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The 4th Industrial Revolution and the Future of Work

A Primer

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A Background paper

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I. Introduction

"You cannot wait until a house burns down to buy fire insurance on it. We cannot wait until there are massive dislocations in our society to prepare for the Fourth Industrial Revolution,"
Robert J. Shiller, 2013 Nobel laureate in economics, Professor of Economics,
Yale University.

The world has been on a grand march of economic growth as human seek to improve their well- being. This has been manifested in relentless attempts to harness nature that has seen discovery of new knowledge that has changed the relationship between human beings and nature.

Technological progress has been a crucial driver of this human progress as technology can augment human productive capacity. Essentially giving more output for same input and thus increase what is available for consumption and thus human welfare. While technological progress is continuous, occasionally a breakthrough occurs launching human on a new trajectory of productivity. These shifts have been referred as revolutions. The first profound revolution was the agrarian revolution that saw human settle from hunter and gatherer to more sedentary lifestyles as agricultural technologies were mastered. This revolution witnessed the first large scale and organized human settlements that led to the development of first civilizations.

The next most profound revolution was the harnessing of the power of nature that caused a complete re-organization of societies. By harnessing power of nature through the steam engine that productive capacity of human increased tremendously and allowed a different way of organizing productive activities to take advantage of this power. This was the so-called first industrial revolution. Since then, we have had a number of revolutions (we will come back to this)

Much like the agrarian revolution that saw the re-organization of society from mobile to sedentary, the industrial revolutions are accompanied by significant re-organization of society. The way we live, work, and relate to one another. It also comes with new challenges and new opportunities. It also expands the horizons. Indeed, the industrial revolution drove the colonization enterprise as new found economic power and technologies allowed amazing of significant armies able to project power far and wide.
So these revolutions tend to be periods of significant tumult as lifestyles are upended and as actor jostle to protect their interests or take advantage of new opportunities.

The world is yet again at inflexion point as innovations in four technologies domains converge: energy/power through renewable energies; Communications through internet technologies, production through 3D printing and transportation through autonomous vehicles. The convergence of these technologies has the potential of completely transforming society. This is the so called 4th Industrial Revolution (Schwab undated).

Schwab (n.d.) argues that the current revolution is different from others in terms of velocity**, breadth and** depth and system wide impact. The fact that technological trends driving 4IR are building and amplifying each other make the trajectory of 4IR to be exponential and thus the need for action now[1].

As with previous revolutions, this revolution is likely to foment a period of great uncertainty and angst. The changes being witnessed will transform business, markets and the global economy. As whole industries "die", other adjust and new ones are born, many occupations will undergo a fundamental transformation. While some jobs are threatened by redundancy and others grow rapidly, existing jobs are also going through a change in the skill sets required to do them. However, we are yet to grasp fully the speed and breadth of this new revolution. True impact will come from transformation of the economic, social, ecological and cultural contexts in which we live that these technologies will foster. Notions about ownership and how we create value may need some revision. It will lead to radical revision of values that have underpinned modern society.

Change, especially that which threatens livelihoods even temporarily, requires careful attention to manage it. People are not likely to sit and watch their livelihoods evaporate. Militant resistant like the Luddites resistant of mechanical looms (or even outright revolution) is one extreme manifestation of this resistance. Thus, 4IR is a major political issue.

These challenges of 4IR require proactive adaptation by corporations, governments, societies and individuals. As Schwab empathizes, the changes are so profound that, from the perspective of human history, there has never been a time of greater promise or potential peril. Thus, the key challenge that we face today is how to understand and shape the new revolution. This paper aims to explore the trajectory of 4IR and what it means to society (opportunities and challenges) The paper will also explore policy options to shape a better future. Section II provides a historical background of the various industrial revolutions, section III explores the drivers of the 4IR, section IV explores the impact and implications of 4IR, section V concludes

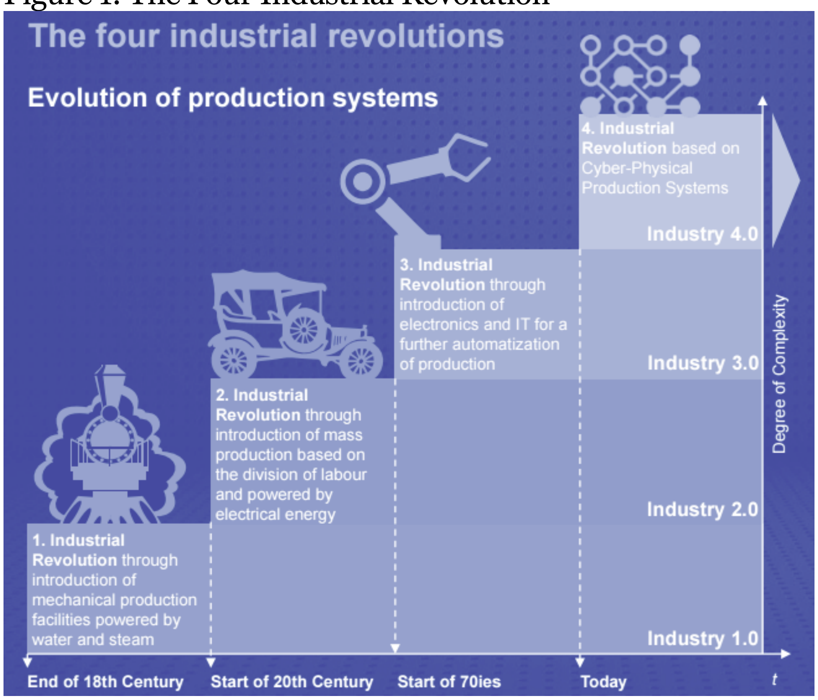
II. The 4 Industrial Revolutions – A Historical Perspective

There has been debate on what stage of industrial revolution that we are in now. Depending on what one sees as the defining features of an industrial revolutions, different conclusions have been reached. Using energy/power as the defining feature Rifkind (2013) argues that the world is currently in the 3rd Industrial revolution (1st-Coal, 2nd-Oil and 3rd-Renewable energy). Rifkind (2013) does indeed make a compelling case of energy being the key determinant of previous revolutions. He also highlights energy as being the key determinant of global geopolitical arrangements as countries seek energy security thus underscoring the primacy of energy. The Economist, (2012) also calls the current revolution, the 3rd Industrial Revolution but bases it on the evolution of production technologies (from factory to mass production to additive manufacturing or 3D printing).

[1] It took more than 10 years at a cost of 2.7 billion U.S Dollars, to complete the Human Genome Project. Today a genome can be sequenced in a few hours and for less than a thousand dollars

Others are calling this the 4th Industrial revolution. Marsh (2014) argues for four industrial revolutions as follows: First Industrial Revolution (1780-1850) characterized by steam power, textile machinery; Second Industrial Revolution (1840-1890) characterized by communications, railways, telegraph; Third Industrial Revolution (1860-1930) characterized by science-based methodology; electricity, chemistry; Fourth Industrial Revolution (1950-2000) characterized computers, electronics. Ellicot (2016) characterizes the first Industrial Revolution as about harnessing steam power so that muscle could be replaced by machines; The second was driven by electricity and a cluster of inventions from the late 19th century onwards – including the internal combustion engine, the aeroplane and moving pictures; A third revolution that began in the 1960s based on digital technology, personal computing and the development of the internet. And 4th Industrial Revolution underway that will be shaped by a fresh wave of innovation in areas such as driverless cars, smart robotics, materials that are lighter and tougher, and a manufacturing process built around 3D printing.

Figure 1: The Four Industrial Revolution



Accenture

Allen (2010) argues that the 1st Industrial Revolution was primarily an engineering challenge rather than a scientific challenge. Much of invention was the hard work of perfecting machinery and new products. This technology-product centric approach has been adopted by Accenture (see figure 1) in classifying industrial revolution into four waves.

Schwab (2017) asserts that the world has experienced four industrial revolutions: the first employed the use of steam engines for mechanical production; the second utilized electricity and the concept of division of labor to create mass production; the third introduced information technology; and automated production processes; the 4IR, which we are witnessing, is about a digital transformation that pervasively impacts every work of life across the globe.

It is clear that both developments in energy and in computing technology have been crucial in driving the transformations seen. **Given the crucial role computing technology is going to play in shaping all aspects of production and consumption of goods and services one can argue that the dawn of computing era marked a paradigm shift and thus maybe deserves the label of 3rd Industrial Revolution.** At the same time Rifkind (2013) argument of primacy of energy is also justifiable as a new way of producing energy has a profound impact and thus rise of renewable energy also marks a paradigm shift thus the 4^{th} Industrial revolution.

However, these are still simplistic distinctions. Indeed, one can also argue that perfecting machinery and products is not sufficient to cause an industrial revolution. Also, energy is not the only factor. Rather it is a series of innovations across four domains that really make a revolution. The paradigm shift in production of goods (and services) which are the key motivations requires four types of technologies: (i) Energy/Power; (ii) production/organization; (iii) Transport and (iii) Communication.

Power/energy is the crucial first step as power limits what human capacity can achieve. But once power is harnessed and new activities are undertaken, there is need for (i) production technologies and organization/management expertise, (ii) communication to coordinate new activities; (iii) inputs and finished goods need to be transported. Innovations in all four areas is what creates a new trajectory as costs go down and the distance is shrunk.

If one of the domains is not well developed it becomes a bottleneck which results to a progress rather than a true revolution. This explains the long interregnum between the agrarian and the 1^{st} industrial revolution. Though production technologies continued to improve (e.g. irrigation technologies in Egypt, crop rotation, breeding technologies in 1700-1800s), the transportation technologies advanced too (wheel was invented in Babylon, the first highways were developed in Roman Empire that allowed agricultural goods to be transported far and wide) and also communication technologies mandate made a great leap with invention of printing press in the 1450's and new production technologies /organization arrangements (looms and guilds) emerged, these were seen as part of progression. Human being still largely relied on human and animal power and agriculture dominated the economic activity.

The invention of steam power changed everything. Production technologies could be mechanized (mechanical looms); steam powered printing presses lowered cost of printing and saw rise of newspapers (crucial advertising medium), steam powered trains annihilate distance. This opened new possibilities in terms of markets. Entrepreneurs were quick to re-organize production though setting up factories that allowed economies of scale which made goods cheaper. Railways made markets accessible and newspapers created awareness. It is convergence of several technologies and business model innovations that really makes a revolution.

As we can see from table 1, One can trace the 5 revolutions (the agrarian and 4 industrial revolutions) using this typology. As one can see each revolution has seen a significant shift in production of goods.

However, using the typology developed, it is hard to make a strong case for 4 industrial revolutions. The so called 3rd industrial revolution only really saw two developments that were a step change, computing and automation of production. Though automation did help to lower the cost of production, labor cost remained a dominant cost and this largely explain the movement of manufacturing from high labor cost location in West to low cost location in the East, in particular China. The jet engine also did shrink distance, however much of the goods continued to be transported as in 2nd revolution. So, the 3IR technologies only really affected some aspect of four key ingredients for a revolution while as we saw steam power impacted on production and transport and even communication. In the 2nd IR electricity impacted production and communication and transport (electric trains). Therefore, there is a case to lump to 2nd and 3rd IR as part of one revolution (As Rifkind, (2013) has done). However as pointed out computing has become so pervasive that the dawn of computing era that can be called the 3rd Industrial revolution.

	Energy/Power	Transportation	Communication	Production/industry organization	Comment
Agrarian Revolution	Animal power	-Roads	Writing	-Irrigation -Crop rotation -New Crops -Breeding	Note that agrarian revolution has been ongoing for some time
1st Industrial Revolution	-Coal Steam engine	Railway	Newspapers, telegraph	The factory and the bureaucracy/professional management	
2nd Industrial Revolution	-Electricity+ Electric Motor -Internal Combustion engine	Motor car	Telephone Radio, Television	-Mass production	
3rd Industrial Revolution	-Jet Engine -Cheap Oil	Aircraft Express Motorways	-Computing -Information systems	-Automation (repetitive tasks) -Petrochemical industry (plastics, clothes, fertilizers etc.)	Oil dependence - economic performance tied to price of oil -Geopolitics shaped by oil -Birth of MNCs to secure oil
4th Industrial Revolution	Distributed Power (Renewable Energies + Hydrogen Fuel Cells storage + Smart grids)	Autonomous vehicles (drones, driverless cars etc.)	Internet technologies (WWW, email, social media etc.) -Data science	AI/Machine learning (automation of knowledge work) Additive manufacturing (3D printing)	

a) Pre-Requisites for Industrial Revolution

i. The Agrarian Revolution

As pointed out, the first revolution was really the Agrarian revolution which occurred over a long period. The period just before industrial revolution was also the period when Britain was undergoing another wave of agrarian revolution. As Allen, (1992) points out, the English corn yields were amongst the highest in the world and had doubled since the middle ages. Output per worker was 50 per cent above the next highest European country. At the end of the eighteenth century, British agriculture was indeed the most productive in the world. Allen, (1993) further argues that the growth in agricultural productivity gave a strong boost to England's early industrialization and indeed one can argue that it was prerequisite. The manufacturing cities were built with savings from the agricultural surplus, they were **peopled** with labor freed from farming, and they were fed with the food produced by improved methods. Thus, he argues, the First Industrial Revolution was the result of the British Agrarian Revolution[2]

Thus, the crucial role of agriculture transformation cannot be understated especially in African economies. In these economies the cost of food is a significant part of household budget and so unless cost of food can be lowered dramatically through productivity increases, workers cannot have surplus to buy other goods and services and wages cannot be low to be competitive thus limiting the establishment of competitive non-agricultural sectors. Also, as agricultural products are a major input in easy to enter sectors of industrial agro-processing (key to starting the learning journey of industrialization), cheap agricultural raw materials are key to competitiveness. Therefore step-shift change in agricultural productivity (a green revolution) is a key pre-requisite to industrial revolution.

So, while the linear transformation from 1st to 2nd to 3rd then to 4th industrial revolution is not necessary, one can just leapfrog to the current stage by building the needed infrastructure (soft and hard) for the 4IR. Otherwise it is almost impossible to make any revolution without transformation of agriculture.

ii. Demand and Supply of Technology

As pointed out, technological innovation is the prime mover of revolutions. For this to happen there must be demand for technology and also supply. The demand and supply explain why some countries have been at the vanguard of technological revolution and others have lagged. Allen (2010) makes this point by explaining why Industrial revolution

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[2] However, Allen, (1992) points that this happened only in the first phase of the English Agrarian Revolution (which he call Yeoman's revolution). The second phase (which he calls the landlords revolution) which saw more extensive enclosures and farm amalgamation made less of a contribution to the increase in national income. Technical change no longer raised yields, so it did not directly raise agricultural output and GDP. Enclosures and farm amalgamations reduced employment per acre, but the labour released was not successfully reemployed in manufacturing. The revolution paupers-not proletarians. The dream of industrious weavers gave way nightmare of thieves. Some of them, indeed, were hanged; many were transported to Australia.

occurred in Britain rather than in in Europe or Asia which were vibrant trading partners and contemporaries of Britain in many ways. Two reasons are given:

- Demand of technology: The demand for technology depended on factor prices, market size, and the imitation of novel products. Wages were remarkably high in Britain, while coal and energy were cheap. This price structure underpinned the Industrial Revolution by creating a demand for labor-saving, energy-using technology.

- Supply of Technology: The supply of technology which depends on accumulated knowledge, skills and inventive institutions was also a crucial advantage. First, Britain (and also North-western Europe) had high levels of literacy and numeracy. The driving force behind literacy was urbanization and the expansion of commercial society. Literacy was valuable in trade and cities, and that value led parents to pay for schooling for their children. Secondly, the Scientific Revolution of the seventeenth century included scientific discoveries that led to two important General-Purpose Technologies (GPTs)[3]. The GPTs were steam power and 'clockwork', or gearing. However, both technologies required Research and Development (R&D) projects to make them effective in the various settings. The R&D projects were more profitable in Britain than elsewhere due to high wages and low fuel cost[4]

This was the key, not the folklore that goes to explain this on basis that the British were more practical, more enterprising, or better governed. Economic incentives were critical in explaining why that work was done and, hence, why inventions took place. Research and development had become a more common business activity in the eighteenth century Britain (Allen 2010).

b) Impact of Revolutions

While the immediate impact of the revolutions as discussed include lowering cost of production of goods and services and thus greatly increasing consumption, the effects of the revolutions tend to be far reaching by completely re-organizing societies and lurches societies into very turbulent periods as roles change, industries die and new industries that can take advantage of new technologies are born.

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[3] The concept of General Purpose Technology was inspired by the computer and refers to technologies that can be adapted to many sectors of the economy.

[4] Allen (2010) makes the point that from the first steam engine (Newcomen engine) in 1727 to the highly efficient engines of the mid-nineteenth century, fuel consumption dropped from 44 pounds of coal per horsepower-hour in 1727 to 3 pounds in 1847. Though this improvement was a triumph for British engineering, and it also destroyed the country's competitive advantage by turning the steam engine, which had mainly benefited Britain in the early eighteenth century, into a technology that could be used anywhere in the world. Once the coal consumption was reduced to 3 pounds per horsepower-hour, the price of coal became irrelevant to the engine's commercial application and industrial revolution spread

The first industrial revolution saw the death of the cottage industry which could not compete with the factory business model. This lead to the Luddites revolt. The Luddites were angered by new technologies, like automated looms, which were being used in the textile industry in place of the skilled work of artisans, threatening their livelihoods as a result. The insurgents broke into factories and wrecked the offending equipment[5].

In line with the factory production model, the retail sector also adjusted its business model. The department stores came into being taking advantage and mass production and cheap rail transport. This started the decline of the family shop that could not compete. A new industry, the telegraph, was born to service railway industry. The telegraph in-turn gave birth to the mail-order /catalogue industry. These new industries created jobs that were never there before, and fears of mass unemployment were not realized. While automation destroyed jobs in the 3rd IR, the birth of the PC opened new industries and new opportunities that could not be imagined. This cycle of destruction and creation has been the hallmark of the last 3 industrial revolutions.

The revolutions also called for changes in public policy. In the wake of 1st Industrial Revolution, school systems were reformed on factory model and with a highly hierarchical command and control system to train students to work in a factory in the future (Rifkin 2013). In addition, sharing and collaboration was seen as cheating and discouraged in this model. But, competition was encouraged and rewarded. In response to 2nd industrial revolution that needed more educated workers, mass secondary schooling was introduced (Autor, 2014). While in 3rd IR, tertiary schooling opportunities were greatly expanded to meet the emerging demand of knowledge workers.

Revolutions has also given birth to new social movements that has led to reshaping of society and politics. The labor movement arose in response to excess of the factory system. As a result of the industrial revolution many women were in full-time employment, which meant they had opportunities to meet in large organized groups to discuss political and social issues. Organised campaigns for women's suffrage began to appear. The rise of consumerism as result of mass production and the resulting environmental degradation gave birth to the sustainability movement.

III. Drivers of 4th Industrial Revolution (4IR)

As seen, Industrial revolutions open new frontiers but also come with potential dangers as the status quo is disrupted. To better appreciate what the 4IR augurs it helps to delve a little more the technological trends that are driving 4IR and what they mean.

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[5] Luddites were skilled workers – a relatively "elite" group, whose role had traditionally been protected by legislation regulating the supply and conduct of labor. These skilled workers had to spend seven years in apprenticeships before they could take up their chosen profession. At the end of it, they tended to feel that they were owed a living. New machinery in the textile sector was starting to deny them this

http://www.cam.ac.uk/research/news/rage-against-the-machine

Technology Drivers

Many (see Moavenzadeh, 2015, MGI 2013) see 4IR as largely being defined by the fusion of cyber and physical world creating what they call **Cyber physical systems that** combine communications, IT, data and physical elements integrating a number of core technologies including: Sensor receptor networks; Internet communication infrastructure; Intelligent real time processing and event management; Actors for mechanical activities; Embedded software logic; Big data and data provisioning; Automated operation and management of system activities; Advanced robotics; 3D/4D printing. This definition tends to mix trends/drivers and outcomes.

Rather than listing a plethora of technologies, which seems to be the way many see 4IR, it may be more useful to think of grouping of technologies based on how they are unleashing new capabilities. This can then give insights into what 4IR means at a macro level. At the core the technologies driving the 4th industrial revolution are:

Processing technologies

Computing power continues to be key as it enables new applications that were not possible due to limitations of computer power. Computer power has been doubling every 18 months (Moore's Law) however the limits of computer under the current designs is being reached. However new designs are now being proposed with quantum computing the new frontier in computing. So, we expect the unrelenting growth in computer power to even accelerate further allowing more and more powerful applications to be built on top of it.

Machine Learning /Artificial Intelligence/Robotics

Perhaps this is the aspect of technology that most defines the 4th Industrial Revolution. AI is enabling machines to undertake task that were previously thought to be the domain of human beings. Much like human machines are now being able to learn and become better continuously improving their capability. Significant milestones in this arena include the first computer to beat a human being in the Go game. More recently a machine has been able to do a better job of lip reading than a human expert[6].

Companies are investing in these technologies as they seek to capture the benefits. In the past 10 years, the number of global industrial robots in U.S. has grown 72%, while the number of U.S. manufacturing jobs has fallen 16%. The robotics technology market is expected to grow 9-11% by 2020, with global spending on robotics reaching $43 billion by then (BofAML).

Internet Communication and Proliferation of Devices linked to Internet (Internet of Things (IoT))

[6] The computer read lips with 95 percent accuracy, outperforming professional human lip readers who tested at 52 percent accuracy. Hal Hodson, "Google's DeepMind AI can lip-read TV shows better than a pro," New Scientist, November 21, 2016

Computing and communication power is increasingly being embedded in all kinds of hardware and devices e.g. washing machines, coffee makers. Further these devices are being connected to the internet. The Internet-of-Things (IoT) is this giant network of connected "things" (which also includes people). Cisco estimates that the number of connected devices will double from 25 billion in 2015 to 50 billion in 2020 (BofAML)[7].

The relationship will be between people-people, people-things, and things-things. The reality is that the IoT allows for virtually endless opportunities and connections to take place, many of which we can't even think of or fully understand the impact of today.

Data Mining Technologies/Data Science

The proliferation of mobile devices, online sensors and other means of collecting information digitally i.e. IoT has made it possible to obtain detailed, accurate and real-time data on everything from purchases to patient care. Digital platforms, including sharing-economy apps such as Uber and supply-and demand matching services such as Airbnb, allow for instant interaction, information exchange and closer and broader collaboration, be it to develop a rapid test for people with a fever or connect a driver with a car to a passenger who needs to get somewhere fast (WEF 2017).

This has seen the capture of vast amounts of data. This is growing exponentially. Annual data traffic is expected to see a compounded annual growth rate (CAGR) of 40% from 1.2 zeta byte in 2012 to an estimated 100 zeta byte by 2020 (BofAML). When huge amounts of data are combined powerful computing capabilities and Artificial Intelligence algorithms then insights generated are unprecedented. It is putting some much power into the hands of a few entities that are nodes of data captures that there is now growing concern about their power.

Block Chain or Trust Technologies

As pointed out new revolution cause significant disruption in the way society is ordered and this erodes trust systems developed over a long period of time. At the same time new communication technologies are bringing diverse range of people (and things) together in a common network. This creates new challenges of creating trust as trust systems based on cultural traditions, legal systems become inadequate. Yet the power of the networks that come with the IoT is from multitude of transactions and interactions (social capital) it can potentially enable. Without trust systems many transactions are unlikely to happen.

Trust is crucial in enabling transactions. Indeed contracts, transactions, and the records of them are among the defining structures in our economic, legal, and political systems. They protect assets and set organizational boundaries. They establish and verify identities and chronicle events. They govern interactions among nations, organizations, communities, and individuals. They guide managerial and social action (Iansiti and Lakhani, 2017). Currently big intermediaries including banks, government, big

[7] some even estimate this number to be much higher, over 100 billion

social media companies, credit companies, and so on establish trust in in economies

The blockchain lets people who have no confidence in each other collaborate without having to go through a neutral central authority. Blockchain is an open, distributed ledger that can record transactions between two parties efficiently and in a verifiable and permanent way. With blockchain, we can imagine a world in which contracts are embedded in digital code and stored in transparent, shared databases, where they are protected from deletion, tampering, and revision. In this world every agreement, every process, every task, and every payment would have a digital record and signature that could be identified, validated, stored, and shared. Intermediaries like lawyers, brokers, and bankers might no longer be necessary. Simply put, it is a machine for creating trust (The Economist...)

More crucially, blockchain technologies can cut time of transactions drastically, from weeks or months to days, hours, or minutes. With block chain, the economies are poised to undergo a radical shift, as new, blockchain-based sources of influence and control emerge. (Marvin 2017, Iansiti and Lakhani 2017).

The most well-known application of blockchain is the cryptocurrency, Bitcoin[8]. The Finance sector is rapidly adopting this technology, perhaps because it is the sector most likely to impacted. 92%of banking and capital markets strategy officers agree that by 2030 distributed ledger technology will underpin much of our financial architecture while 50%of institutional investor and sovereign fund strategy officers agree that by 2025, the majority of financial transactions as well as management of important documents will take place on block chain architecture. (Mozadveh 2015). The first cross-border transaction between banks using multiple blockchain applications took place between the Commonwealth Bank of Australia and Wells Fargo, resulting in a shipment of cotton to China from the United States (Marvin 2017).

Beyond the financial sector, blockchain technology is being piloted in many diverse fields. IBM and Walmart are partnering in China to track the movement of pork to keep people from eating tainted meat (Marvin 2007). Perhaps the biggest revolution that will be enabled by blockchain is disrupting government. Blockchain-based identity that can capture all kinds of records e.g. land registries, health, academic etc. Additionally, it can record citizenship and ability to vote securely[9]. Several countries including Russia, Honduras, Greece, Sweden, India are piloting deployment of blockchain to implement land registries.

[8] Bitcoin has built a monetary revolution on the back of an all-seeing ledger, one that's everywhere and nowhere at once, and gave the cryptocurrency its power
[9] while providing 100 percent assurance that the vote was counted for the person voted, that it can't be reallocated, and that it was private (Marvin 2017)

Likewise, business firms may look very different in the future. Firms are built on contracts, from incorporation to buyer-supplier relationships to employee relations. If contracts are automated, then what will happen to traditional firm structures, processes, and intermediaries like lawyers and accountants? And what about managers? Their roles would all radically change. The traditional organization as we know maybe be drastically altered even the rationale of the business organization may cease to exist (Iansiti and Lakhani 2017).

Crypto-currency and Financial Inclusion

Stellar, a nonprofit that aims to bring affordable financial services, including banking, micropayments, and remittances, to people who've never had access to them. Stellar offers its own virtual currency, lumens, and allows users to retain on its system a range of assets, including other currencies, telephone minutes, and data credits. Stellar initially focused Nigeria. It has seen significant adoption among its target population and proved its cost-effectiveness. But its future is by no means certain, because the ecosystem coordination challenges are high. Although grassroots adoption has demonstrated the viability of Stellar, to become a banking standard, it will need to influence government policy and persuade central banks and large organizations to use it. That could take years of concerted effort.

Renewable Energy and related technologies

Rifkind (2103) makes a compelling case for energy as the prime mover of Industrial revolutions. Moving from animal power to coal power led to the jump to 1st Industrial Revolution (1IR) and moving from Coal to Electricity (and oil) led 2nd IR revolution. He argues that control of and mastery of the energy source (discovery, extraction, distribution) determines who is at the vanguard of the revolution. So, Britain with the cheapest coal was the leader of 1st industrial revolution while America (where electricity was harnessed and also a leader in development of Oil) became the leader of the 2nd Industrial Revolution.

He argues that the current primary energy source, oil, has many challenges. It is located in a few places and is also running out[10] which has created vulnerability and indeed limits the current development trajectory irrespective of development in communication technologies[11]. Further, fossil fuels have been a major driver of climate change which has created a significant impetus for new energy sources that are less harmful.

[10] He claims peak per capital oil as opposed to peak oil has been reached even though peak oil has not been reached

[11] Rifkind (2011) argues that fossil fuel led growth has reached its limits as peak oil/capital has been reached and every growth spurt will hit a brick wall and collapse as growth leads to rise in oil prices and when this reach $150 per barrel growth tends to collapse as the cost arise across board as current carbon based economies is so dependent on oil from agriculture to construction to pharmaceutical etc.

The shift to a new energy regime is beginning to happen. The World Energy Outlook (2017) points that one of the defining trends in it world energy outlook is the rapid deployment and falling costs of clean energy technologies. It forecasts that in the European Union, renewables could account for 80% of new capacity and wind power becomes the leading source of electricity soon after 2030. In general RES are likely to be the least cost source of new energy generation by 2040.

However, for transition to an RES dominated energy regime, three technologies are going to be critical. These are generation technologies, storage technologies and the distribution technologies. The competitiveness of RES will be determined by the weakest link in the three technologies.

Generation

Technologies for renewable generation range from fairly mature e.g. hydroelectric to highly experimental e.g. tidal wave energies. The sector showing the greatest growth are solar and wind. Cost of RES are also rapidly falling, since 2010, costs of new solar PV have come down by 70%, wind by 25% (WEO 2017). As a result, RES technologies are being deployed rapidly with China at the forefront.

Storage

Large-scale deployment of intermittent renewable energy (mainly wind energy and solar PV) entails challenges in power systems as power maybe generated when it is not needed. Energy storage can diminish this imbalance and promoting distributed generation. Accordingly, the European Commission has recognized electricity storage as one of the strategic energy technologies in achieving the EU's renewable energy targets[12] (Zakeri and Syri, 2015). Storage technologies vary widely and has become an area of active research[13]. Research is yielding significant benefits, battery costs are falling by 40% (WEO 2017)[14].

The technologies that seems to be at the forefront in terms of commercial applications are the Lithium-ion battery. This technology has already grabbed headlines with the installation of a super battery that has exceeded expectations (see box).

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12 20% share of Renewables in energy mix by 2020

13 The more established technologies include: mechanical energy storage systems (e.g. flywheel); secondary electrochemical batteries (e.g. Li-ion); flow batteries (e.g. vanadium-redox flow battery (VRFB)); electro-magnetic energy storage systems (SMES and SCES); and hydrogen-based energy storage systems

14 We could also be on the verge of technological breakthroughs that might change the economics of batteries. MIT researchers have developed an "air-breathing" battery that could store electricity for very long durations for about one-fifth the cost of current technologies, with minimal location restraints and zero emissions http://news.mit.edu/2017/air-breathing-battery-making-renewable-power-more-viable-grid-1011

Hornsdale Power Reserve

Tesla has installed the world's largest lithium-ion battery, a new backup power system in South Australia. Fed by wind turbines at the nearby Hornsdale wind farm, the battery stores excess energy that is produced when the demand for electricity isn't peaking. It can power up to 30,000 homes, though only for short periods - meaning that the battery must still be supported by traditional power plants in the event of a long outage.

The performance of the battery has so far exceeding expectations. It has smoothed out at least two major energy outages, responding even more quickly than the coal-fired backups that were supposed to provide emergency power. The project is the biggest proof-of-concept yet that batteries can help mitigate one of renewable energy's most persistent problems- intermittent power generation. Already, Tesla has equipped a small island in American Samoa with thousands of solar panels and batteries that could serve the area's 600 inhabitants, shifting them almost entirely off fossil fuels.

http://www.independent.co.uk/news/world/australasia/tesla-mega-battery-south-australia-outage-reaction-time-hornsdale-power-reserve-a8130986.html

Smart Grid

Beyond the challenges on intermittent power generation, RES have potential to bring a paradigm shift in how energy is generated shifting from a centralized utility model where one large generator supplies to many consumers to a distributed generation model where many consumers are also generators as other times. Any consumer with a roof is potentially a generator of solar power. The evolution of a near real-time spot market, and by proliferation of smart appliances (the Internet-of-Things) that can ramp up or ramp down their energy use in near real time. This added complexity to the grid which traditional grids, designed with a centralized model in mind and a few predictable devices connected, cannot handle. This requires a smart grid.

A smart grid is an electricity network that can integrate in a costefficient manner the behavior and actions of all users connected to it - generators, consumers and those that do both - in order to ensure economically efficient, sustainable power system with low losses and high levels of quality. and security of supply and safety (*European Commission Task Force for Smart Grids). A smart grid is* set of software and hardware tools that enable generators to route power more efficiently, reducing the need for excess capacity and allowing two-way, real time information exchange with their customers for real time demand side management (DSM) (Smart2020, 2008). An important factor that facilitates the connection of renewables is the capability of smart grids to accommodate storage ( ).

Towards a Hydrogen Economy

As alternative are sought to shift from carbon-based economies, the term hydrogen economy has gained traction. Hydrogen is a quite versatile option, offering applications for heating/cooling, power generation, energy storage as well as a transport fuel. The so-called Hydrogen Economy attempts to combine the cleanliness of hydrogen as an energy carrier with the efficiency of fuel cells as devices to transform energy into electricity and heat.

As pointed above storage is going to be a crucial piece in the new energy regime where renewables play a key role. This is perhaps the key entry point for hydrogen. Hydrogen Energy Storage systems (HES) are unique when compared with other types of energy storage. One key feature is the large scale at which energy can be stored, on the order of 1 GWh to 1 TWh which is much higher than competing technologies[15]. Crucially the existing natural gas networks are capable to store additional hydrogen up to 5% of their capacity[16], without significant degradation in the performance. This way, energy can be transmitted and delivered in higher capacities (4.5 times more than high-voltage transmission lines) with lower transmission losses (1% in gas pipelines while 4% in power transmission lines).

HES basically utilize the electrolysis process where excess energy is used to split water to hydrogen. Stored hydrogen can then be used to generate energy (e.g. electricity using fuel cells) as need be. Beyond storage service the hydrogen systems can offer other key services: (i) hydrogen generated from HES systems can be used for Fuel Cell Electric Vehicle (FCEVs); (ii) The biological or chemical combination of hydrogen and carbon dioxide to produce synthetic natural gas[17], which can then be injected into natural gas pipelines; (iii) As feedstock supply to refineries (for hydrocracking or sulfur removal), ammonia production facilities (for fertilizer production), or for other industrial processes (Melaina and Eichman, 2014).

Marge Ryan (2011) and Barton and Gammon (2011) make the point that with HES, the grid now takes on a role as the major means of energy distribution and supply – for electricity, heat and transportation – and by removing the distinctions between these three sectors overall energy efficiency is greatly increased.

Proofs of concept projects for a hydrogen economy are already underway. In 2011, four states of Germany have embarked on an initiative is to set up demonstration projects in order to develop and optimize wind-hydrogen hybrid systems and prepare their commercialization for the time after 2020. Beside the conversion of hydrogen into electricity and fuel for cars, further markets like raw material for the chemical, petrochemical, metallurgy and food industry are going to be addressed. The name of this concept is power-to-gas. Power-to-gas could serve both for fuel and for the storage of extra energy produced by renewable sources.

[15] Batteries typically range from 10 kWh to 10 MWh, Compressed air storage (CAES)and pumped hydro (PHS) range from 10 MWh to 10 GWh (Marbán and Valdés-Solís, 2007). Also, the energy density of hydrogen (can be pressurized and stored in 200 bar) is as high as Li-ion batteries, which implies the need for significantly smaller storage reservoirs compared to PHS and CAES

[16] Can go upto 26% with some modifications ()

[17] $2H_2 + CO_2 = CH_4 + O_2$ Note that when the hydrogen is produced from renewable sources, the resulting synthetic gas is referred to as a renewable gas.

Further, in 2012, the German Energy Agency set up the "Power-to-Gas" bringing together R&D institutes, renewable energy project developers and park operators, utilities, underground storage providers in order to create political support for this new technology. Demonstration projects will be completed by 2020 in order to develop business models (for storage, production and trade of "green gas") and devices (electrolysers, turbines, smart gas metering, compressors, storage capacities amongst others) to enable the implementation of this concept on a broad scale (Winkler-Goldstein and Rastetter 2013).

Cornell University (2017) argues that the he future is in redox flow batteries and hydrogen fuel cells. They couple well with renewables, and so can be completely carbon-free. Hydrogen has the same fast-response, wide dynamic range, as natural gas or gasoline. It will let EES deliver on its promise to be the Swiss-army knife of functionality for the grid -- and literally change the way we use energy for the better."

The future of energy as the world Energy Outlook points will be a story of many energy types as new sources become competitive and with old sources continuing to show resilience in wake of new technologies (e.g. fracking). As well put, there will be no single silver bullet but a 'technological ecosystem' of complementary 'species' which will be dominated by the symbiotic partnership of electricity and fuel (Marge 2011)

IV. Impacts of 4IR

The trends discussed above have significant implications on organization of societies in the coming future. 4IR like other revolutions come with opportunities and also challenges. These are elaborated below.

a) The Opportunity

Productivity gains

The 4th Industrial Revolution is seen as presenting unprecedented opportunities. Accenture (Herold, undated) points that the Internet of Things, or Industry 4.0, could add $14.2 trillion to the world economy over the next 15 years (Hatzakis 2016). MGI (2016) argue that systems enabled by machine learning can provide value everywhere and these technologies could generate productivity gains and an improved quality of life. At a macroeconomic level, they point that automation could raise productivity growth on a global basis by as much as 0.8 to 1.4 percent annually. At a microeconomic level, businesses everywhere will have an opportunity to capture benefits and achieve competitive advantage from automation technologies, not just from labor cost reductions, but also from performance benefits such as increased throughput, higher quality, and decreased downtime[18]. Safety is another area that could benefit from increased automation[19]

New competitive bases, New Job opportunities

Data is now a critical competitive asset. Data and analytics are changing the basis of competition. Leading companies are using their capabilities not only to improve their core operations but to launch entirely new business models. However, data itself will become increasingly commoditized, thus value is likely to players that aggregate data in unique ways. This requires data scientists but business translators who combine data savvy with industry and functional expertise. This demand is creating new and well-paying job opportunities. It is estimated that there could be demand for approximately two million to four million business translators in the United States alone over the next decade[20] (MGI 2016). WEF (2017) also points to that computer-,mathematical-, architecture- and engineering-related jobs are likely to surge in the 4IR era.

Why Hasn't Automation Already Wiped Out Employment For The Vast Majority Of Workers? - Complementary Automation And Human Work

Contrary to popular wisdom, Autor (2014) contends that computers are not going to wipe out jobs. He argues that this is due to an economic reality that is as fundamental as it is overlooked: Tasks that cannot be substituted by automation are generally complemented by it. Further most work processes draw upon a multifaceted set of inputs—labor and capital; brains and brawn; creativity and rote repetition; technical mastery and intuitive judgment; perspiration and inspiration; adherence to rules and judicious application of discretion. Typically, these inputs each play essential roles; that is, improvements in one do not obviate the need for the other.

Information technology (IT) and employment in banking provides a good example. Automated Teller Machines (ATMs) in the U.S. quadrupled to approximately 400,000 between 1995 and 2010. Rather than eliminating bank tellers, their employment rose modestly from 500,000 to approximately 550,000 over the 30-year period from 1980 to 2010. By reducing the cost of operating a bank branch, ATMs indirectly increased the demand for tellers: the number of tellers per branch fell by more than a third between 1988 and 2004, but the number of urban bank branches rose by more than 40

[18] Rio Tinto has deployed automated haul trucks and drilling machines at its mines in Pilbara, Australia, and says it is seeing 10–20 percent increases in utilization there as a result.[1] Google has applied artificial intelligence from its DeepMind machine learning to its own data centers, cutting the amount of energy they use by 40 percent (MGI 2017)

[19] . For example, of the approximately 35,000 road death in the United States annually, about 94 percent are the result of human error or choice

[20] However the current education systems is hard pressed to deliver. Roughly 9.5 million US graduates in business and in the STEM fields are expected over the same period, nearly 20 to 40 percent of these graduates would need to go into business translator roles to meet demand.[5] Today that figure is only about 10 percent. The scarcity of elite data scientists has even been a factor in some acquisitions of cutting-edge artificial intelligence (AI) startups; deals can command around $5 million to $10 million per employee (MGI 2016).

percent. Secondly, IT enabled a broader range of bank personnel to become involved in "relationship banking," using tellers as salespersons, forging relationships with customers and introducing them to additional bank services like credit cards, loans and investment products.

Thus, automation does, indeed, substitute for labor—as it is typically intended to do. However, automation also *complements* labor, raises output in ways that lead to higher demand for labor, and interacts with adjustments in labor supply. Too often expert commentators tend to overstate the extent of machine substitution for human labor and ignore the strong complementarities between automation and labor that increase productivity, raise earnings and augment demand for labor.

David H. Autor (2016). Why Are There Still So Many Jobs? The History And Future Of Workplace Automation and Anxiety. MIT IDE Research Brief Vol. 2016.07
http://ide.mit.edu/sites/default/files/publications/IDE_Research_Brief_v07.pdf

<u>Increased Consumer Surplus = Opportunity for new enterprises</u>

4IR technologies have enhanced consumer welfare by providing access to goods and services more cheaply, faster and with more convenience e.g. e-books, Uber cabs, social media, etc. Their impact has been to transfer enormous amounts of value-add to consumers, freeing up their buying power for other goods and services (Hatzakis, 2016). This creates opportunities for entrepreneurs to create new products and experiences as new-found buyer power can support these new industries.

b) The Challenge

<u>Obliteration of Jobs</u>

Frey and Osborne (2016) estimate that in the OECD, on average 57% of jobs are susceptible to automation. This number rises to 69% in India and 77% in China. From an analysis of more than 2,000 work activities across 800 occupations, Mckinsey (MGI, 2017) concludes that almost half the activities have the potential to be automated by adapting currently demonstrated technology. They point that, while less than 5 percent of all occupations can be automated entirely using demonstrated technologies, about 60 percent of all occupations have at least 30 percent of constituent activities that could be automated. As expected, activities most susceptible to automation involve physical activities in highly structured and predictable environments, as well as the collection and processing of data. They are most prevalent in manufacturing, accommodation and food service and retail trade. However, for some industries including manufacturing and agriculture that have predictable physical activities that have a high technical potential to be automated, but lower wage rates in some developing countries could constrain adoption.

<u>Building Skills for IR</u>

In the new world of 4IR, most jobs will require very different skill sets as the ecosystems within which they operate change. On average, by 2020, more than a third of the desired core skill sets of most occupations will be comprised of skills that are not yet considered crucial to the job today ( ). While basic skills in the STEM fields of science, technology, engineering, and mathematics will be crucial there will be need to put a new emphasis on creativity, as well as on critical and systems thinking as many formerly purely technical occupations are expected to show a new demand for creative and interpersonal skills. For healthcare practitioners, for example, technological innovations will allow for increasing automation of diagnosis and personalization of treatments, redefining many medical roles towards translating and communicating this data effectively to patients (MGI 2017).

Developing agility, resilience, and flexibility in addition to the right technical skills will be crucial in the coming future. However, this is a major challenge. The pace of change and scale of disruption, will need different policy response than in the past. In previous IR, changes took longer by giving governments and other stakeholder time to build training systems and labor market institutions. These luxury is not afforded now, For example, in the core curriculum content of many academic fields, nearly 50% of subject knowledge acquired during the first year of a four-year technical degree outdated by the time students graduate, (MGI 2017).

Rising Uncertainty

The rapidly evolving landscape is creating uncertainty that makes decision making, especially for policy makers, extremely challenging. For example

- One estimate puts that 65% of children entering primary school today will ultimately end up working in completely new job types that don't yet exist ( ). How does one then craft an education policy to prepare the children when we do not know what we are preparing them for? In such a rapidly evolving landscape, the ability to anticipate and prepare for future skills requirements, job content is increasingly critical for businesses, governments and individuals in order to fully seize the opportunities presented by these trends—and to mitigate undesirable outcomes.
- 4IR technologies are several each developing at exponential speed and also technologies interacting in unpredictable ways. A material that is critical today may not be of much use tomorrow while material of little value today could become critical tomorrow. For instance, Indium, a material that was of little value a few years ago is now in great demand due to touch screens used in Smart Phones that use it. The demand for lighter car, to save fuel and reduce green house gas emissions, has seen shift from Aluminium to Steel and thus lowering of demand of Zinc (used to galvanized steel), This has created shortage of indium which is mined as by-product of zinc

The rise in renewable energies is creating demand for many rare metals creating new vulnerabilities. In the new energy regime, geopolitical concerns may shift from Middle East to new locations that have the critical metals needed for renewables[21]

Privacy concerns, disinformation and security threats

The increased capability to collect vast amounts of data on people has created concerns about privacy. More than 30 percent of the global population now uses social media platforms to connect, learn, and share information. This makes them powerful tools for both good and bad. The tools can propagate unrealistic expectations as to what constitutes success for an individual or a group, as well as offer opportunities for extreme ideas and ideologies to spread (Schwab undated(b). Indeed, discontent can also be fueled by the technologies e.g. the Arab Spring was a social media driven revolution. More worryingly these tools have become the primary tools for would be terrorists' recruitment, training and coordination The Fourth Industrial Revolution technologies are changing the traditional ways that states anticipate and plan for security risks, and the actions they can take to protect their people (WEF 2016b)

Impact of Society Foundations

Rather than a discussion of opportunities and the benefits, greater insights can be gained from a more deeper understanding of how these technologies are going to impact the basic structure of society as we know it. Some of the key implications are discussed below:

Energy Independence – The coming of Cheap and Clean Energy?

Renewable energies which are globally available promises a new era of energy independence as practically any country has access to this form of energy. At global level energy independence means a significant shift in geopolitics as securing energy supplies has been at the of current geopolitical arrangements. Beyond independence from other countries, the fact that anyone can be a producer of energy has significant political and economic implications. Energy independence is moving to the individual level.

Production of goods and services – The end of the Factory?

Production of goods and services has been at the heart of the industrial revolution. At each iteration, new methods have enabled significant drop in cost of production. Both technology and energy have been crucial. The factory and machines of 1st industrial revolution introduced the economies of scale. The mass production methods of 2nd

[21] Metals include indium (In), germanium, (Ge), tantalum (Ta), PGM [platinum group metals, such as ruthenium (Ru), platinum (Pt) and palladium (Pd)], tellurium (Te), cobalt (Co), lithium (Li), gallium (Ga) and REE(rare earths) are the basis for cleaner technology innovation. Batteries, Wind turbines, Solar panel, electronics systems needed for all kinds of control used all need these critical metals. China has a monopoly in production of Rare Earth Elements

industrial further dramatically cut the cost (at the expense of customization). Economist (2012) argues that now were are at the cusp of paradigm shift in manufacturing with 3D printing which combines the customization of cottage industry and cost efficiencies that can beat the mass production model. Now a product can be designed on a computer and "printed" on a 3D printer. The digital design can be tweaked with a few mouse clicks. The 3D printer can run unattended, and can make many things which are too complex for a traditional factory to handle. In time, these amazing machines may be able to make almost anything, anywhere[22]. The cost of producing much smaller batches of a wider variety, with each product tailored precisely to each customer's whims, is falling. The factory of the future will focus on mass customization—and may look more like those weavers' cottages.

This has huge implications. As pointed out business model that arise in the wake of IR follows the template of production technology. The geography of supply chains will change dramatically. A customer in need of spare part can simply download the design and print it. And more crucially with the internet allowing ever more designers to collaborate on new products, the barriers to entry are falling. The end of the factory is not too far away. The factory of the future is likely to be a communal space where people go to print the item that need.

Manufacturing is at an inflection point: The rules from the industrial era of mass production are giving way to a digital era of individualization and optimization. This fact has been internalized by industry. A recent survey shows that 63%of consumer industries strategy officers agree that by 2030 at-home manufacturing will be mainstream in both developed and developing markets as consumers 3D/4D print a wide variety of products at home. (Moavenzadeh, 2015).

Manufacturing is also being transformed from product to a service industry. Today Rolls-Royce no longer sells jet engines; it sells the hours that each engine is thrusting an aero plane through the sky (Economist, 2012)

The Market Place/ Business Landscape

Increasing computing power, increasing machine intelligence and advances in data science coupled growing amounts of data presents boundless opportunities for disruption in the traditional industry. New startups have upended very powerful traditional companies. Online platform enabled by internet are disrupting all kinds of business. The biggest retailer, Amazon, has no physical presence, the biggest taxi company, Uber, does not own a single taxi and the biggest hospitality company AirBnB does not own a single hotel room.

The leading firms in this new landscape have a remarkable depth of analytical talent that are actively looking for ways to enter other industries. These companies can take advantage of their scale and data insights to add new business lines, and those expansions are increasingly blurring traditional sector boundaries. For instance Google is developing

[22] 3D printing creates a solid object by building up successive layers of material

autonomous cars while Tesla, a car company, sees itself as an energy company. The importance of data has also upended the traditional relationship between organizations and their customers since every interaction generates information. Sometimes the data itself is so prized that companies offer free services to obtain it e.g. Facebook. An underlying barter system is at work, particularly in the consumer space, as individuals gain access to digital services in return for data about their behaviors and transactions (MGI 2016). Data revolution promises to reconfigure industry as testimonies of business leaders attest (Maovedzeh 2015)

- 88%of automotive strategy officers agree that by 2030 at least one major automaker will earn more revenue from selling data and mobility services than from selling cars and auto parts.
- 70%of professional services strategy officers agree that by 2025, digital solutions will generate more revenue for professional services firms than services delivered by people
- 50% of media, entertainment & information strategy officers agree that by 2025 90% of the news read by the general public will be generated by computers
- 100%of insurance and asset management strategy officers agree that by 2020 real time data streams from sensors will be core to insurer's competitive positioning

The nature of the current revolution is that even the so-called winner in the industry 4.0 today maybe out of business tomorrow. The changing fortunes of Yahoo! And Nokia is a testimony of the turbulent times. Pierre Nanterme, CEO of Accenture, recognized this gap when he stated, "Digital is the main reason just over half of the companies on the Fortune 500 have disappeared since the year 2000."19

WEF (2016) points that there are four main effects that the Fourth Industrial Revolution has on business—on customer expectations, on product enhancement, on collaborative innovation, and on organizational forms. The inexorable shift from simple digitization (the Third Industrial Revolution) to innovation based on combinations of technologies (the Fourth Industrial Revolution) is forcing companies to reexamine the way they do business. Business leaders need to understand their changing environment, challenge the assumptions and relentlessly and continuously innovate or otherwise perish.

The Nature of Work

WEF (2017) points that business are redefining traditional notion of work. Work is what people do and not where they do it. They point that businesses will increasingly connect and collaborate remotely with freelancers and independent professionals through digital talent platforms. Indeed, telecommuting, co-working spaces, virtual teams, freelancing and online talent platforms are all on the rise, transcending the physical boundaries of the office or factory floor and redefining the boundary between one's job and private life in the process. Modern forms of workers' organization, such as digital freelancers' unions, and updated labour market regulations are beginning to emerge to complement these new organizational models. The challenge for employers, individuals and governments alike is going to be to work out ways and means to ensure that the changing nature of work benefits everyone.

The big question is whether this redefinition of work will lead to better jobs

The Economy

The marginal cost of some goods and services in digital platforms is almost zero, allowing millions of people connected to the Internet of Things to produce and exchange things with one another, for nearly free, giving rise to a Sharing Economy.

Initially confined to digital world where for instance people produced and shared music, this is changing, the evolving Internet of Things allows consumers to make and distribute their own renewable energy, use automated car sharing services, and manufacture an increasing array of 3D-printed physical products and other goods at very low marginal cost in the market exchange economy, or at near zero marginal cost in the Sharing Economy, just as they now do with information goods.

The assumptions that have underpinned economic policy are tested. The sharing economy is moving from the concept of ownership to concept of buying a service. Therefore, car companies are unlikely to sell cars in the future but rather the transport service it offers[23].

The internet technology platform is allowing new forms of capital that are more valued than material to be built. For instance, "Couch Surfing" service allows people to invite other to stay in their houses for free. The social capital created from developing new friends and networks is more valued than what the owner could earn from say listing the house on AirBnB and getting a paid visitor.

The Society

While all industrial revolutions had significant impact on how the society was organized. 4IR is likely to be very different as it questions some of the fundamental assumptions of what it is to be human. Work and profession have defined humans. Thought and autonomy have also defined humans. These notions are all being undermined as machines 'encroach' what are seen as human domains.

<u>Work and Leisure</u>

Work has continued to define who we are and indeed the modern western civilization steeped in Judeo-Christian values places human worthiness based on work. For instance, the essence of Protestant ethic, was that work and acquisition of possessions were legitimated in a religious way, while pure consumption and enjoyment were devalued or even condemned. Individuals were able to prove that they deserved to become part of

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[23] The is likely to spell doom for car companies. 1 car is a sharing economy removes 22 cars from the road. This is based on the fact that in the current ownership model a car spend 93% of its lifetime idle.

those elected for eternal salvation, of the “aristocracy of the saints in the world,” only by living in a serious and systematic way and avoiding idleness (Weber 1984:123 cited in Haller et al 2013). Waste of time was “the first and in principle most serious of all sins” and luxury and unnecessary relaxation, are condemnable from this ethical point of view. (Weber 1984:167 cited in Haller et al 2013).

Yet we are now in a situation where people can live a life of more leisure with machines working for people.

Human Autonomy - Machine in Charge?

More fundamental concern is the place of the machine in society as they become more and more “intelligent” and help in decision making, will this see people surrender autonomy to machines, for example a recent case of a woman who drove into a lake following instructions from a GPS[24]. An article published by The Atlantic in 2008, has become a seminal article about the advancements in the technological age and the effects on human intelligence details the fundamental shift in learning, reading, and memorization that has taken place in recent years because of the digital proliferation. It suggests that the shifting landscape of modern times is resulting in a dumbing-down of society because of the over-reliance on technology[25]. More crucially there are concerns that robots could have significant say in human affairs, sitting on corporate boards[26] and even able to launch a world war (see box)

The Third Revolution in Warfare

UN **has** argue that Lethal autonomous weapons threaten to become the third revolution in warfare. Nations, including the US, China, Russia and Israel are seeking to develop autonomous weapons technology, with the capability to independently determine their courses of action without the need for human control. They point that once developed, they will permit armed conflict to be fought at a scale greater than ever, and at time scales faster than humans can comprehend. (**Boffey 2017)**

More crucially, it is possible that emboldened machines could demand rights like those humans. A recent study by the International Bar Association claimed robotics could force governments to legislate for quotas of human workers (Boffey 2017). This notion is not farfetched as the US already allowed companies to be treated like people with freedom of speech and ability to influence outcomes of elections. Indeed the renown scientist, Prof Stephen Hawking, has warned that powerful

[24] Woman follows GPS into lake”. May 16, 2016. Retrieved from: *http://www.news.com.au/technology/gadgets/woman-follows-gps-into-lake/news-story/a7d362dfc4634fd094651afc63f853a1*

[25] “Is Google Making Us Stupid?”, a

[26] Schwab (2015) predicts that by 2025 an AI machine will be on a corporate board of directors;

artificial intelligence would prove to be “either the best or the worst thing ever to happen to humanity”.

Entrenching Inequality

The technology developments of 4IR threatened to create a social chasm like never been seen as a small class of highly skilled workers and owners of capital to capture much of the benefits of new technologies. This trend is best illustrated in the wealth creation and capture in the 2nd and the 3rd Industrial revolution sector. In 1990 the three biggest companies in Detroit (the epicenter and apogee of 2IR) had a market capitalization of $36bn, revenues of $250bn and 1.2 million employees. In 2014, the three biggest companies in Silicon Valley (the birthplace of 3IR) had a considerably higher market capitalization ($1.09tn) generated roughly the same revenues ($247bn) but with about 10 times fewer employees (137,000). (**Ellicot, 2016**).

Schwab (2015) points that Inequality represents the greatest societal concern associated with the Fourth Industrial Revolution. The largest beneficiaries of innovation tend to be the providers of intellectual and physical capital—the innovators, shareholders, and investors—which explains the rising gap in wealth between those dependent on capital versus labor.

Whither the Middle Class?

Technology is therefore one of the main reasons why incomes have stagnated, or even decreased, for a majority of the population in high-income countries: the demand for highly skilled workers has increased while the demand for workers with less education and lower skills has decreased. The result is a job market with a strong demand at the high and low ends, but a hollowing out of the middle. Autor (2014) also observes that automation is leading to polarization of the labor market which is squeezing out mid-level wage earners and widening the gap between those at the top and those at the bottom.[27]

Schwab (2015) points that this explain why middle classes around the world are increasingly experiencing a pervasive sense of dissatisfaction and unfairness. He further warns that a winner-takes-all economy that offers only limited access to the middle class is a recipe for democratic malaise and dereliction.

Even as the middle is hollowed out, the lower end is likely to experience highly depressed wages. Brynjolfsson and McAfee (cited in Schwab 2015) point that as automation substitutes for labor across the entire economy, the net displacement of workers by machines might exacerbate the gap between returns to capital and returns to labor. In the future, talent, more than capital, will represent the critical factor of production. This will

[27] Indeed, an analysis by MGI (2017b) of impact of automation finds that that just over $1 trillion in wages could be economically automated with a technology cost of $20 per hour, and $2 trillion could be captured with an automation cost of $10 per hour. Which they point, supports the argument that some occupations in the middle of the income and skill distribution are more susceptible to automation than others at the top and bottom ((McK 2017)

give rise to a job market increasingly segregated into "low-skill/low-pay" and "high-skill/high-pay" segments, which in turn will lead to an increase in social tensions.

MGI (2017b) warns that one of the challenges of the new era will be to ensure that wages are high enough for the new types of employment that will be created, to prevent continuing erosion of the wage share of GDP, (which has dropped sharply since the 1970s) and recommends that if automation does result in
greater pressure on many workers' wages, some ideas such as earned income tax credits, universal basic income, conditional transfers, shorter workweeks, and adapted social safety nets could be considered and tested.
.
The issue of inequality has risen to the top of global policy and political debates, some advocate better access to opportunities through education and jobs; others argue for redistribution, for example, through the tax system[28]. The more affluent are also becoming more receptive to higher taxes to address inequality[29].

All the same, Ellicot (2016) makes that point that it is a myth that all will be well provided the fruits of an economy dominated by artificial intelligence and smart robots can be redistributed, perhaps through a citizen's income so that we can all have more leisure time when machines do all the work. He makes the point that re-distribution, even assuming it happens, is only part of the story. Supporting the argument of the Archbishop of Canterbury who argues that the changes likely to be brought by IR required not just an economic but also a spiritual response.

The way forward is not clear, and this issue is likely to be of growing concern as 4IR unfolds.

Inequality in a historical perspective

Technological change has always been disruptive. There was a huge polarization of income and wealth in the first wave of industrialization at the beginning of the 19th century, and this gave rise to political and institutional change over the 100 years between 1850 and 1950: the spread of democracy; the emergence of trade unions; progressive taxation and the development of social safety nets. These helped create bigger markets for the consumer goods that were spawned by the second Industrial Revolution: TVs, radios, vacuum cleaners and the like.

[28] . As Nobel Prize winning economist Joseph Stiglitz said: "Our economic system isn't working for the majority of our citizens. You have to ask why. If we had fair tax systems, we wouldn't need redistribution" (WEF 2016).
[29]. Chrystia Freeland, Canada's Trade Minister, said that during her door-to-door campaigning in the October 2015 federal election in Rosedale, Canada's most affluent neighborhood, she warned voters that a Liberal government led by Justin Trudeau would raise taxes. She asked whether people would rather live in a society of inclusive prosperity or a gated community of the 1%. The result? Freeland won the election (WEF 2016)

But over the past four decades a political model that both facilitated the spread of technology and provided some protection against its disruptive consequences has come under attack. Welfare states have become less generous, levels of long-term unemployment are much higher, taxation has become less progressive, politics has increasingly been dominated by those with the deepest pockets who can lobby the loudest

https://www.theguardian.com/business/economics-blog/2016/jan/24/4th-industrial-revolution-brings-promise-and-peril-for-humanity-technology-davos

V. Looking Ahead – What does the Future Hold?

The technological developments of 4 IR are different from technological development that drove the previous industrial revolutions in a number of ways. In the 1st industrial revolution the prime mover was energy/power innovations. The enabled new ways of communications and new ways of production. Energy (this time electricity) was the prime mover in the second IR. In the 4th industrial revolution information and communication technology is the prime mover. While technology trends discussed will be crucial in shaping the future as shown, the changes are happening in a larger context of where other big shifts are occurring. Some in response to 4IR, others independent and yet still others being drivers of 4IR technologies.

WEF (2016) points that the future will be driven by technology on one hand and demographic and socio-economic factors on the other. Some more impactful, others not so impactful. Some are already having impact and others not yet felt. WEF (2016) argues that demographic and socio-economic shifts are expected to have nearly as strong an impact on business models and organizational structures as technological change. Table 2 summarizes drivers that business leaders see as crucial including the relative impact of each, and the time frame (WEF 2016).

Table 2 : Survey of business leaders on the drivers of social and technology change

Socio-Economic and Demographic Drivers	Importance (% reporting)	Timescale	Technology Drivers	*Importance (% reporting)*	Timescale
Changing Work Environment and flexible work arrangement	44%	Impact felt already	Mobile and Internet cloud technology	*34%*	2015-2017
Rise of Middle Class in Emerging Markets	23%	Impact felt already	Advances in computer power and big data	*26%*	2015-2017
Climate Change, natural resource constraints and the transition to greener economy	23%	Impact felt already	New Energy supplies and technologies	*22%*	2015-2017
Rising Geopolitical Volatility	21%	Impact felt already	The Internet of Things	*14%*	2015-2017

New Consumer concerns about ethical and privacy issue	16%	2015-2017	Crowdsourcing, The sharing Economy and peer-to-peer platforms	*12%*	Impact felt already
Longevity and aging societies	14%	2015-2017	Advanced robotics and autonomous transport	*9%*	2018-2020
Woman's rising aspiration and economic power	12%	2015-2017	Artificial Intelligence and machine learning	*7%*	2015-2017
Rapid Urbanization	8%	Impact felt already	Advanced Manufacturing and 3D printing	*6%*	2015-2017
			Advanced Materials, Biotechnology and genomics	*6%*	2018-2020

WEF 2016

In a similar study that is looking at the future of work in the UK Stormer et. al. (2014) identified 13 factors across 5 domains (See table 3). Though there are some overlaps there are also important differences. The divergence between WEF (2016) factors which reflect a global perspective and Stormer et al. (2014) which reflect a UK perspective is a clear testimony that while there are clear drivers that are universal, the circumstance of a region or country will determine which drivers beyond the global ones should be given attention. Thus the appropriate response to the challenges of shaping a better future will require action at country, regional and global levels.

Table 3; Drivers of Future of Work, UK

Technology & Innovation	Business and Economy	Laws & Politics	Resources & Environment	Society & Individual
Converging technologies & Cross disciplinary skills	Changed Business perspectives	Decreasing scope for political action and constrained public finance	Growing scarcity of natural resources and degradation of ecosystem	Growing desire for better work life balance
ICT developments and the Age of Big Data	New business ecosystems			Income uncertainty
Digitization of production	Shift to Asia			Changing work environment
				Growing Diversity
				Demographic change

Stormer et. al 2014

The Sustainability Movement

At the global front, the key driver beyond technological developments is the question of sustainability. This has been ongoing for some time initially rising to counter environmental degradation in the wake of consumerism unleashed by the second industrial revolution. This has been given further impetus by the growing concerns over climate change as the carbon-based economies of (IR1, IR2 and IR3) continue to spew unsustainable amounts of CO_2 into the atmosphere. The apogee of this movement is the promulgation of the Sustainable Development Goals (SDGs) as the new global development agenda and also more binding greenhouse gas reduction targets as outlined in the Paris Agreement.

This movement is giving boost to the drive to have more energy derived from Renewable Energy Sources (RES). As pointed before the shift to RES is the defining trend of 4IR with significant implications on geopolitics as well as local politics, as power is literally moved to the people leading to an emergence of a more lateral (as opposite to a hierarchical) society in its wake. A true social revolution.

The Future of Work (Or Future of Value Creation?)

As discussed, the development and convergence of multiple technologies are leading to unprecedented paradigm shift in economies. The changes are disrupting almost every industry in every country. And the breadth and depth of these changes herald the transformation of entire systems of production, management, and governance. While these impending changes hold great promise for future prosperity and job creation, many of them also pose major challenges requiring proactive adaptation by corporations, governments, societies and individuals (WEF 2016b)

Much of the literature on 4IR is devoted to concerns about the work. This reflects the centrality of work in current society. Indeed, the value of people is intrinsically tied to work and yet this is the area of human endeavor that will be most impacted by technologies driving the 4IR. Unlike the previous IR where only a certain segment of work was impacted e.g. skilled artisan in 1IR, and repetitive jobs in 3IR, 4IR technologies have the possibility to obliterate all types of jobs and drastically change the work environment.

While previous revolutions were really death and birth of new industries in their wake, more than anything else 4IR promises a very different workplace. The blockchain technology spells doom for many involved in "trust business"[30]. Indeed, the current form of organization structures in both public and private sector, traditional bureaucracy is really system of creating trust that enables transactions to happen. For the first time this organizational form is threatened (note that in other revolutions this organizational form became even stronger and indeed the modern bureaucracy is a child of the 1IR as new emerging mega corporations sought to find an optimal structure, while developments in subsequent IRs strengthened it through development of Management Science/Operations Research techniques (2IR) and Management Information Systems (3IR). With blockchain technology, it is not hard to envisage a future dominated by pure peer-to-peer relationship eschewing the need of both governments and business organizations. Bitcoin is already bringing this concerns to the fore as for the first time there is a currency that does on depend on central banks and also the traditional banks.

[30] the centralized institutions and bureaucracies, such as banks, clearing houses and government authorities that are deemed sufficiently trustworthy to handle transactions

The search for a growth path

The 4IR will happen in a world that is also dealing with many issues, for example the threats posed by climate change. For a large part of the world, a significant number of people are living in poverty. So, while cutting edge technologies will occupy the technology domain, the social domain will be pre-occupied with issues of food and safety as people seek to uplift themselves. Therefore, the future of jobs will be shaped by how governments, businesses and civil society address the social and technological drivers.

How to grow and sustain growth continues to be a major pre-occupation. However, there is no template for growth in the wake of 4IR. For many developing countries, the march of robots may truncate traditional manufacturing-led growth that countries like China and the Asian Tigers blazed (WEF 2017). The spectre of massive loss of jobs in the wake of automation has raised concerns of dampened aggregate demand which will affect growth.

However, MGI (2017) makes the point that a growing and dynamic economy—in part fueled by technology itself and its contributions to productivity—would create jobs. These jobs would result from growth in current occupations due to demand and the creation of new types of occupations that may not have existed before, as has happened historically. This job growth (jobs gained) could more than offset the jobs lost to automation. They point to a number of trends that will lead to this and model potential impacts:

- Rising incomes and consumption, especially in emerging economies. They estimate that global consumption could grow by $23 trillion between 2015 and 2030, and most of this will come from the expanding consuming classes in emerging economies. As incomes rise, consumers spend more on all categories. But their spending patterns also shift, creating more jobs in areas such as consumer durables, leisure activities, financial and telecommunication services, housing, health care, and education. They estimate that 300 million to 365 million new jobs could be created from the impact of rising incomes.

- Aging populations. By 2030, there will be at least 300 million more people aged 65 years and above than there were in 2014. As people age, their spending patterns shift, with a pronounced increase in spending on health care and other personal services. This will create significant demand for a range of occupations, including doctors, nurses, and health technicians, but also home health aides, personal care aides and nursing assistants in many countries. They estimate heath care and related jobs from aging and rising incomes could grow by 80 million to 130 million by 2030.

- Development and deployment of technology. Jobs related to developing and deploying new technologies may also grow. These jobs include computer scientists, engineers, and IT administrators. Overall spending on technology could increase by more than 50 percent between 2015 and 2030.

- Investments in renewable energy, energy efficiency, and climate adaptation: Investments in renewable energy, such as wind and solar, energy efficiency technologies, and adaptation and mitigation of climate change may create new demand for workers in a range of occupations, including in manufacturing, construction, and installation. Up to 20 million jobs could be created if countries make the needed investments to meet the commitments to the Paris climate accord.

- Paid housework: Individual decisions within the household to use paid services or government investment to provide universal childcare and pre-school could marketize 50 million to 90 million unpaid jobs globally, mainly in occupations such as childcare, early childhood education, cleaning, cooking, and gardening

- Leisure Industry: Over the long term, productivity growth enabled by technology has reduced the average hours worked per week and allowed people to enjoy more leisure time. The growth in leisure has created demand for new industries, from golf to video games to home improvement.

Education and Training

For the education and training sector, it will mean vast new business opportunities as it provides new services to individuals, entrepreneurs, large corporations and the public sector. The sector may become a noteworthy new source of employment itself.

Formalization of economies

The developing countries expect particularly large impact from the mobile internet given that the technology has the potential to bring millions of formerly unconnected workers and consumers into the formal economy for the first time. Digital platforms is opening a new kind of informal economy, the “gig” economy. The platforms can foster improved work by better connecting people who need services with those who can provide them. Companies like TaskRabbit provides consumers across the country with reliable people in their neighborhood who will happily take care of their burdensome chores.

The Dawn of The Age of Creative Class?

The trends and impact of 4IR are pointing to a reorganization of society and the very nature of work itself. The transformation of traditional hierarchical organization of society (say through blockchains), the decentralization of power (through renewables) and rise of the coming back of the craftsman (through price competitive 3D printing) can potentially create a very different world. Riel (2009) point to the possibility of the emergence of a learning society that share some similarity to the agrarian society in-terms of relative importance of household and craft production which overtake industrial production as society transitions to a creation economy.

In this economy, the unique creation overthrows the centrality of the two profound dualisms of industrial society, between demand and supply, conception and execution. This comes about from a change in the ownership of the means of production and a decisive break with the image of the pyramidal hierarchy of creativity and talent. There is also a craft dimension to unique creation, highly specialized skills that are networked with both household and industrial production through coproduction creating what he calls "banal creativity". This is already evident as seen in the growing importance of do-it-yourself and of the social networks of Web 2.0 as platforms for collaborative unique creation.

Riel (2009) makes the point that the 'banal creativity' of every person as artist does not negate the role of craft but integrates and extends it in new ways. In the LIS, both the objective of the production process and the way of organizing production change profoundly (16). First, the relationship between conception and execution is different, since the key steps are personal and involve a fusion of what were formerly two sides of a clearly demarcated division between supply and demand. Second, given the spontaneous nature of the banal creative insights that drive personalised unique creation (material and immaterial, including identity), these innovations arise as people question, encounter, collaborate, discuss, reflect, etc.

Florida (2002) also alludes to the rise of a creative class being the key competitive advantage of cities, regions and countries. He points that the 'creative class' will play an increasingly important role in determining how work is organized, which companies will ultimately be successful, and even which cities and regions are most likely to grow and prosper. He stresses the importance of nurturing the creative class as it is a more stable economic base. He asserts here that even when economic conditions shift dramatically, these changes usually have little effect on the motivation of creative individuals as they always value intrinsic satisfaction over tangible rewards. The significant point is that what creative individuals tend to want from their work remains relatively constant, regardless of fluctuations in their personal financial situations. Florida (2002) believes that for a region ultimately to be successful, it must possess what he calls the '3Ts' of economic development: technology, talent and tolerance. To attract creative individuals, stimulate ongoing innovation and generate substantive economic growth, a location must have all three of these components.

Navigating The 4th Industrial Revolution -Policy Choices and Potential Pathways

Schwab (undated) argues that shaping the fourth industrial revolution to ensure that it is empowering and human-centered, rather than divisive and dehumanizing, is not a task for any single stakeholder or sector or for any one region, industry or culture. The fundamental and global nature of this revolution means it will affect and be influenced by all countries, economies, sectors and people.

The issues are more complicated for policy-makers. They must embrace the opportunity for their economies to benefit from the productivity growth potential and put in place policies to encourage investment and market incentives to encourage continued progress and innovation. At the same time, they must evolve and innovate policies that help workers and institutions adapt to the impact on employment. This will likely include rethinking education and training, income support and safety nets, as well as transition support for those dislocated (MGI 2017)

Time Horizon

The time horizon for 4IR changes to fully playout is highly uncertain. The MGI (2017) scenarios suggest that half of today's work activities could be automated by 2055, but this could happen up to 20 years earlier or later depending on the various factors.[31] Similarly the shift to renewable technologies will take a long time.

While the macro effects may take long to play out, at the micro-level the pace maybe very different. Some industries are already in turmoil and many people already displaced underscoring the need for action now. Indeed, action now not only means actively shaping the trajectory of 4IR so that it is beneficial to larger society but also the very act of building the 4IR infrastructure e.g. putting the new RES based energy regime and equipping people with skills and competencies for 4IR has potential to create many jobs on the way to this new future.

Some of the considerations going forward are discussed below:

a) Preparing the future Workforce

Individuals in the workplace will need to engage more comprehensively with machines as part of their everyday activities, and acquire new skills that will be in demand in the new automation age (MGI 2017). Three key actions will be crucial moving forward:

- Better Forecasting of skills demand: An ability to understand the current skills base in near-real time and to accurately forecast, anticipate and prepare for future job contents and skills requirements will be increasingly critical for businesses, labour market policymakers, workers' organizations and individuals to succeed. Drivers of change to job markets such as Big Data analytics may themselves become useful tools in managing this process.
- Greater attention to schooling: Cognitive abilities take much longer to develop, and thus calls for high quality and inclusive secondary, primary and pre-school education. Appropriate government policies will be required. However, companies can work with governments to clearly define the need. Businesses should work

[31] 5 factors that matter are: (i) technical feasibility; (ii) the cost of developing and deploying solutions (iii) labor market dynamics, including the supply, demand, and costs of human labor; (iv) are economic benefits; (v) regulatory and social acceptance

closely with governments, education providers and others to imagine what a true 21st century curriculum might look like and introduce new learning models[32]

- Continuing training: Basic skills are relatively straightforward to acquire compared to cognitive abilities. This is a field in which companies have an opportunity to take a proactive approach to building their talent pipelines by working much more directly with education and training providers.

- Collaboration: Collaboration across many Groups of companies may unleash further synergies. For example, formalized inter-industry collaboration in facilitating the transfer of these skills and enabling the receiving industries to acquire experienced talent from industries that have declining demand for those same skills.

Pre-Emptive training?
Proactive policy to prepare workers is an even better option. For example, Denmark allocates funding for two weeks' certified skills training per year for adults, and the strong emphasis the country places on in-work training helps explain its very high degree of employment mobility, with 70% of workers considering mid-career transitions a 'good thing', compared to 30% or less in most other European countries

b) **Navigating the maladjustment phase**

Though history does tell that deployment of new technologies in the past has led to new forms of work, including in cases when shifts in the activities performed in the workplace have been very substantial[33]. The question then remains; what happens in the transition period as people transition to new careers[34]?

MGI (2017) point that a very large number of people may need to shift occupational categories and learn new skills in the years ahead. They argue that beyond retraining, a

[32] Note that During the transition out of agriculture, for example, the United States made a major investment in expanding secondary education, and for the first time required all students to attend. Called the High School Movement, this raised the rate of high school enrolment of 14- to 17-year-olds from 18 percent in 1910 to 73 percent in 1940, making the US workforce among the best-educated and most productive in the world, and enabling the growth of a vibrant manufacturing sector unleashed by the 2nd IR. In period after 2nd world war, the US government with the GI Bill, enabled just under eight million veterans returning from war to go to college or be retrained further entrenched it leaderships in 3IR

[33] In the United States, for example, the share of farm employment fell from 40 percent in 1900 to 2 percent in 2000; similarly, the share of manufacturing employment fell from 25 percent in 1950 to less than 10 percent in 2010.4 In both cases, while some jobs disappeared, new ones were created, although what those new jobs would be could not be predicted at the time. (McK 2017)

[34] John Maynard Keynes coined the term "technological unemployment" to describe a situation in which innovation that economized the use of labor outstripped the pace at which new jobs could be created. Keynes warned that this was akin to a "new disease"—but he also described this malady as being a "temporary phase of maladjustment."2

range of policies can help, including unemployment, insurance, public assistance in finding work, and portable benefits that follow workers between jobs. They also point that wages for many occupations can be depressed for some time during workforce transitions. More permanent policies to supplement work incomes might be needed to support aggregate demand and ensure societal fairness. Possible solutions to supplement incomes, such as more comprehensive minimum wage policies, universal basic income, or wage gains tied to productivity, are all being explored.

c) More Agile Governments

Current systems of public policy and decision-making evolved alongside the Second Industrial Revolution, when decision-makers had time to study a specific issue and develop the necessary response or appropriate regulatory framework. The whole process was designed to be linear and mechanistic, following a strict "top down" approach. But such an approach is no longer feasible. Given the Fourth Industrial Revolution's rapid pace of change and broad impacts, legislators and regulators are being challenged to an unprecedented degree and for the most part are proving unable to cope (WEF 2016). Some proposals going forward include:

- Regulators must continuously adapt to a new, fast-changing environment, reinventing themselves so they can truly understand what it is they are regulating. To do so, governments and regulatory agencies will need to collaborate closely with business and civil society.
- Governments need to innovate within education and labour-related policymaking, requiring a skills evolution of its own.
- Governments are often not particularly adept at anticipating the types of jobs that could be created, or new industries that will develop. However, they could initiate and foster dialogues about what work needs doing, and about the grand societal challenges that require more attention and effort.

d) Proof of Concept Platforms

To get a better grip of 4IR the opportunities and what it takes, poof of concepts platform maybe helpful to allow stakeholder to experiment and learn. Two examples provide some pointers:

- Germany funded research and projects to encourage cross-disciplinary collaboration in the new industrial era. Specifically, there has been a focus on uniting government agencies with universities and businesses
- In the United States, a non-profit organization "Smart Manufacturing Leadership Coalition" (SMLC) supports the manufacturing industry through pursuing a comprehensive technology that no one company can undertake. SMLC was founded because leaders understood that manufacturers needed an avenue to pursue the development of smart manufacturing systems without independently taking costly risks. Initiatives like SMLC benefit all stakeholders because they provide a collaborative, low-stakes environment to develop in a high-stakes future.

Conclusion

The 4th Industrial Revolution is unfolding powered by developments in communications and information technology and creating opportunities and significant disruptions that threaten to upend society. **As well put, technology is Not Destiny - Institutions and Policies Are Critical.** Policy plays a large role in shaping the direction and effects of technological change. "Given appropriate attention and the right policy and institutional responses, advanced automation can be compatible with productivity, high levels of employment, and more broadly shared prosperity.[35]"

Policy makers, business leaders, and individual workers all have constructive and important roles to play in successfully navigating the 4IR. History shows us that societies across the globe, when faced with monumental challenges, often rise to the occasion for the well-being of their citizens. The literature is alight with interest on future of work especially as technologies accelerate and machines break new ground. Equally as people worry about the future of the earth especially the dangers of global warming become evident as extreme weather events become more frequent and more devastating. This then provides an opportunity for rethinking of strategy and policies to reshape a better future. However, this is likely to be a non-trivial affair.

Action is likely to be much harder in steering the world in the desired direction. For much like the earlier IR, there were losers and these losers fought hard to protect their interests. The challenges are that losers could be more entrenched in the current economic and political systems than before. So, the shift to renewables, the move to peer-to-peer industrial organization and sharing economies are a threat to well established business and government bureaucracies. At same time a more empowered population that can be more easily mobilized and is quick to embrace the increased freedoms and experiences that 4IR offers points to a highly contested transition.

Beyond formulating policy, weaving a strong narrative able to carry people along will be key to navigating and shaping the ongoing revolution. This will require new kinds of leadership in politics, business and more critically in civil society as 4IR flattens traditional hierarchies that business and political leaders are steeped in.

If you are going to paint a picture of the future where there is sackcloth and ashes, don't be surprised if you don't have a long line of people following you. We have to paint a picture of opportunity. (Obrien 2015, p105)

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