/Control	Report	Public	Commerce	Guest	Experience	Patient	Attitude
Mechanical	Clean	Market	Road	Means	Payment	Design	Doctor	
Intelligence	Environment	Client	Internet	Inexpensive	Order	Artwork	Elderly	
Industrial	Green	Speed	Robocop	Square	Coffee	Artwork		
Technology	Vertical	Progressive	Person	Maintenance	Bean			
Firm	lighting	Innovative	Equipment	Venture	Drink			
Warehouse	Farmer	Collaborative	Security	Promotional	Taste			
Monitoring	Lettuce	Team	Legal	Helpful	Salad			
Intelligence	Agriculture	Physical	Offender	Esthetic	Ingredient			
Precision	Chemical	Cost	Lawyer	Future	Crew			
Intricate	Hybrid	Smart	Work	Demand	Food			
Vision	Pollution	Advanced	Fast	Valuable	Facility			
Boost	Climate		Construction		Pizza			
Growth	Emission		Crime		Recipe			
Efficiency	Indoor		Grocery		Contamination			
Distribution	Sustainable				Refreshing			
Settings	Solar				Healthy			
Hour					Delivery			
Amazing					Experience			
Revolution								
Solution								
Handling								
Quality								

> "You can't have people in the production. . .you drop to people speed. . .People will maintain the machines. . .deal with anomalies" (DeBord, Business Insider UK, 2016).

Apart from increased performance, the other prominent driving force to facilitate robot deployment is profit maximization. Robot deployment in labor-intensive sectors leads to a reduction in cost and resources. Robotization allows firms to minimize time, reduce workforces and improve efficiency. Robots speed up the work process and are less prone to errors, adding to the overall performance and profit of the firms.

However, there is a different side of the story where the robot deployment can lead to the loss of redundant jobs and create economic and social disruption. As robots evolve in capabilities, they may displace a higher proportion of the workforce in a small span of time as compared to previous technological waves. The technological boom in the form of robots can reduce the value of human labor. As per the basic economic understanding, robots generate wealth, but the distribution and accumulation of wealth in the traditional way can pose problems. The unsatiated human demand motivates the firms to produce more goods within less time, through robot deployment. However, demand for the goods produced may become somewhat saturated, as people may soon discover new areas of demand leading to a loss in the long run.

Sustainable agriculture

Certain firms aim to address environmental concerns through automation and ensure environment-friendly steps in agriculture, such as policing of water and reducing the use of crop chemicals. Such companies utilize specialized LED lights, environmental controls and promote water recycling to induce an eco-friendly mode of automated cultivation and cost reduction. The concept of automated cultivation curtails the dependence on climate and enhances productivity. In the age of growing population, where food insecurity is a significant issue, the concept of automated cultivation can be developed as a novel solution to the increasing global food problem.

Table 2
Summary of themes and relationships with Robotization.

Themes	Robotization
Productivity	Robot deployment leads to accelerated productivity and benefits through • Profit Maximization • Reduced Time • Efficiency • Reduced workforce
Sustainable agriculture	Introduction of robots in agriculture draws major incentives addressing environmental and food insecurity issues • Eco-Friendly • Water Recycling • Reduction in chemicals • Pollution Control • Led Lights • Increased Production
Incentives	Firms draw several incentives to climb the value chain through • Accelerated production • Improved Performance • Accuracy • Precision
Public orientation	The introduction of robots to deal with the regular tasks of daily life has made lives easy for masses • Law and Order • Daily chores (vacuum, gardening, cleaning, home security, grocery) • Surveillance • Car Parking/Transportation • Lawyers • Education
Value Addition/creativity	Robotization has several rewards as it adds value to the economy through • Creation of skilled Jobs • Innovativeness • Digital Know-how • Creativity
Consumer satisfaction	Robot presence in the various sectors of consumerism adds to hassle-free and profitable consumer experience • New Shopping Experience • Customer Trust • Customer Loyalty • Hassle-free Shopping • Competition-driven
Entertainment/leisure	The field of art and music accepts automation to add in • Experience • New artwork • Innovation
Healthcare	Robots in healthcare are an essential addition making the sector more innovative and friendly • Autism • Therapy • Elderly care • Routine health check up • Surgeries requiring precision
Human–robot Interaction	Human–Robot interaction raises issues related to ethical and novel robots • Moral • Over-reliance • Novel • Attitude

> *"The birth of many new technologies have. . .automated cultivation, water recycling, specialized LED lights for plant factories, and environment controls. . ."* (Spread Co. Ltd., 2017).

While there is a surge to introduce automation in agriculture, there are a few basic principles that should be taken into account. First, the farmers should realize the long-term benefits of robotic agriculture compared to the cost involved. Second, the technology should be easy to adapt and simple to use. The technology should be sophisticated and revolutionary, but simple on the surface to allow easy adaptation and exercise.

Incentives

While the majority of media headlines are condemning the widespread deployment of robots within firms, our results advocate the numerous incentives of robotization. Whether robotization will be good or bad in the long run will depend crucially on the response of private firms and public policies.

There are real signs that robotization is facilitating firms to move up the value chain, through accelerated production and improved performance. Robots are capable of producing increased high-quality products. They are accurate, can produce more in a small span of time, and are capable of undertaking repetitive applications efficiently compared to humans. The innovations associated with robots add to the incentives drawn from this form of technology. Creativity, speed, advancement, progressive are some incentives that help firms to increase communication with other firms and open the gateways for further development and collaboration with new clients. Surging online commerce platforms and tight labor markets pose difficulty in filling in warehouse jobs, and robots provide the best option in such circumstances. The above arguments fall in sync with the statement of Robotic firms stated below.

> *"Robotics firms . . .help people work faster and boost productivity during busy times, such as the holidays, when extra labor is harder to find. . . .not meant to replace human labor, greater throughput . . .same size workforce."* (Smith, The Wall Street Journal, 2017)

High-end technology such as automation can reduce market risk for firms. Deployment of robots provides a safe work environment as robots can do dangerous tasks and can work in a hazardous environment that can be lethal to humans. Robot deployment saves time, reduces waste, and provides more flexibility and smaller footprint production lines.

Public orientation

The technological innovation in the form of robots is remarkably being introduced in various spheres of human lives leading to transforming impact. The introduction of the first Robocop in Dubai poses an excellent example of technological advancement embracement. Dubai plans to create a human-free police station by 2020, with the initial crime reports and fine processings being carried out by robots. Robots parking cars, delivering grocery at the doorstep, constructing roads, home security, are some spheres that are facilitating comfortable and hassle-free day to day lives.

Value addition

Firms consider that deployment of robots in low-skilled sectors would enable the employees to concentrate better on the jobs that require creativity and high-skilled activities. The accelerated rate of deployment of robots in business and increasing job insecurity motivates the existing employees and the future workforce to enhance their skills and create high-skilled jobs. The technological intervention is a medium to enhance efficiency. The reduced dependence on humans in labor-intensive tasks saves time and motivates the employees to concentrate on other precise and core specialized tasks. Hence, this motivates workers and allows them to invest in more skilled tasks adding to value creation and innovativeness. As future work requirement will be more concentrated on highly specialized streams such as digital know-how, creativity, management capability, complex problem solving and entrepreneurship, the continued success of firms will be dependent on the correct anticipation of future skills requirements.

"While automation technology has contributed to the loss of 800,000 low-skilled jobs in the last 15 years. . .replace them with 3.5 million higher-skilled ones . . .not destroy it" (Deloitte, 2015).

The above argument reflects that the emulation of humans is more common in low skilled jobs where routine or repetitive tasks are involved.

Consumer satisfaction

Increased customer satisfaction and better shopping experience are also a key motivation behind the adoption of robots. Introduction and acceptance of robots in companies are often competition driven. The extremely competitive market environment forces firms to adopt robots, or else they will become obsolete. Firms adopt automation to satisfy the needs of the customers and make their shopping experience hassle-free. Such steps allow firms to gain customer trust and loyalty. In recent times, customers are more interested in encountering new shopping experiences and are focussed on businesses that satisfy their needs and offer them a satisfying shopping experience. The statement from the CEO of Yum brand falls by above arguments

"We take into account all of our customers' needs for everything from food safety to maximum uptime. . .robots can work, say, standing in front of a fryer or chopping onions. . .of high turnover, especially for quick service restaurants" (Kolodny, 2017).

Entertainment/leisure

The random changing pace of the entertainment industry necessitates the adoption of new ideas and innovation to rule the market and robots claim a prominent place in facilitating the spontaneity and newness in the industry. The movie industry, live band performance, dance performance, and video games are a few areas that have exploited robots to create zeal and enthusiasm among the spectators. The inclusion of dancing drones during live performances as stage props is quickly gaining recognition within the entertainment industry. The Roboart competition, 2016 witnessed several mechanical painting devices, CloudPainter being one of them that utilizes AI and deep learning systems to make a creative decision. The exceptional inclusion of robot cameras and robot arms to pull off remarkable shots in the Hollywood movie 'Gravity' set new standards for movie making. Musical or band robots are making a mark in the world of music through the introduction of metallic machines that are designed to play real musical instruments.

Healthcare

Modern healthcare systems have been advancing and innovating and are capable of treating more diseases with the advent of new technologies. However, quality, cost, and access remain concerns causing our current health systems to be unsustainable. The introduction of robots is creating a digital health revolution and transforming impact on health systems worldwide. Robots are transforming medicine by relieving the medical personnel from carrying out routine tasks. Personal health care robots take over the job of domestic nurses by reminding the elderly patients about their medication, counseling the patients about chronic illness, and helping track patient progress. Robots are widely being utilized to perform minimally invasive surgeries that require additional precision. Sanitation and cleaning are other areas realizing efficient deployment of robots. Apart from conventional medicines robots are finding application in other streams such as psychology. Robotherapy for children with autism help to develop and cultivate cognitive skill and emotional, social behavior. The New Robotherapy for children diagnosed with autism could help reduce the patient supervision done by therapists.

"Admittedly, . . .benefit behavioral therapy for children with ASD – diminishing the therapist workload . . .RET provides mixed effectiveness for primary tasks. . .Standard Human Treatment (SHT). (Robotics Magazine, 2017).

Human–robot interaction

As human–robot interaction systems are being developed increasingly, their impact on users and society has gained profound significance and consideration. The increasing proximity between humans and robots as co-workers and colleagues arise many ethical and legal issues. The over-reliance of humans on robots for their pettiest jobs to sharing the work environment with an intelligent machine can lead to behavioral anomalies. Challenges that need attention include unintended consequences of the robot allowable tasks and the emergence of unintended situations. For example, what should be the robot's responsibility if the user needs emergency attention? Furthermore, the issue of the emotional affinity of users with human-looking robots may lead to over trust and attachment, leading to problems when they are not around.

Moreover, the over-reliance on robots can lead to ineffectiveness and inefficiency. The expanding complexities and usefulness of systems and their increased possibilities to enter human lives are introducing the studies on ethical challenges into human–robot interaction (HRI). The attitude of users toward robots and vice versa is of immense attention. The roboticists are warned of the emerging ethical challenges where robots might take over humans leading to dehumanizing impact.

"More recently there. . . from the . . .how to create ethical robots, to avoid them taking over the world" (Glaser, The Guardian, 2017).

Themes and their theoretical implications

In this study, we analyze the impact of robotization through various theoretical lenses including behavioral, economic, and operations management perspectives. From the behavioral perspective, we focus on the interplay between robots and humans and possible theoretical lenses grounded in sociology literature that can extend our understanding of this emerging phenomenon. The future workforce demands the collaborative efforts of humans and robots for the best outcomes. The camaraderie between robots and humans at the workplace offers several behavioral anomalies where humans might get depressed or over-reliant in artificial surroundings leading to ineffectiveness.

On the other hand, humans might treat robots as peers and work to increase the emotional quotient of machines. This process offers challenges when robots could absorb both positive and negative emotions and in adverse situations can result in a disaster and have a dehumanizing impact. Alternatively, humans through their treatment of robots as a mechanical creature could make the machines more mechanistic than human and perhaps defeat the objectives underlying intelligent machines. The theoretical lens through which the response of consumers in the innovative artificial behavior (here robots) is expressed, can be explained by role theory. Role theory (Hindin & Micelle, 2007) posits that individuals can behave according to socially defined position (role congruence) or against this position (role conflict) (Stock & Merkle, 2018). Role theory governs various assumptions such as individuals form expectations about the roles that they and others will play. Individuals subtly encourage others to act within certain role expectations. We expect that the introduction of robots in a social environment and the daily lives of individuals may lead individuals to form

expectation from robots to deliver services as per their desires and requirements. We assume that if such expectations are not fulfilled, individuals may refuse to accept such innovations and indulgence in their daily lives. In positive expectations, individuals may encourage the deployment of robots and would also provide suggestions and innovative ideas to upgrade robot services to provide enhanced customer support and aid. The derived themes such as consumer satisfaction, entertainment, human-robot interaction are well suited to the above theory. We propose that if the deployment of robots in various sectors of human services such as healthcare can provide individuals with advanced healthcare at a reduced cost, it paves the way for the acceptance of robots. Satisfied consumers can propose the introduction of the new technological advancement (here robots) in various other domains of human lives and motivate others to introduce them into their lives and reap benefits. The words such as autism, elderly, therapist under the theme healthcare add value to the robot introduction in the healthcare sector. Elderly care and treatment of autistic children and other patients with robotic therapists would reduce the burden of the hospital workforce. Home robots can effectively help the elderly with their daily chores and simultaneously take their care. The human-robot interaction initiated during such a process may lead to another aspect of robot deployment such as overdependence on technology. Issues such as robot moral and ethics are immediate problems, as depicted by the words such as over-reliance, moral and attitude under the theme human-robot interaction.

From an economic perspective, the same robots, replacing humans in essential sectors, keep the employees devoid of social benefits and pensions creating a social disruption. Economically, deployment of robots in the initial stages of process automation would be a disadvantage as compared to the deployment in the later stages, as it creates a loss. Likewise, the automation that leads to increased production does not guarantee the accelerated demand as compared to production. Robot deployment in the firms can create new jobs and add value to the firms as shown in the themes Value addition/Creativity and Incentives. However, studies do not agree with the promised productivity boost by automation firms (Lindeberg, 2018). The measured productivity growth has slowed down significantly, over the past decade. This deceleration is massive, cutting productivity growth by half or more in the decade preceding the slowdown. (Brynjolfsson, Rock, & Syverson, 2017). While robots and AI researchers advocate their significant role in productivity boost, job creation, wage increment and accelerated performance, such promises are not evident in the immediate future. We can explain such discrepancy through modern productivity paradox, which advocates that the impressive capabilities of AI are yet to diffused widely.

Moreover, like any other general purpose technology, the full impact of AI will not be realized without the development and implementation of complementary innovations (Brynjolfsson et al., 2017). We believe that the potentials displayed by robots in this study are consistent with this theory and it will take time before we can reap the benefits of technological advancements. Organizational changes, development, and the requirement for a skilled workforce are few tangible investments necessary for the complete realization of robotization benefits.

From the operations management perspective, the study reflects the fact that emulation of humans is more feasible when the work environment is unidirectional and the process involved is straightforward, i.e., the performance can be quantified and evaluated effortlessly. The themes of sustainable agriculture and productivity are in line with lean management concept of operations management, as they tend toward resource efficiency, conservation, and minimization of water. Lean is considered to be an indispensable factor for the success of manufacturing endeavors (Selko, 2012; Womack, Jones, & Roos, 1990). The underlying principle of minimization of waste for maximization of productivity has gained influence since been introduced into the lean construct (Ohno, 1988). The words under the theme of 'Productivity' such as boost, growth, efficiency, precision depict the positive impact of robotization on firms' performance. Sustainability is a growing concern among researchers and robots effectively address this issue to some extent as depicted by words like clean, environment, pollution, water. Robots can reduce pollution, increase agricultural productivity and simultaneously conserve natural resources. Robot deployment indicates increased productivity with less effort and more precisions within the reduced time frame. However, this could make the assembly line operations more complicated as there could be inventory accumulation at different stages due to partial automation or could make the downstream supply chain more efficient compared to the upstream supply chain, thus leading to challenges regarding resource efficiency for the firms.

To examine robotization, the study offers theoretical suggestions that are grounded in empirical evidence observed in various archived data sources. These theoretical directions would help extend our understanding of this emerging phenomenon.

Discussion and conclusion

The above points noticeably signify the positive impact of robotization on firm productivity and performance. The above arguments address the research question. Firms are leveraging the concept of robotization through increased performance, efficiency and profit. Innovation, creativity, and precision are some other significant factors that advocate for the deployment of robots in firms. Most firms introduce automation because they realize the fact that robots are the upcoming trends that are undeniable. So, firms do not want to miss the chance to sustain the market.

The findings suggest a positive impact of robotization on a firm's external environment, but its impact on the internal environment remains unaddressed (e.g., employees, the degree of dynamism within the organization) to some extent. The interaction of human and robots pose many ethical and behavioral challenges as discussed in the result section. In respect of the diversity and the complexity of robots, a technology-based framework of ethical values and principles can help to formulate regulations at every single level of conception, fabrication, and utilization of robots. The impact of robotization on the internal environment of the firms is a bit complex and depend on the policies that govern the firms. The study reveals that although robot deployment assures a positive impact on the firms, it does create insecurity in the form of low skilled job loss and financial insecurity in the society. Through the economic perspective lens, robot deployment leads to accelerated supply through production at low cost but does not align with the demand in the market. An economy like this could evolve in some ways. The possible outcome could be the emergence of an economy that pays more to an exceptionally talented few people while paying low wages to many others.

The study reveals that technology and automation specifically robotization in firms have a profound effect on the workforce. Low skilled, routine jobs are being replaced by highly specialized jobs that involve more creativity, dexterity, dynamism, and digital know-how. High-skilled jobs are being created, and the redundant routine jobs are being destroyed with the advent of technology. Automation in the agricultural sector is focused on sustainability and addressing environmental concerns. The adoption of robots points toward productivity and positivity, but it may also present a

few challenges in the future such as inequality and job insecurity. This study suggests implications for policymakers and educators to invest in the creation of a highly skilled workforce to combat the challenges of job insecurity and inequality. The chances of mitigating the risks and maximizing the profits from the technological advancement depend upon the correct anticipation of future skill requirement and the coordination of policies with education strategies.

Moreover, technological intervention raises privacy concerns, which needs to be taken into account by the policymakers. There are several endogenous threats related to robots and AI where robots might take over human intelligence and claim their superiority and coexistence, which have not been displayed in our investigation. However, the study limits in data sample and our investigation partially shed light on such threats such as over-reliance, moral and ethics of robots. The future research may draw upon the robust examination of the adverse impact of robotization on humanity.

Acknowledgments

We would like to thank Dr. Jacqueline Corbett, Associate Professor (Université Laval) for her insightful comments and suggestions to improve this work.

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