India, The Fourth Industrial Revolution and Government Policy

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Abstract

The Fourth Industrial Revolution (also called Industry 4.0) has the potential to bring about changes, which could be called 'revolutionary'. The earlier Industrial Revolutions were in ages when time and technology moved more slowly, especially across boundaries. Now, the time gap for transfer of technologies from one point of the globe to another has dropped. Technology and innovations such as artificial intelligence and 3D printing are spreading more quickly and becoming ubiquitous. The world governments, particularly in the U.S., the European Union, and China, are backing the private sectors where the innovation and investments into latest, ground breaking technologies are taking place. The governments are working to provide an environment to take advantage of the developments as well as to safeguard their economies against potential misuses. The article examined some of the developments related to the Fourth Industrial Revolution in India and across the globe. The article reviewed available literature to understand what some of these benefits could be, and what some of the potential pitfalls are. Given the huge potential impact, the paper sought to examine what the various stakeholders can do to respond and make India better prepared and quicker to adapt to gain the benefits. The article attempted to evaluate whether the government and stakeholders are ready to receive the latest technologies in India and what steps can be taken to create an enabling environment to ensure that the Fourth Industrial Revolution is not another missed opportunity.

Keywords : **artificial intelligence, cyber physical systems, data protection & privacy, fourth industrial revolution, industry 4.0, internet of things, robotics, smart manufacturing, 3D printing, 5G wireless technology**

JEL Classification : E24, I28, I38, J68, L50, O30

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In this article, the abbreviations : 4IR stands for the Fourth Industrial Revolution and I4.0 stands for Industry 4.0. It is necessary to understand these two terms better and what they have in common and where they differ. The phrase Fourth Industrial Revolution appears to have been coined by the World Economic Forum in 2016 (Schwab, 2016a) and is an umbrella term used to cover the fusion or "convergence" (Cunningham, 2018) of different technologies which have emerged almost together in a number of fields such as artificial intelligence, internet of things (IoT), additive manufacturing (also called 3D printing), and in bio-technology along with the expected coming of 5G or ultra high speed wireless technology, and many others.

The term Industry 4.0 was coined in Germany in the context of the integration of several breakthrough technologies in the manufacturing sector, including cyber - physical systems, smart manufacturing, the internet of things and cloud computing, among others (Cunningham, 2018).

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Author and technology strategist Bernard Marr stated that it does not matter which term is used and summarized that the Fourth Industrial Revolution or Industry 4.0 (both) "represent the combination of cyber - physical systems, the Internet of Things, and the Internet of Systems" (Marr, 2016, para 2).

For the purpose of this article, we will use these two terms alternately and without formal demarcation unless the context so requires.

While both terms have now gained common usage, as late as June 2015, a McKinsey article commented that, "mention Industry 4.0 to most manufacturing executives, and you will get raised eyebrows" (Baur & Wee, 2015, para 1).

The beneficial elements of these sets of technologies have been predicted by several scholars and practitioners, and some of these benefits are already visible and several more of these appear to be highly probable.

New technologies have always been seen as threats. We are still wary of genetically modified (GM) food, in spite of the known benefits it has brought to agriculture. Even the advent of CNC machines was seen as a threat with strikes and disruptions announced by workers and unions anticipating large-scale job losses. Even today, the advantages of mechanization of the textile industry are contrasted with the loss of livelihood of skilled weavers and craftsmen who have been making intricate silk sarees in India since generations.

On the other hand, there are also "jarring effects" (Johnston, Smith, & Irwin, 2018, p. 4). There is the availability of destructive power in the hands of a lay person (a 3D printed rifle was available in 2013) (Greenberg, 2013a) and in the hands of governments (the U.S. Army fired a 3D printed grenade launcher in 2017) (Hodgkins, 2017).

The stakeholders to these momentous developments include the Government of India (GoI), public policy makers and elected representatives (law makers), the regulators, the private sector and association of employers, the employees and Unions, and society at large. The need is for all stakeholders to collaborate and create an enabling environment under the benign, but watchful eye of the government.

The President of India, Mr. Ram Nath Kovind put it succulently, "We live in the age of the Fourth Industrial Revolution, throwing up both opportunities and challenges (which) requires us to design strategies for (the) future" (Kovind, 2018, p.2).

Objectives

The Fourth Industrial Relations (4IR) or Industry 4.0 (I4.0) or the Technology Revolution as this paper calls it, is predicted to have more far reaching effects than any of the changes the world has seen in recorded history. From the invention of the wheel to the creation of the world wide web, most revolutionary changes have been linear, progressive, and largely singular (one major change at one time). The 4IR is special for its simultaneous focus on several different technology revolutions happening almost simultaneously, and at great speed. Nations have to be prepared for these changes and indeed, the major developed countries are responding both proactively and sometime relatively to the changes. This paper focuses on what the Government of India and other stakeholders can or should do to take fuller advantage of the ongoing technological changes.

Review of Literature

There exists a large volume of literature about the Fourth Industrial Revolution and Industry 4.0. These are by way of books, newspapers, journals, and online articles, research papers by scholars, companies publishing their accomplishments, consulting companies preparing briefs to update clients, and by governments publishing discussion papers. Most of this literature is available in print, online, and in videos. Even as we were writing this

paper, newer developments have been published continually, extending the library of knowledge already available.

"Industry 4.0" was first unveiled by German researchers at the Hannover Fair in 2011 to herald the revolution to come wherein different advanced technologies would come together in industrial production by integrating and optimizing all the stages of production for improved efficiency (Schwab, 2016b).

These sets of technologies include artificial intelligence (AI), the internet of things (IoT), additive manufacturing or 3D printing, big data, cloud computing, smart manufacturing, wearable devises, cyber physical systems, autonomous cars, amongst others (Schwab, 2016b).

The First Industrial Revolution got underway with steam power, steam engines, and railways moving activity from muscular power to mechanical power. The Second Industrial Revolution saw the boost towards large factories and mass production with the wider availability of electricity. The Third Industrial Revolution saw the world benefit from computational power and the subsequent creation of the World Wide Web.

There is evidence that India was probably the world's largest economy and contributed almost 25% of the world's GDP around the 17th - 18th century, thereafter rapidly decreasing (World Economic Forum, 2017). Today, the gap between the nominal GDP of the first ranked U.S. ($19.42 trillion) and India at sixth rank ($2.45 trillion) is almost eight times and this is huge considering that India's population is about three and a half times that of the U.S. (Chakravarty, 2010).

Now the 4IR is here, and as Klaus Schwab, the then President of the World Economic Forum said, "In its scale, scope and complexity . . . the Fourth Industrial Revolution is unlike anything humankind has experienced before." (Schwab, 2016b, p. 7). He goes on to predict that the 4IR would change the way people live, work, and interact with one another.

The current Industrial Revolution is not about one specific new invention, say, the wheel or steam power. It is about a set of technologies simultaneously evolving and becoming available and with each technology building on the power of the others. This is the new "Technology Revolution," with the innovations developing in parallel. Along with massive increases in computational power and the imminent launch of 5G wireless technology, we are poised to witness a profound change. Probably, the most powerful of these technologies is artificial intelligence (AI). The expression was first coined in 1956 by John McCarthy of MIT, the father of the discipline (Childs, 2011). Artificial intelligence (AI) applies advanced analysis and logic-based techniques (Gartner 2017a) to perform tasks commonly associated with intelligent beings (Copeland, 2019).

Just a few years back (in 2006), AI was called a "nebulous" subject and there were question marks on what it had achieved. According to Smith (2006), significant AI breakthroughs have been promised 'in 10 years' for the past 60 years. However, with increased computing power, advanced algorithms and increased data volumes, artificial intelligence has finally come into its own. Today, AI is considered the "alpha" of all technology trends (Aggarwal, 2018). A Wharton - World Economic Forum joint study called this the golden age of artificial intelligence (Knowledge@Wharton, 2017). Today, AI is already all around us with Amazon's Echo and Google's Home bringing these technologies to the drawing room. By its nature, AI is data intensive. We now have "dataists" whose world view is that data is everything and harnessing that through AI or machine learning (ML) is the only way forward (Harari, 2016).

Some examples show the power of AI :

Ä Diagnostic equipment can spot skin cancer as accurately as a human doctor, artificial intelligence was trained using an image database of 129,000 images (Burgess, 2017).

Ä "Drishti" is an AI based solution to help the visually challenged enhance their productivity (Accenture, 2017).

Ä 3D printing (also known as additive manufacturing) is being used with great benefit to customize medical prosthetics & implants and fabricate living tissues (Ventola, 2014).

Ä India's first smart factory, where machines communicate amongst themselves, is coming up in Bengaluru at the Indian Institute of Science's (IISc) Centre for Product Design and Manufacturing (CPDM) in collaboration with Boeing (Kumar, 2016).

Ä Wipro, one of the pioneering Indian software companies, has developed its own AI system and named it Holmes and is in competition with IBM's AI system, Watson. (IBM's Watson is named after its founder Thomas Watson, and Wipro's Holmes stands for "Heuristics and Ontology-based Learning Machines and Experiential Systems"; so neither is considered a reference to the fictional characters) (John, 2014). Holmes is aimed at applications like insurance claim frauds to improving productivity in engineering drawings (Wipro, 2018).

Ä U.S. giant General Electric's India operations have invested USD 200 million to create digitally interlinked supply chains, distribution networks, and servicing units as a part of an intelligent ecosystem (GoI, 2017).

Ä 3D printing is giving customizable footwear for our athletes with their names being factory printed (Nike, 2017).

Ä Deep learning experts at Siemens Corporate Technology are developing an intelligent traffic management solution based on artificial intelligence around the Electronics City in Bengaluru. The processing takes place at the intersections itself (Siemens, 2018).

The Need for Caution

Scientists and technologists (this paper calls them "technology intellectuals") have at the same time sounded a note of caution. Artificial intelligence is also often cited for the potential of its misuse.

Legendary physicist Professor Stephen Hawking stated that, "Success in creating effective artificial intelligence could be the biggest event in the history of our civilisation. Or the worst. We just don't know" ("Should we be worried about artificial intelligence ?, " 2017, para 1). (He probably meant that we do not know, as yet.).

Microsoft founder Bill Gates added that we should be "very careful about artificial intelligence . . . if I had to guess at what our biggest existential threat is, it's probably that. With artificial intelligence, we're summoning the demon" (Should we be worried about artificial intelligence ?, " 2017, para 6).

Noted technology investor Elon Musk agrees, "I'm increasingly inclined to think that there should be some regulatory oversight, maybe at the national and international level, just to make sure that we don't do something very foolish" (Gibbs, 2014, para 3).

Technology writer Katharine Dempsey is more specific when she says, "A healthy modern democracy requires ordinary citizens to participate in public discussions about rapidly advancing technologies" (Dempsey, 2017, para 3).

Some examples of the potential misuse or malicious use of AI are given below :

Ä The first 3D printed gun was available from 2013, with designs freely available on a website (Greenberg, 2013b). Aided by the availability of Open Source software, 3D printer costs have come down (Ventola, 2014).

Ä We know that soldiers sitting in one location can remotely fly an unmanned drone over an "enemy" location and release a bomb with pinpoint accuracy using AI technology, which is only a generation or two removed from that of an advanced video game (Betz, 2017).

Ä The news from China is that advanced technology is being used to harvest data and contacts from phones for action against suspected terrorists (Johnston, 2018 ; Li & Cadell, 2018).

Ä In a major collaborative work, researchers from several universities put together a comprehensive report on

"Malicious use of Artificial Intelligence". The report pointed out that less attention has been paid to the potential malicious use of AI and listed security threats from three domains, namely digital security, physical security, and political security. For example, they predicted that changing a few pixels at a traffic signal could cause autonomous cars to crash (Brundage et al., 2018). While autonomous cars may not be a reality, the technology to disrupt the cars already exists.

Ä In an experiment, researchers hacked into and tampered with a few lines of code and then using 3-D printing installed the faulty part on a drone, which then malfunctioned and crashed. The experiment was designed to show how the malicious manipulation of 3-D blueprints can lead to mechanical failure (Johnson, 2018).

The Fear for Jobs

The one scare most often quoted is of artificial intelligence taking over jobs. There is large body of research on what jobs have been or will be lost to automation or artificial intelligence.

An OECD study predicted that 50% of all jobs are vulnerable ("A study finds nearly half of jobs are vulnerable to automation, " 2018). Other research studies have shown that these fears may be overblown. Gartner's latest study predicted that AI will create 2.3 million jobs and eliminate only 1.8 million jobs (Gartner, 2017b).

Take one example. The world is moving towards electric vehicles (EV) and so is India, where the government at one time proposed to switch over to EVs from 2030 ("India to sell only electric vehicles by 2030 : Piyush Goyal, " 2017). Practical difficulties may have pushed the deadline. Now, research by a German institute for industrial engineering predicted that the EV push threatens 75,000 German auto industry jobs since EV power trains have only a sixth of the components when compared to combustion-engine variants, which means EVs can be assembled more quickly (Wissenbach, 2018).

Global and Indian Responses

The role of the government is both proactive in keeping the legal framework updated and prevent loop holes from being exploited and reactive (enforcing the law) (Johnston et al., 2018). While professing a market economy and benefiting from private sector investments and successes in high technology areas, the U.S. and European countries have also adopted policies which provide opportunities to the private sector. Governments such as Germany have been pioneers, for example, in nudging Industry 4.0 (or "Industrie 4.0" in German) forward (UNIDO, 2018).

China appears to be aggressively investing in AI and "has called for an AI industry worth hundreds of billions over the next few years, and the government has challenged Chinese AI researchers to surpass their international counterparts by 2030" (Knight, 2018, para 10).

Governments of countries like U.S., France, China, the UK, and Japan have released policy and strategy papers on artificial intelligence. Some governments already have dedicated departments, such as the UAE Council for Artificial Intelligence (Zacharias, 2018) ; the United Kingdom has set up an AI Council with some distinguished members (UK Government, 2018). India too has announced the development of a National Strategy for Artificial Intelligence, where the goal has been articulated as the optimization of social goods rather than maximization to top-line growth (Niti Aayog, Government of India, 2018). Meanwhile, the European Union (EU) has released the General Data Protection Regulation (GDPR) effective from May 2018.

India's draft of Personal Data Protection Act is in circulation to regulate the way data can be accessed and used by technology companies and make it possible to analyze data in a responsible way to boost artificial intelligence based innovations. Again, what is equally important as good policy and regulations is the speed of action. With

countries like the U.S., European Union, and China surging ahead, India cannot afford the postponement of these initiatives.

Countries have realized that the largest amount of raw data lies in government records or within government control. In the U.S., a senior official said that the government is looking for ways to open up data with the federal government to researchers in artificial intelligence. "Anything that we can do to unlock government data, we're committed to" (MS Mash, 2018, para 2). Similar is the case with China, which has also stated its commitment to open up government data for developing products and services based on artificial intelligence (Knight, 2018).

Recommendations

This section provides inputs on what more the Government of India and other stakeholders can implement to address the challenges of the Fourth Industrial Revolution.

Borge Brende, then President of the WEF, said that the world is witnessing the Fourth Industrial Revolution and India needs to bolster its investment in infrastructure to take advantage of it (Grover, 2018). However, India is a diverse country and many initiatives of the Government of India (need to be) aimed at achieving an economic growth that is also inclusive (Subramaniam & Ben, 2018).

Some broad recommendations are highlighted below. These are in the categories of : Legal & policy frameworks, ethical considerations, skilling & education, and enabling infrastructure.

We have shown in earlier sections that technology is evolving very rapidly and the changes are coming up fast. If that is the case, then the responses of stakeholders and policy makers will have to be equally rapid.

The first recommendation is that there is a need to speed up the pace of Government of India's responses to the challenges of the technology revolution. India simply cannot be reactive and needs to be proactive and with speed in all the measures discussed in this article and in implementing the recommendations below.

(1) Legal & Policy Frameworks

(i) Ease of Doing Business : There have been efforts by governments to raise India's competitiveness with some success in raising India's ranking in the Ease of Doing Business Rankings under The World Bank. However, The World Bank report stated that India still needs to improve in terms of "starting a business" and "enforcing contracts" (The World Bank, 2017).

(ii) A New Industrial Policy : In 2017, the GoI released a discussion paper (DP) on a new Industrial Policy (IP) to replace the Industrial Policy still in existence since 1991 (Department of Industrial Policy & Promotion, Government of India, 2017). The discussion paper sought an answer to the question, "What can be done to enable adoption of Industry 4.0 technologies?" and "to establish an ecosystem of advanced and smart manufacturing" (Department of Industrial Policy & Promotion, Government of India, 2017). A part of the IP is also on The National Manufacturing Policy, which is the first such dedicated policy measure for the manufacturing sector in the country, and is expected to change the manufacturing landscape of the Indian economy (Kulkarni, 2013). However, this remains under years of discussion and is now likely to be finalized only after the General Elections of 2019.

(iii) Data Protection and Privacy : Artificial intelligence needs large volumes of data and massive databases to be able to identify patterns, analyze and draw conclusions, and thereby suggest possible solutions to a variety of problems thrown up, whether in developing and improving maps or voice and speech recognition. From the consumer point of view, there is a fear that personal data could be misused, could be illegally obtained, or could be extracted using the fine print of contracts which are barely read, and so on.

A judgement in August 2017 by a nine judge bench of the Supreme Court (SC) of India unanimously held that "right to privacy is protected . . . under Article 21 of the Constitution (of India)" (Supreme Court of India, 2017) and other profession specific regulations (such as those for doctors).

Responding to concerns (including those raised through the above quoted Supreme Court judgement), the Government of India appointed the Justice Srikrishna Committee (on 31st July 2017) to study the various issues related to data protection and help draft a new legal framework. Based on the recommendations, the Government released a draft of the Personal Data Protection Bill, 2018. The draft bill includes a provision for a new regulator, the Data Protection Authority of India (DPA), which will have the capacity to act against violations of data protection obligations.

(2) Ethical Considerations : The ethical considerations of artificial intelligence are also being extensively discussed under the FAT framework (fairness, accountability, and transparency). There are annual conferences to bring together researchers and practitioners in complex socio-technical systems. The FATE framework ("Ethics" added) initiatives have also been announced by companies like Microsoft, which are extensively involved in AI research (Microsoft, 2018). Such coming together of experts will help curb or monitor malpractices in the use of AI. Sundar Pichai, CEO of Google, has expressed that we should borrow ethical standards from medical, biological, and genetics research, for example, which could serve as a guideline for developments in AI (NDTV, 2017).

As the malicious use of AI report pointed out, international collaboration between governments and researchers on a continuous basis will help to keep the dual use, misuse, and the malicious users, at some bay (Brundage et al., 2018). Therefore, an India legal framework on ethical practices in use of artificial intelligence is required.

(3) Education, Training, and Continuous or Re-education : The Government of India's National Skills Development Mission and a supporting World Bank initiative - Skills India Mission Operation were launched in 2015 and 2017, respectively to cater to the skills gap. The industry also needs to train their people with new skills and competencies (example, on big data analytics). We have recently observed some companies laying off senior employees who may not be able to easily adjust to the new environment (Phadnis, 2018).

(4) Investment in Infrastructure : To obtain the full benefits of technology revolution, India will need to introduce 5G broadband wireless technologies, involving much greater bandwidth and faster speed. The Government's Bharat Net project to provide affordable broadband connectivity for all households and institutions in India and the National Optical Fibre Network (NOFN) project to connect all villages, set to be completed by 2019, (GoI, 2018) will create a good base. Remote robot surgery and autonomous cars are to be a reality with 5G speed and bandwidth to ensure near instantaneous communication ; hence, control would be essential.

While the first global commercial rollout of 5G is expected within this year, India will need to wait for a few more years. According to Ericsson Mobility Report, 5G subscriptions (in India) will become available by 2022 (India Brand Equity Foundation, 2018). Can this be speeded up?

Conclusion

The innovations and disruptions of new technology revolution, the Fourth Industrial Revolution or Industry 4.0 have already started to make a huge impact in the lives of users of products, services, and applications. As we have observed, scholars have asserted that in its scale and scope, the impact of the revolution will be more far reaching

and profound than in the past, aided by faster movement and more ready availability of technologies. The stakeholders to these massive and rapidly developing technologies include all of us.

The challenges before India are vast and include issues relating to policies, infrastructure, educational and skill gaps, an ecosystem for innovation and entrepreneurship, and a conducive regulatory framework. As this paper argues, the challenges are also of speed – both of change and stakeholder responses.

The leading companies that are innovating and investing in the new technology revolution are largely U.S. and China owned, including Indian unicorns like Flipkart, Ola, or Paytm, which are owned by international companies like Walmart, Alibaba, and Softbank. Therefore, India needs a thoughtful technology policy that encourages innovation but safeguards the interests of society (Venkatesan, 2018).

A pertinent question would be – if India were to have the next technology based unicorn, controlled by Indians and funded by Indians – what are all the factors, the changes needed in laws and regulations which will make this possible ? It remains a challenge for policy makers to always balance the complicated risk of not doing anything with the costs of stepping into a dynamic, bubbling field.

There is a much more basic question as AI takes over routine tasks and then more complex ones. In August 2016, the Israeli historian Yuval Noah Harari asked the question, "If algorithms decide all our choices, what happens to free will?" (Sengupta, 2018). A related question would also be that if superior AI systems came about, would they potentially understand the human mind better than humans have understood it themselves? At a philosophical level, the fear would be that machines would become so much better at decision making than humans, to such an extent that humans might not be required for decision making at all! As one report said, if we do not transform and put "people first," we risk becoming robots ourselves (Forbes, 2016).

Research Implications

While researching this topic, we found very few research papers published on the topics central to this paper - the Government of India's responses to the challenges of the Fourth Industrial Revolution. However, there are a large number of papers on the technological implications of the revolution and some papers on policy implications for specific countries. This paper is, therefore, an important addition to the body of literature globally on the subject since it concentrates on the Indian context.

Policy Implications

Research papers on the Fourth Industrial Revolution and its implications within India are limited, though books and newspaper articles are available. There are articles and research papers on the impact on skills availability or say, the tax implications for encouraging start-ups and other specific aspects of the on-going global developments, not specific to the 4IR. We, however, did not find any research papers on what policies the Government of India can undertake with reference to the 4IR or I4.0. In that sense, this is an important contribution on the policy implications for the Government of India.

Limitations of the Study and Scope for Further Research

This study is a generalized and conceptual study on what the Government of India and other stakeholders can undertake in a wider variety of areas. It does not try to cover all the areas and certainly not each of these areas in great detail. It does not, for example, attempt to prepare a new policy document or a legislative draft on any of the areas under focus.

The Fourth Industrial Revolution and Industry 4.0 have huge implications for all stakeholders in India. These stakeholders include the Government of India, the general public who may be the customers for technology

innovations, the global technology companies in India, and the Indian established and start-up companies. All these stakeholders need inputs which are well researched and could help the government and stakeholders to address the key issues. The scope for further research on all the topics related to the 4IR and I4.0 therefore remain large.

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