Extreme automation and connectivity: The global, regional, and investment implications of the Fourth Industrial Revolution

UBS White Paper for the World Economic Forum Annual Meeting 2016

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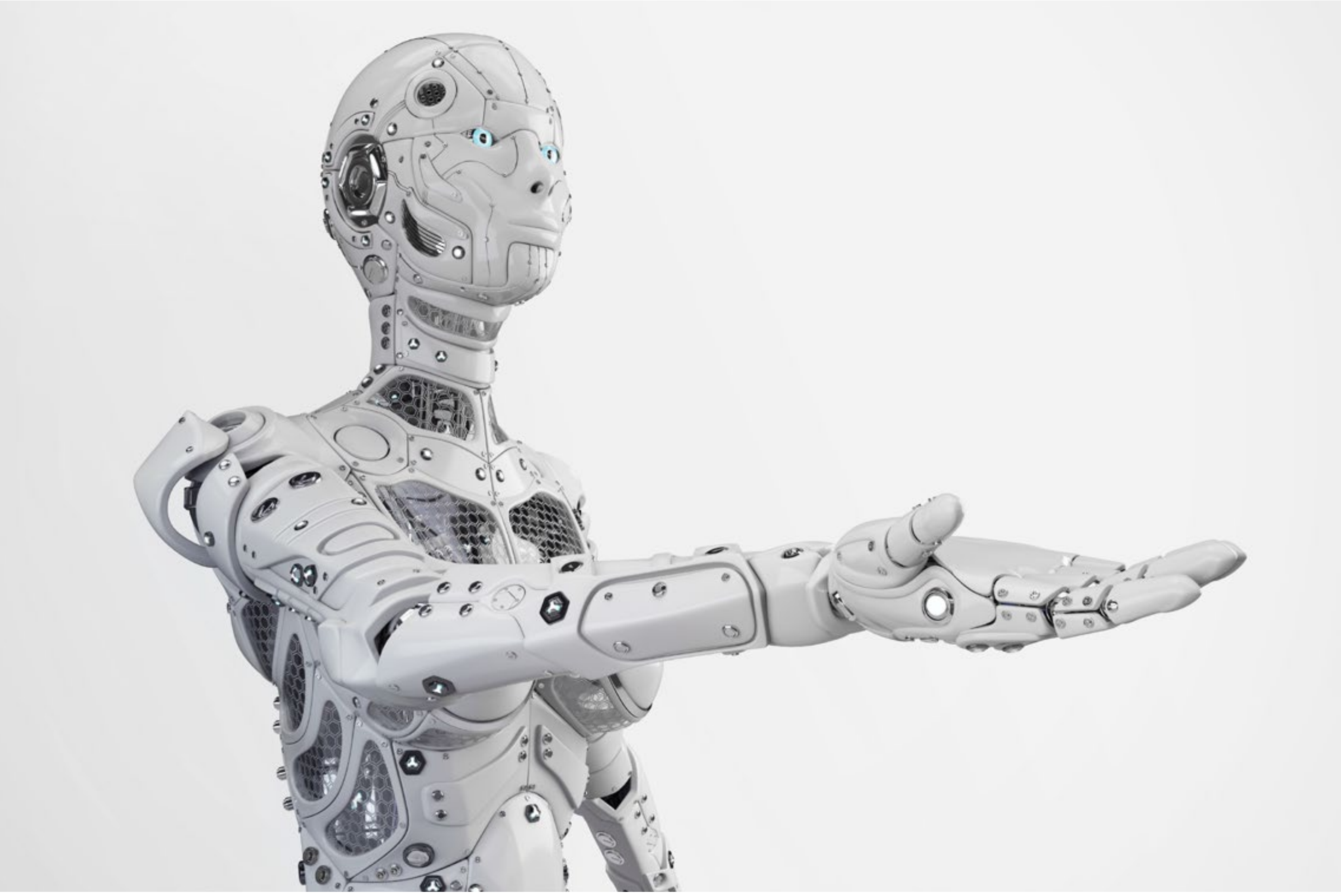

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Foreword

The global economy is on the cusp of profound changes that are comparable in magnitude to the advent of the first industrial revolution, the development of assembly line production, or the invention of the micro-chip. Technological advances are permitting ever greater levels of automation. Meanwhile, the near universal ownership of smart devices in many parts of the world is leading to a degree of interconnectedness that was previously unimaginable.

These developments, which we believe are part of a technology-driven Fourth Industrial Revolution, have significant implications for investors, the global economy and the relative competitiveness of developed and emerging nations. Thus, these changes are an interesting and important topic for discussion at the World Economic Forum.

In this White Paper, we have tried to put recent technological shifts in a broader historical context. Previous industrial revolutions have been driven by rapid advances in automation and connectivity, starting with the technologies that launched the First Industrial Revolution in 18th century England through to the exponential increases in computing power of recent decades. The Fourth Industrial Revolution is based on the same two forces. The first is extreme automation, the product of a growing role for robotics and artificial intelligence in business, government and private life. The second, extreme connectivity, annihilates distance and time as obstacles to ever deeper, faster communication between and among humans and machines.

These changes will have very different effects on nations, businesses and individuals. Automation will continue to put downward pressure on the wages of the low skilled and is starting to impinge on the employment prospects of middle skilled workers. By contrast the potential returns to highly skilled and more adaptable workers are increasing. Among corporations, a wide range of traditional businesses – especially those that act as intermediaries – can be expected to suffer. Many labor-intensive firms should be able to boost profit margins as they substitute costly workers for cheaper robots or intelligent software. And a range of entirely new companies and sectors will spring into existence. For nations, the largest gains from the Fourth Industrial Revolution are likely to be captured by those with the most flexible economies, adding a further incentive for governments to trim red tape and barriers to business.

At UBS we believe in embracing change, rather than fighting it. Our technology lab in London, established in early 2015, is already exploring a range of innovations. These include blockchain, the shared ledger system that underpins Bitcoin and offers the potential to enhance transparency and trust, while reducing transaction costs. In addition, the UBS Future of Finance Challenge aims to identify disruptive ideas and support their commercialization. Last year's competition drew 600 participants from 52 countries.

In the same vein, we hope this White Paper will stimulate debate as well as offering useful insights into the forces that are reshaping global business.

Your sincerely,

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Contents/ Executive Summary

Industrial Revolutions

Automation and Connectivity

1st 1784

mechanical production

steam power energy

2nd 1870

mass production

electrical energy

3rd 1969

electronics

IT

4th Today

artificial intelligence

big data

1. A brief history of industrial revolutions

Prior industrial revolutions have centered around improvements in automation and connectivity.

The First Industrial Revolution introduced early automation through machinery and boosted intra-national connections through the building of bridges and railways.

The Second Industrial Revolution began when automation enabled mass production and fostered more efficient, productive connectivity via the division of labor.

We have characterized the prior three industrial revolutions using the timeline proposed by Nicholas Davis, the World Economic Forum's Head of Society and Innovation. Our central view is that all industrial revolutions involve advances in two fields – automation and connectivity.

The First Industrial Revolution

The First Industrial Revolution ushered in early automation via machinery, in lieu of agricultural inputs. 1784 saw Henry Cort's invention in England of the "puddling" process that turned pig iron into wrought iron. This was seen by economic historians as a key inflexion point of the First Industrial Revolution, marking the beginnings of automation. Mechanization became a key element of economic development, leading to a profound split between the East and West that has only recently started to converge.

Manufacturing progress and the nascent use of higher energy-intensive fuels such as coal and petrol followed, paving the way for steam power and locomotives. This in turn spurred both a connectivity revolution via wider travel, and a surge in the construction of infrastructure projects, including bridges, tunnels, aqueducts, and ports. We also note that an agricultural revolution supported by the inclusion of crop rotation and selective breeding boosted farm productivity and helped contain the costs of labor-intensive foodstuffs.

The Second Industrial Revolution

The Second Industrial Revolution (typically seen by historians as beginning around 1870, the second half of the "long 19th century") was characterized by three factors: higher levels of automation via the development of mass production; more efficient connectivity in production via the division of labor; and further progress in the use of energy sources such as electricity and petroleum.

While at first the Second Industrial Revolution was limited to "within company" supply chains, automation and connectivity gains allowed supply chains to evolve into the complex systems we know today. These supply chains rapidly expanded across different firms and, increasingly, between different nations. Automation also contributed to a second agricultural revolution by boosting agricultural yields via industrial fertilizer production, and by introducing more productive food storage methods through refrigeration.

Standardization was one of the key drivers of these achievements, including of quality standards (for example, within trade blocks) and transportation systems (for instance, the shipping container). Legal and trade protections were also needed to assure innovators that they would be able to enjoy the financial rewards of their creativity, without being exposed to early competition from rivals copying their technologies.

The Third Industrial Revolution was propelled by the rise of the digital age, of more sophisticated automation, and of increasing connectivity between and within humanity and the natural world.

The concept of the corporation was key to this. In the absence of this integrated entity, the high transaction costs involved in individuals contracting every single economic interaction would have restrained profit growth, and heavy capital goods could never have achieved economies of scale.

The Third Industrial Revolution

The rise of the digital age characterized the Third Industrial Revolution. 1969 was the year in which connectivity took a leap forward, with the first message sent over ARPANET, the forebear of today's Internet. Equally, the scope for automation was vastly enhanced by the implications of Moore's Law – the observation that the number of transistors on an integrated circuit has doubled approximately every two years. This advancing automation coupled with the growing appreciation of the environmental damage caused by more intensive farming led, from an agricultural revolution perspective, to the rise of a "green revolution."

Moore's Law generally refers directly to electronic circuitry, the foundational technology of this era. It captures the wider phenomenon of output growing as an exponential function of input. Moore's Law resulted in greater computing power and the ability to automate ever more complex tasks. In some areas, such as biotechnology, the pace of progress has even exceeded Moore's Law.

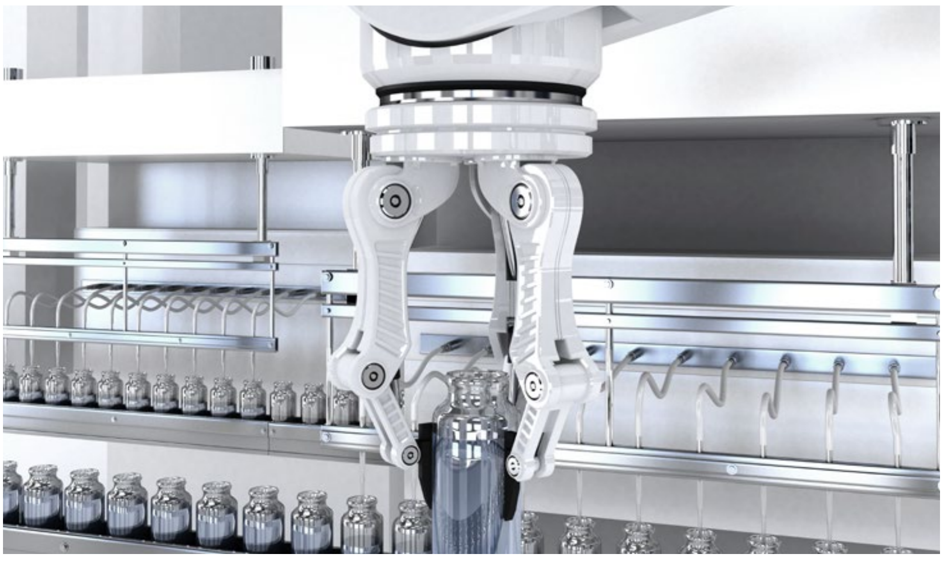
The Fourth Industrial Revolution is being driven by extreme automation and connectivity. A special feature of the Fourth Industrial Revolution will be the wider implementation of artificial intelligence.

Take, for example, the cost of sequencing a genome, which has fallen from as high as USD 100,000 in 2001 to USD 5,000 last year to USD 1,400 today. The concept of crossing the chasm recognizes the gap between the early adopters of new technology and an early majority who play "catch-up" as later adopters. This chasm is most easily bridged by continuous innovation, allowing minimal disruption to the consumer. Advances in computing set the stage for the Fourth Industrial Revolution in three broad areas, according to the WEF's Davis: the "technosphere" or digital world; the natural world that technology now allows us to monitor, analyze and digitize; and the human world, as technology impacts the way in which we connect and with whom we connect (human & machine, human & human, machine & machine).

The Fourth Industrial Revolution

The Fourth Industrial Revolution is being driven by extreme automation and extreme connectivity. Extreme automation will, as a first step, expand the range of jobs it is possible to automate, to include not only highly repetitive low-skill jobs, but also highly routine medium-skill jobs. As we outline in the next section, the relative impact of this extreme automation on income inequality between low-skill and high-skill labor looks set to intensify[1].

We expect artificial intelligence (AI) to be a pervasive feature of the Fourth Industrial Revolution. Extreme automation via AI will increasingly automate some of the skills that formerly only humans possessed. Where AI could be poised to make the biggest gains is in big data processing,



[1]We note that the need for lower-skilled, relatively lower-paid labor to provide sufficient affordable food may intensify. Coupled with growing environmental concerns, this factor may spur a fourth agricultural revolution, in line with historical experience.

potentially including the processing of language and images, which have thus far been off-limits for computers to understand. Extreme automation could allow more robots and AI to produce output, analyze results, make complex decisions, and adapt conclusions to environmental factors.

Extreme connectivity enables more universal, global and close-to-instant communication. It is giving rise to new business models and is opening up economic supply in ways previously not possible. Indeed, the creation of Uber, the taxi-hailing smartphone app, was only made possible by the explosive increase in portable Internet-enabled devises. Supply effectively created its own demand. Services like Facebook, WhatsApp, Pinterest, Snapchat, Twitter, and Instagram have come to play a pivotal role in the social interaction of citizens around the world.

Extreme automation can also be coupled with extreme connectivity, allowing computing systems to control and manage physical processes and respond in ever more "human" ways. This represents a democratization of the ability to communicate between and among governments, corporates, humans, and machines. The advent of "cyber-physical systems" may allow robots and AI, via extreme automation and connectivity, to "cross the chasm" between the technosphere, the natural world, and the human world.

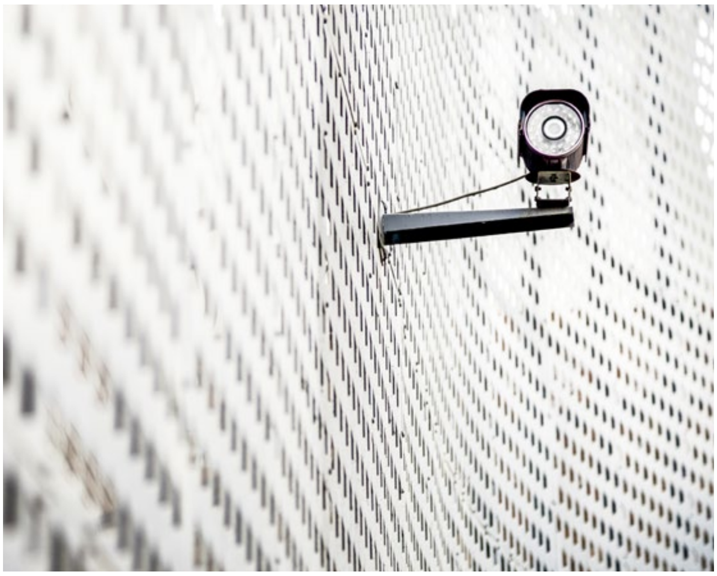
A number of radical implications may arise from the Fourth Industrial Revolution. We shall now look at how extreme automation and extreme connectivity may impact the global macroeconomy, regional economies, and investment opportunities.

2. What are the potential global consequences?

Polarization of the labor force as low-skill jobs continue to be automated, and this trend increasingly spreads to middle-skill jobs. This implies higher potential levels of inequality in the short-run, and a need for labor market flexibility to harness Fourth Industrial Revolution benefits in the long-run.

Greater returns accruing to those with already-high savings rates. In the short-run, this could exacerbate inequality via relatively lower borrowing costs and higher asset valuations.

A polarized labor force
While technological revolutions often stoke fears of declining employment as "robots do all the work," we believe a decline in aggregate employment is unlikely. As we discuss in our assessment of regional winners and losers, the attributes of the Fourth Industrial Revolution – extreme automation and particularly extreme connectivity – could improve the productivity of existing jobs or create demand for entirely new jobs. It is usually difficult to envision today what the jobs of the future might be. But we believe that extreme automation and extreme connectivity could actually increase demand for customized "human" work.



That is not to say we will not see an impact on relative differences in regional labor forces in the short-run. Low-skill employment will likely continue to contract, and an increasing range of middle-skill jobs will become vulnerable as extreme automation is rolled out. While aggregate employment is unlikely to fall in the long-run, we could start to see polarization in the labor force and frictional unemployment until workers reskill, relocate or alternatively adapt. Additionally, labor-intensive goods could see their prices fall relative to more capital-intensive goods.

Some of the low-skilled parts of the labor force (for instance, assembly line work) that have already been heavily affected by basic automation could be further impacted. The advent of "cobots," or collaborative robots, which are able to "move around" and interact without the need for fixed positions, have the potential to work at a higher rate of production relative to that of lower-skilled human workers. The greatest disruption, however, could be experienced by workers who have so far felt immune to robotic competition, namely those in middle-skill professions.

As the issuer of the world's reserve currency, the US' competitive advantages, sitting at the heart of the Fourth Industrial Revolution, could tighten effective monetary conditions among US dollar-linked economies.

We expect developments in extreme automation and extreme connectivity, blended in AI solutions, to have a significant impact on the nature of knowledge work. Automation will initially affect clerical work, sales, customer service, and support functions. Robotic process automation, automatic reporting, and virtual assistants will become common. Minor claims in insurance could be processed without human intervention, most incoming customer queries answered automatically, and many customer calls deflected. In finance, "robo-advisors" are already available in the market. In the legal world, computers can quickly go through millions of emails and dramatically cut the cost of investigations. And if fewer people are employed in a sector, fewer managers will likely be needed in that sector.

This combination could force a broad swath of workers to adapt. Lower-skilled and middle-skilled workers may face greater unemployment in the near term unless a number of criteria are met, allowing them to reskill into tasks that extreme automation cannot perform, or move into industries where extreme connectivity permits them to work outside of traditional global or regional boundaries. Equally, higher-skilled workers, particularly those who do routine tasks, may face future threats from the developments in advanced artificial intelligence such as natural language processing. Once again, we do not expect the Fourth Industrial Revolution to result in an aggregate increase in global unemployment; however we do examine, in our regional section below, which countries may be best placed short-term to harness fully extreme automation and connectivity benefits.

Higher savings at the top

Near-term polarization in the labor force and greater income inequality imply larger gains for those at the top of the income, skills and wealth spectrums. These individuals are likely to be best placed from a skills perspective to harness extreme automation and connectivity; they typically already have high savings rates and will benefit from holding more of the assets whose value will be boosted by the Fourth Industrial Revolution.

And the pattern may not be limited to individuals. The Fourth Industrial Revolution can be characterized by relatively low capital intensity via deployment of extreme automation and connectivity. Put another way, the prototype company in the Fourth Industrial Revolution may enjoy a small human capital pool, but a large economic value, either private or in equity market capitalization. An example from our 2015 whitepaper on "The New Global Context": WhatsApp generated impressive returns for a small group of founders and investors when Facebook agreed to pay what ended up being USD 22 billion for the company in February 2014, despite the fact that the firm had only 55 employees. By contrast, US airline United Continental has a similar market capitalization as of mid-December 2015 of around USD 22 billion, but around 82,300 employees. The USD 400 million of enterprise value per person garnered by WhatsApp is an extreme example, but it highlights the possible outsized gains and inequality that may arise from low capital-intensity business models of the future.

Even in low capital-intensity businesses, the capital goods that are employed – that perhaps used to suffer from "asset specificity" – are now divisible into smaller and more accessible units of usage, as exemplified by AirBnB and Uber. The growing use of the Internet of Things and extreme connectivity allows these more accessible units to be monitored and their efficiency evaluated in real time. (The October release from AirDNA, a data analytics company that aggregates AirBnB listing data, may be one example.)

As such, investments by firms benefiting from the Fourth Industrial Revolution may become more efficient and, over time, less burdensome in terms of capital deployed. Consequently, even companies who invest heavily may often be able to fund these investments out of earnings, without the need to borrow. In this regard, it perhaps should not be regarded as a coincidence that many tech giants run such large cash surpluses, in sharp contrast to the capital-intensive investment cycle of many basic resources funds.

Eventually, as we highlight later on, flexibility of capital and infrastructure may balance out some of this capital inequality. Yet early adopters of extreme automation and connectivity may enjoy lower borrowing costs in the short run, and put downward pressure on interest rates in parts of the economy where they operate. This is likely to drive up asset valuations of Fourth Industrial Revolution beneficiaries and further widen inequality levels.

The dollar dilemma

As we highlight in the regional analysis of this paper, the United States possesses many of the key attributes necessary for success in the Fourth Industrial Revolution. While technology is ultimately universal, economic structures tend to exacerbate differences between regions in the short run.

While the United States faces a variety of structural issues, including falling high school education rankings, increasing income and wealth inequality, and a problematic healthcare system, it remains an attractive destination for investment, company establishment and headquartering. This creates a plausible scenario where the USD maintains its structural strength. This trend has been in evidence during 2015, as the US business and credit cycle looks to be more advanced than those of other regions.

The Fourth Industrial Revolution increases the magnitude and probability of tail risks related to cybersecurity and geopolitics, but may spur regional action to invest and embrace Fourth Industrial Revolution benefits.

Further dollar strength would add to the difficulties of emerging market economies whose struggles are currently garnering headlines. Countries maintaining dollar pegs would face extra competitive pressures. And the cost of debt servicing would also rise for emerging countries and companies that have used the period of low US interest rates and broad USD weakness since the financial crisis to increase significantly their USD-denominated borrowing.

Furthermore, we noted in a previous UBS whitepaper, "Macro problems, micro solutions," that shifts in technology may prove disruptive for other economies and sectors. Labor markets in manufacturing could be materially affected as capital such as robotics and 3D printing, for example, displace low and middle-skill jobs. For some economies on the cusp of joining the global manufacturing and trading system (for example in South Asia, the Middle East, Africa, and parts of Latin America), extreme automation of capital in the US could have short-run negative demographic and employment effects. In addition, the "onshoring" of work back to the US (and shortening of global supply chains) from areas with a former comparative advantage of labor could be seen as a risk to developing nations.

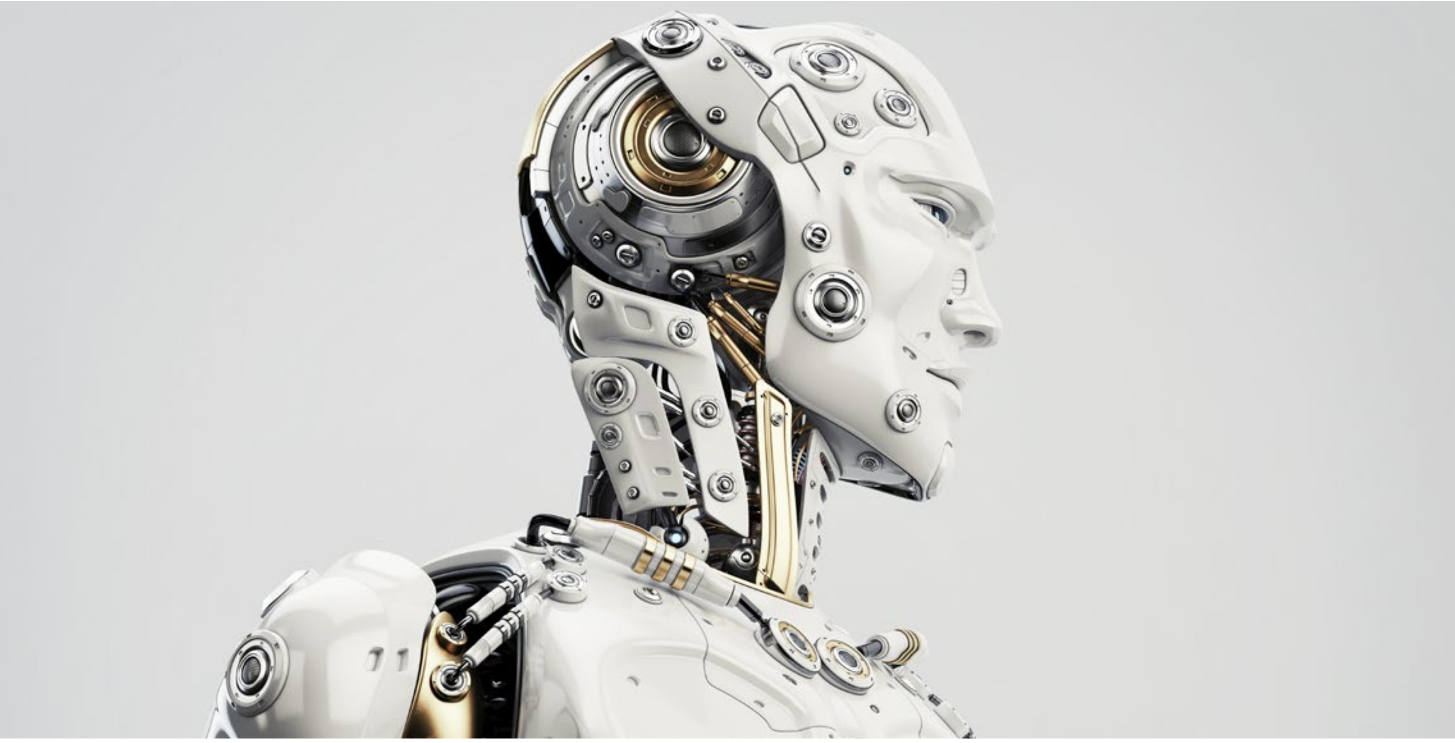
As highlighted in more detail in a later section of this paper, however, extreme connectivity may allow a shortening in the length of global supply chains. One particular implication of extreme automation and connectivity in the Fourth Industrial Revolution will be the role of "virtual" trade in ideas and intellectual property versus "traditional" trade in physical goods. Relative advantages in developed market legal protections of intangible ideas may lead to "onshoring" from emerging markets to the developed world initially, but this trend may reverse over the longer term as emerging nations grow and develop their infrastructure to embrace extreme automation and connectivity.[2]

Rising risks relating to cyber warfare and geopolitics
Extreme connectivity also increases the risks posed by cyber security breaches, as we have highlighted in previous White Papers, including "The New Global Context: Could economic transformations threaten stability?"

In particular, the rise of extreme automation and connectivity via "smart grid" systems, while improving energy efficiency and helping match supply with demand more effectively, may be vulnerable to hacks which shut down electricity transmission or generation systems entirely. According to Symantec, the energy sector is now one of the five most-targeted sectors for hackers globally, and in 2012 Saudi Aramco spent weeks repairing its computer systems after a virus attack. In 2013, parts of the Austrian and German power grids were threatened after an IT accident led to the network being flooded with data.

Similarly, cloud computing allows companies to outsource a host of IT tasks via extreme connectivity, including software installation and server maintenance. This gives them more flexibility and allows them to better deploy capital to their core business. But if the IT infrastructure of a large number of companies is being managed and distributed

[2]We also acknowledge that Leontief's Paradox may arise, whereby the US could end up importing capital-intensive products while exporting labor-intensive products, albeit where the labor intensity used to produce US exports is highly skilled, relative to other nations.



by a single cloud-computing provider, the damage inflicted by hackers could be significantly greater than an attack on a single company.

Cyber security dangers vary significantly between nations, with many emerging markets more exposed. Eurasia Group's cyber risk index, which rates the threat to businesses from 1 to 100, indicates a relatively elevated risk reading of 88 for Chinese firms, versus a safe score of just 14 for Swiss firms. The United States, despite its relatively robust cyber environment, is considered a prestige target by foreign states and dissidents and as a result Eurasia Group gives it a rating of 77, putting it at far greater risk than most rich nations.

The potential magnitude of such impacts could increase as connected networks grow larger due to the Fourth Industrial Revolution. Without strong international and institutional frameworks governing the protection of data, cyber security, and Internet privacy, access to the full benefits of extreme connectivity may be stymied. In January of last year, UBS' whitepaper "The New Global Context" called for greater global coordination on cyber-security. We expect these calls to continue and intensify.

Extreme connectivity is also fostering geopolitical tensions in several ways. It increases the ability of diverse groups to organize protests and offers the potential for greater publicity to violent extremists. Recent examples have highlighted the convening power of social media across the world. Widely distributed images of Mohamed Bouazizi, and his self-immolation in protest over police corruption, helped give rise to a mass movement that displaced the Tunisian government and triggered the broader Arab Spring in the Middle East. Extreme connectivity has also proved a threat to mainstream political parties across the globe. The 2015 mass protests in Brazil drew millions to the street, with social media again proving a driving force. In Western Europe too, mainstream political parties have been threatened by the rapid rise of protest movements that have exploited social media to galvanize their followers.

Extreme connectivity has the potential to aid violent extremists – both in recruitment and in generating publicity. A large quantity of online propaganda material is now being posted on social media platforms. The Islamic State has been deploying the Internet to win supporters throughout the world, managing to recruit citizens from the US and Europe to their cause. Furthermore, social media has tended to magnify the impact of violent events – such as the tragic terrorist attacks in Paris. The photographs and videos taken by witnesses can now be broadcast worldwide, providing the kind of mass publicity that terrorists are eager to generate. The possibility of global coverage increases the incentive for extremist groups to perpetrate further assaults.

Technology also has the potential to heighten political tensions by increasing economic inequality. The returns to technology have been uneven, with automation threatening the job security of lower- skilled workers and helping boost the pay and investment returns of their highly-skilled counterparts. This economic inequality may be exacerbated further if higher-income, higher-skilled workers consume more low capital-intensity goods and services (facing disinflationary pressures) relative to lower-income, lower-skill labor.

This may further contribute to the appeal of more populist political parties, but should also incentivize governments to bridge inequality gaps by investing regionally in technologies that allow extreme automation and connectivity to thrive. We focus on regional impacts of the Fourth Industrial Revolution in the next section.

3. Who will be the regional winners and losers?

"Flexibility" will be key to success in the Fourth Industrial Revolution – economies with the most flexible labor markets, educational systems, infrastructure, and legal systems are likely to be relative beneficiaries.

Developed economies are likely to be relative winners at this stage, whereas developing economies face greater challenges as their abundance of low-skill labor ceases to be an advantage and becomes more of a headwind.

Emerging markets in their demographic prime may find that extreme automation displaces low-skill workers, but that their limited technology infrastructures do not allow them to reap the full benefits of extreme connectivity.

An industrial revolution leads to significant changes in how economies work. Traditional economic structures change or become obsolete, and new economic structures establish themselves. Through this process, an industrial revolution can also become a significant force for specific disruption to the structures of the labor market.

How an economy and its labor force adapt to changing economic structures will determine how successful a nation is in responding to the Fourth Industrial Revolution. By and large, the nature of the technological change is not that relevant to the relative economic performance of different sectors and economies in the wake of an industrial revolution. There may be peculiar instances where extreme automation and connectivity can overcome problems that are specific to an economy – capital that helps an ageing workforce remain productive or overcomes an environmental challenge, for instance.

As a general rule, however, it is an economy's ability to adapt to the changes associated with new technology that matters.

A framework for determining regional winners and losers

There are four areas where flexibility and the ability to adapt are likely to determine economic success in the Fourth Industrial Revolution.

1. Capital for labor substitution
Past industrial revolutions have been about substituting capital for some forms of labor. This often leads to what has been described as the “lump of labor” fallacy – the false idea that there is a finite amount of work to go around.

Some jobs will be replaced by capital following extreme automation. Yet because people tend to extrapolate from current circumstances, the idea that we will all be replaced by AI often causes concern in the population at large. In fact, some existing jobs are likely to be replaced by machines, and new jobs in hitherto unimagined professions will emerge.

However, if the Fourth Industrial Revolution is to be a net benefit to an economy, then it is vital that the jobs market is flexible enough to adapt. All too often the reaction to structural change and associated selective job losses is to throw up barriers to labor flexibility and labor mobility. If the market starts to resemble medieval guilds with arcane qualifications or other barriers to entry, then either the economy will be unable to adapt to new technology, or it will be left behind in comparison to other economies.

2. Skills and inequality
Related to the importance of the flexibility of labor is the importance of the nature of skills in the labor force. This comes about in two ways. The Fourth Industrial Revolution should value high-skilled groups of workers more than low-skill labor. High-skill labor is likely to be able to understand the new technology more effectively and to adapt and maximize subsequent economic returns.

Perhaps more importantly, however, the skills that are required need to be flexible in themselves. An engineer, educated in a traditional system of rote learning, may be well equipped for the standards and economic structures of today. But they are likely to find it harder, at least in the short-run, to adapt their skills to a world of extreme automation and connectivity that will shape future economic structures. The issue of flexibility in learning skills can work against an economy that has a high education level. Being skilled in change, as well as being skilled in one’s profession, is crucial.

This issue also highlights the risk that the Fourth Industrial Revolution will raise income inequality. The monetary return to skills is likely to benefit those who are already on high incomes. Lower- skilled, lower-paid workers will suffer from relative income underperformance. But middle-income workers who face declining barriers to entry due to extreme automation, or who lack the flexibility to be able to change their skills to meet the requirements of extreme connectivity, could face a decline in relative standard of living. The resulting increase in inequality risks slowing the progress of extreme automation and connectivity. A threatened middle class may press for restrictive or repressive policies in a futile attempt to hold back the tide of technological change. This would damage the ability of an economy to benefit, as an early adopter, from the Fourth Industrial Revolution.

3. Infrastructure and inertia
Infrastructure is generally thought of in its physical manifestation, but from an economic perspective it is the behavior that infrastructure helps to shape that is important. For instance, an economy cannot easily move to a car-free transport system if the existing transport infrastructure is centered around an extensive road network. The cost of scrapping the sunk costs of existing infrastructure may ossify economic behavior, in spite of the advantages of adapting to a post-industrial revolution environment.

Economies that have built an infrastructure designed for the economic status quo, which is not readily adapted, will therefore be at a potential standard of living disadvantage in the future. This does not necessarily have to be a growth disadvantage; rebuilding existing infrastructure that has become obsolete can be growth-positive.

The Fourth Industrial Revolution is likely to change the physical location of human economic activity – localized production, home working and the idea of the factory complex or the urban central business district. Having a physical infrastructure that is adaptable will speed the pace of adjustment for an economy.

4. Robustness and flexibility of legal system

The Fourth Industrial Revolution will likely emphasize intellectual property. Trade in ideas that can be converted into a product at a local level (close to the demand) will become more economically attractive as a business model. As already highlighted in the previous section, global trade could become more "virtual" than physical (aside from basic materials).

Extreme connectivity raises the imperative of protecting intellectual property, where practical. An economy that offers robust protection is more likely to have a relative advantage, in the sense that the legal structures offer innovators the ability to capitalize on their ideas, and foreign innovators will be happy to sell their ideas into that economy.

The legal approach also needs to be flexible to deal with any new legal challenges that may arise. If a person's DNA contains a cure for a disease, who owns the rights to that DNA? There are questions as to how such a product should be developed, and indeed whether it should be legally protected at all.

Country assessment

Revolutions are not linear (one of the reasons that they are called what they are). This means that assessing beneficiaries in advance is always subjective and fraught with difficulty. However, using the framework outlined above, it is possible to take a systematic approach to the Fourth Industrial Revolution.

The following table examines the relative strengths of different economies using rankings from the World Economic Forum (WEF) Global Competitiveness Report. Given the importance of responsive human capital to the success of any industrial revolution, the labor market element is covered by a skills level and a proxy for skills adaptability (in the form of its output, innovation).

Each figure represents either a rank or an average of ranks in specific WEF categories. The WEF Global Competitiveness Report does provide specific scores as well as ranks. However, the purpose of this table is to judge the relative readiness of different economies to take advantage of the Fourth Industrial Revolution. A lower score implies a better relative readiness. The "overall impact" ranking in this table should therefore be treated as a means of obtaining a relative positioning, and not as a statement about the degree of an economy's absolute suitability for dealing with the Fourth Industrial Revolution.

It should not come as a major surprise that developed economies cluster towards the top of this list currently, and developing economies cluster towards the bottom. The competitive disadvantages of a developed economy (lower availability of low-cost labor) are in some way mitigated by the consequences of extreme automation and connectivity. Yet the competitive advantages of developing economies (abundance of low-skill labor) become more of a relative liability in the context of the changes that the Fourth Industrial Revolution is expected to bring about.

Adapted relative rankings from World Economic Forum Global Competitiveness Report, using Fourth Industrial Revolution categories[3].

	Labour structures flexible?	Skill level high?	Education allos adaptive skills?	Infrascructure suitable?	Legal protections?	Overall impact	Developed (DM), emerging market (EM) or frontier market (FM)?
Switzerland	1	4	1	4.0	6.75	3.4	DM
Singapore	2	1	9	3.5	9.00	4.9	DM
Netherlands	17	3	8	6.5	12.50	9.4	DM
Finland	26	2	2	19.0	1.25	10.1	DM
United States	4	6	4	14.0	23.00	10.2	DM
United Kingdom	5	18	12	6.0	10.00	10.2	DM
Hong Kong	3	13	27	4.5	10.00	11.5	DM
Norway	9	7	13	19.0	11.50	11.9	DM
Denmark	10	9	10	15.5	17.75	12.5	DM
New Zealand	6	10	24	21.5	6.25	13.6	DM
Sweden	20	12	7	12.0	19.75	14.2	DM
Japan	21	21	5	12.0	18.00	15.4	DM
Germany	28	17	6	9.5	18.75	15.9	DM
Ireland	13	15	21	19.0	11.50	15.9	DM
Canada	7	19	22	16.0	20.50	16.9	DM
Taiwan	22	14	11	20.0	31.25	19.7	EM
Australia	36	8	23	18.5	17.75	20.7	DM
Austria	40	16	17	19.5	17.25	22.0	DM
Belgium	54	5	16	17.5	21.5	22.8	DM
France	51	25	18	12.0	31.00	27.4	DM
Israel	45	28	3	26.0	38.50	28.1	DM
Malaysia	19	36	20	35.5	34.50	29.0	EM
Portugal	66	26	28	24.5	32.25	35.4	DM
Czech Republic	47	29	35	35.0	44.75	38.2	EM
South Korea	83	23	19	20.0	62.25	41.5	EM
Chile	63	33	50	42.0	39.25	45.5	EM
Spain	92	30	37	17.5	61.25	47.6	DM
China	37	68	31	56.5	64.25	51.4	EM
Kazakhstan	18	60	72	59.5	68.25	55.6	FM
Poland	81	31	64	48.5	58.00	56.5	EM
Russia	50	38	68	47.5	114.00	63.5	EM
Thailand	67	56	57	51.0	88.00	63.8	EM
Italy	126	45	32	31.5	87.75	64.5	DM
Hungary	77	57	51	48.0	90.25	64.7	EM
South Africa	107	83	38	59.0	42.75	66.0	EM
Greece	116	43	77	35.0	67.00	67.6	EM
Philippines	82	63	48	79.0	78.00	70.0	EM
Indonesia	115	65	360	73.5	70.25	70.8	EM
Turkey	127	55	60	58.5	77.75	75.7	EM
Colombia	86	70	76	77.0	102.75	82.4	EM
India	103	90	42	100.5	81.50	83.4	EM
Mexico	114	86	59	66.0	100.00	85.0	EM
Brazil	122	93	84	64.0	97.75	92.2	EM
Peru	64	82	116	88.5	113.25	92.8	EM
Argentina	139	39	93	78.0	125.75	95.0	FM

4 Labor market flexibility takes the ranking for the seventh WEF pillar "Labor market efficiency." Skills level uses the fifth pillar "Higher education and training." The question as to whether education allows adaptive skills takes the ranking for the twelfth pillar, "Innovation," as innovation can be thought of as a benchmark of the output of adaptive skills. Infrastructure suitable is an average of the rankings in the ninth and second pillars "Technological readiness" and "Infrastructure." Legal protections is an average of the rankings for "property rights" (1.01), "intellectual property protection" (1.02), "judicial independence" (1.06) and "ethical behaviour of firms" (1.17) – this last category being included as trade in intellectual property necessitates a degree of confidence in the honor of one's trading partners. Market description in the last column is based upon MSCI country classification methodology.

However, it does highlight that EM economies are at risk of squandering their demographic prime, if they are yet to move from low-income to middle-income. Many of these economies have still not dealt with the challenge of previous industrial revolutions. Their output and employment are still largely driven by agriculture, small-scale manufacturing and low-skilled services, large parts of which are in the informal economy. These are economies with low capital stock and high population growth rates. They will face the threat of the Fourth Industrial Revolution compromising low-skilled jobs via extreme automation, but may not have the technological ability to enjoy the relative gains that could be re-distributed via extreme connectivity.

When the Fourth Industrial Revolution arrives, a country's present state of industrial technology and demographic patterns will together determine how successfully it adapts, economically and politically, to extreme automation and extreme connectivity. The Fourth Industrial Revolution will take the emphasis away from demographic quantity to demographic quality.

Historically, there has been a quite consistent pattern among economies that have been able to benefit from their demographic dividend (through their demographic prime, they galvanized serious increases in productivity by shifting labor from agriculture to manufacturing through education and by promoting more flexible skills). This in turn substantially raised manufacturing's share of GDP. This is the same pattern seen earlier in many developed markets such as Germany, US and Japan.

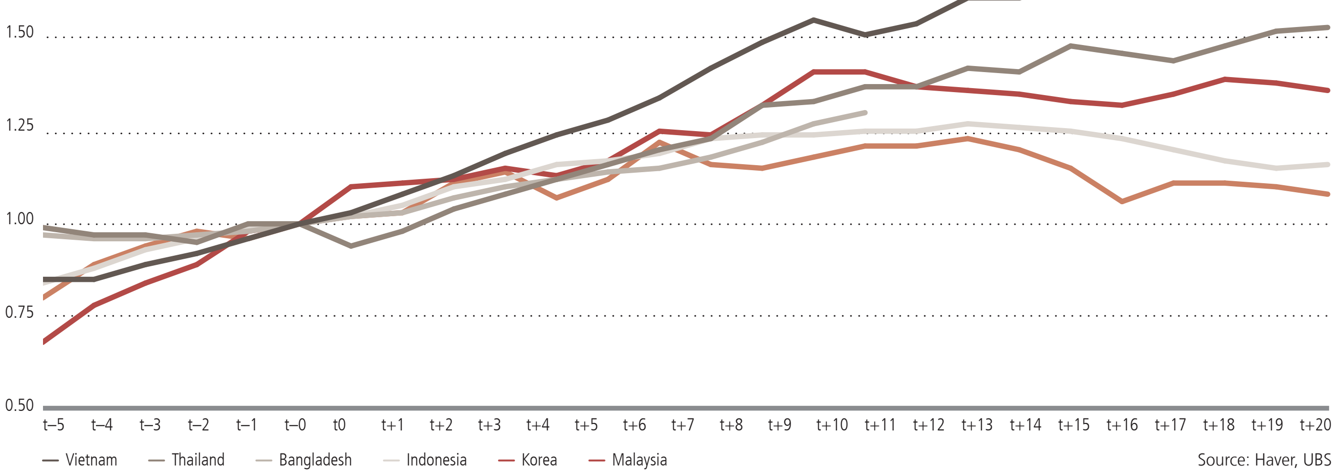
In **Figure 1** and **Figure 2** we attempt to show how manufacturing has evolved along with demographics in various economies. We define t0 as the year when the working age population as a proportion of the total population of an economy rose above 60%. This is the time we use as a proxy for the point of inflexion, the year we subjectively define as the beginning of an economy's demographic bulge[4]. We track how manufacturing as a percentage of GDP evolved just before and well after this inflexion point.

[4] The years for the various economies we studied are as follows. India: 1996; China: 1981; Korea: 1977; Thailand: 1984; Indonesia: 1991; Brazil: 1990; South Africa: 1995; Mexico: 1997; Turkey: 1992; Malaysia: 1993; Vietnam: 1998; Bangladesh: 2003; Egypt: 2002.

Figure 1: Path of Manufacturing to GDP – demographic successes

Demographic inflexion year (t0) defined as one when working age population as % of total population rises above 60%; Manufacturing to GDP ratio is set at 1 at t0).

Indexed, t0=1



Source: Haver, UBS

Figure 1: shows the success stories. It is well known that China, Korea, and Thailand are past their demographic prime. But they did make the moment of demographic bulge count. Correlation does not imply causation, yet it is telling that in these countries manufacturing as a percentage of GDP rose significantly once the working age population rose above 60%. This coincided with a big upswing in higher per capita incomes, savings, and typically also in export shares.

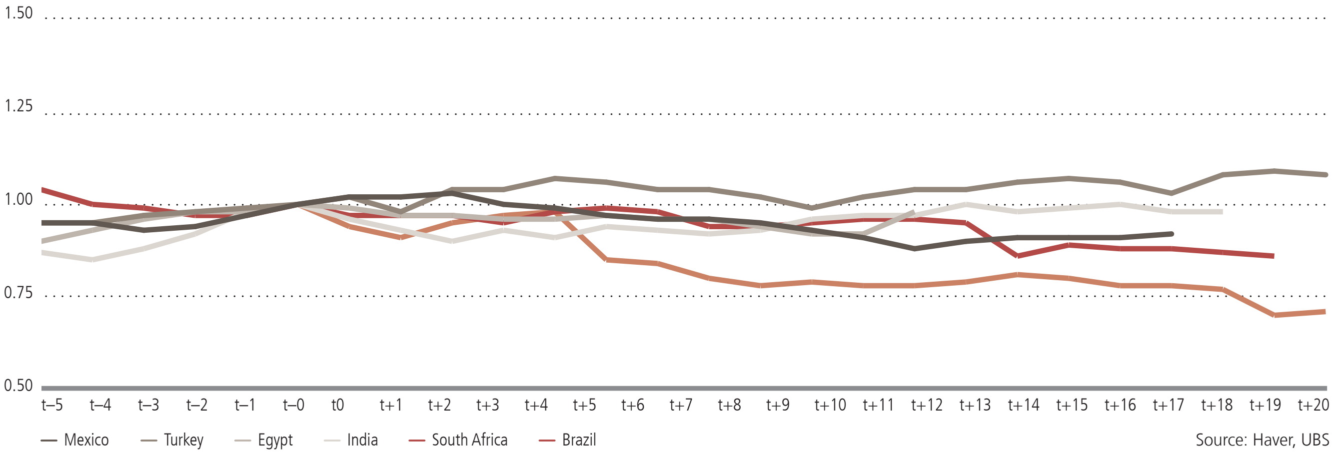
In **Figure 2** we show the countries – some of which, like India, are current market darlings – which do not really display the historical pattern (evident in demographic success stories) of a big boost to manufacturing when their demographic prime began. In a sense, this latter group of countries has not yet adapted even to the Second and Third Industrial Revolutions.

As we will show in our final section on investment conclusions, the power of extreme automation and connectivity to change global manufacturing may pose nearer-term challenges for emerging market (EM) lower-skill labor and EM assets, relative to developed market peers. We reemphasize the need, in the Fourth Industrial Revolution, for "flexibility" as the key to relative competitiveness.

Figure 2: Path of Manufacturing to GDP – demographic question marks

Demographic inflexion year (t0) defined as one when working age population as % of total population rises above 60%; Manufacturing to GDP ratio is set at 1 at t0).

Indexed, t0=1



Source: Haver, UBS

4. What are the investment consequences?

Given current assessments of relative competitiveness, emerging markets may be less well placed to profit from Fourth Industrial Revolution benefits, relative to developed markets.

Like prior industrial revolutions, the Fourth Industrial Revolution will likely have major repercussions across geographies and industries. Extreme automation is likely to generate substantial productivity gains for incumbents. But extreme automation using AI could also disrupt traditional business models. While there is a lot of hype surrounding the theme, we believe some of the long-term investment implications are under-appreciated. We highlight below some likely implications and how extreme automation and connectivity are starting to shape investment debates.

Four investment implications from the Fourth Industrial Revolution are outlined below:

1. Emerging market assets relative to developed market assets

Based on the economic and regional assessments outlined earlier in this Whitepaper, the Fourth Industrial Revolution is expected disproportionally to benefit developed markets at the expense of emerging markets, at least given current infrastructures.

We expect further disruption to traditional industries from extreme automation and connectivity.

We have noted how current labor market composition means emerging markets have more lower-skilled workers and less flexibility to raise skills than developed markets. We have also noted the nearer-term risks of a higher US dollar due to the US' current advantage in Fourth Industrial Revolution technologies. Furthermore, we have noted that the shift from physical to "virtual" trade may impact emerging market growth drivers and large proportions of the emerging market labor demographic, at least until investments in infrastructures are made and bear fruit.

The beta of global trade to global growth already seems to have declined since the global financial crisis, and this is one of the key reasons EM growth rates have been so weak in recent times. A further decline in import propensity of advanced economies, along with the risk of a structurally stronger US dollar, has the potential to hit emerging markets' earnings and cost of equity at the same time. However, this may also be a catalyst for emerging markets to invest in labor markets, transferable skills, and infrastructure over time to counteract this relative disadvantage.

2. Traditional industries disrupted

A number of traditional industries will likely be disrupted by the advances that the Fourth Industrial Revolution will bring to market. Investors may be tempted to pursue disruptive trends by investing in the early beneficiaries of extreme automation and connectivity, including robotics, artificial intelligence, or social media firms.

However, directly picking winners from the new crop of technology firms may not be straightforward. This proved to be the case during the Dotcom boom of the late 1990s and, recently, the aggressive valuations granted to several tech "unicorns" – a term for a start-up worth USD 1 billion or more – have come under pressure.

For example, payment provider Square was valued at USD 6 billion in a round of private financing in 2014. But an initial public offering in late 2015 gave the firm a value of closer to USD 4 billion. That has raised worries about the prospects for other leaders of the Fourth Industrial Revolution which may also go public over the coming year.

It may be more prudent for investors not to invest in richly valued disruptor firms, but rather to avoid traditional industries that have been disrupted. In retail, for example, automation seems to be mainly a threat, as it could have an indirect negative impact on traditional retailers by fostering online competition. Particularly in food, the online business is growing quickly but still represents less than 1% in most markets.

UBS summarizes the possible disruption threats and productivity benefits, by sector, in the below table:

Figure 3: Which sectors are at risk from disruption by artificial intelligence?

		Assessment relative to the plan	
		Medium	High
Productivity benefits	High	Utilities	Autos, IT services
	Medium	Insurance, banks, travel and leisure, medtech	Construction
	Low	Food retail, general retail	

Source: UBS, as of November 15, 2015.

For more detail please see the UBS Research Q-Series report entitled "How disruptive will the new dawn of artificial intelligence be?", published on 15 November 2015.

Big data beneficiaries include firms that harness big data to cut costs or target sales, firms that automate big data analysis, and firms that keep big data secure.

3. Big data beneficiaries
Big data is arguably a result of both extreme automation (in data analysis) and extreme connectivity (in terms of data collection). One could argue that big data is a “child” of the Fourth Industrial Revolution. As explored in our historical analysis of industrial revolutions, big data may be another example of how extreme connectivity is giving rise to new business models and expanding economic supply in ways previously not possible. Among the most prominent potential beneficiaries of the Fourth Industrial Revolution are firms that are able to harness big data effectively, provide data analysis, and offer protection from the threat of cyber-attacks.

Digital data usage globally is doubling every two years. The size of the digital universe is on track to reach 44 zettabytes (ZB) by 2020, a 50-fold increase over 2010, according to IDC and IMC. That is equivalent to 318 iPhones (32 GB) per household. This surge reflects both the expanding use of Internet-enabled devises in rich nations, embodied by the trend toward extreme connectivity via the Internet of Things, by which household appliances are linked to the Internet.

First, there are several industries with the potential to harness big data and cut costs, increase efficiency, and boost profits:

- Within retail, for example, large supermarkets have long been analyzing big data sets collected through store card use to understand customer behavior. But improvements in AI are now enabling extreme automation in the data analysis process. Customer data on physical in-store movements, collected by tracking smartphone data, may allow more targeted sales strategies. When linked to existing AI infrastructure in supply chains, it implies an almost total, highly intelligent and demand-flexible automation of retail supply chains, with potentially significant cost savings.

- Within utilities, a combination of automated big data analytics and extreme connectivity should have efficiency and profit-boosting impacts over time. By 2014, General Electric's big data product Predix had been installed in 23,000 wind turbines and close to 4,000 gas turbines, according to a New York Times article.

- Applications of big data in healthcare also offer possible investment opportunities. Recently, medtech firm Medtronic announced US Food and Drug Administration approval of the first app-based remote monitoring system for pacemaker users. Extreme connectivity now allows pacemaker patients to send diagnostic data from their device, via smartphone or tablet, directly to their doctor, who can assess patient health and suggest any changes to the course of treatment.

- Increasing computing power has also been driving down the cost of analyzing the genome and the proteome, the sequence of proteins expressed by genes. An increasing understanding of the genome is leading to medical breakthroughs in fields such as oncology. The impact of big data, however, extends beyond the treatment of a single class of diseases. The falling cost of sequencing could make it possible to tailor treatments to best suit each individual, which could reduce waste and in turn boost medical outcomes and the profitability of hospitals.

Second, software firms that provide tools to analyze large untapped pools of data, too complex to manipulate with standard methods available until now, will continue to benefit. The analytics software market alone is expected to reach USD 75 billion by 2020, with solid mid-teens growth, according to UBS estimates.

Lastly, firms that can protect big data should thrive in a Fourth Industrial Revolution. Already in 2014, more than 348 million identities of customers or employees were exposed to cybercrime, with an average 21 hours and USD 358 per person wasted on resolving online crime, according to Symantec's Norton Cybersecurity Insights Report. UBS research predicts that by 2020 the projected market size for security and safety (including measures to prevent cyber warfare) will have grown to around USD 700 billion (from USD 500 billion in 2014).

Blockchain applications could benefit firms that use them to automate processes securely, to cut out costly intermediaries, and to protect intellectual property.

4. Blockchain applications

Blockchain, a shared digital ledger system that underpins Bitcoin, is the ultimate product of extreme connectivity since it relies for its existence on the interconnection of a large number of computers. The technology works by producing a record of ownership on a shared database that should be impossible to edit or forge. It is a system that could have significant investment implications.

Though Bitcoin gave rise to blockchain, it is not clear whether the original crypto currency will survive and flourish. It is already facing competition from online monetary units that are more secure and easier to transact. The first mover advantage may not be sufficient to ensure the future of Bitcoin. The outlook for its technological underpinning, blockchain, looks more secure, given possible applications in other industries:

Financial services

In the financial services sector, the potential effects are mixed, with widely different implications for bulge brackets to retail banks and from money transfer firms to insurers.

Although the technology remains immature, a host of mainstream financial institutions are expressing interest in developing it.

For example, UBS is also one of 30 banks to have joined R3, a global consortium working on ways to use blockchain in financial markets. Exchanges like NASDAQ have said they plan on using a blockchain system to track deals in private company shares. Furthermore, the Lloyd's insurance market has expressed interest in the system as part of a modernization initiative.

Blockchain could prove a double edged sword for the banking industry. On the one hand, it has the potential to boost profitability in several ways. First, when money is transferred between banks, each institution needs to engage in a labor-intensive process of ledger reconciliation to confirm that the correct sums have been processed. A blockchain system, by eliminating the need for such a process, could allow banks to cut middle-skill administrative labor, a point cited in our assessment of the economic impacts of the Fourth Industrial Revolution. According to Santander, more efficient digital ledgers could cut costs in the banking industry by up to USD 20 billion a year.

On the other hand, the ability to process transactions directly between parties without the need for the trusted central utilities that currently serve the function of reducing counterparty risk poses a risk to traditional banking. Extreme connectivity could therefore lead to further disintermediation, a theme we touched upon first in our 2014 Whitepaper, "Macro problems, micro solutions: How trade, technology and finance can help keep the recovery going."

For international transfers, especially those involving small institutions and correspondent banks, payments can take

three to four days before they are settled. Since blockchain transactions can be processed in as little as 15 seconds, extreme connectivity shortens this process, freeing up capital for trading, investment, and other purposes. While near real-time settlement would be good for bank clients, it could possibly reduce intra-day liquidity for banks since end-of-day settlement gives them access to capital for longer.

Insurance could also be transformed. It is possible to envision insurance processing using extreme automation, with blockchain policies that instantly pay claims based on preset information from a trusted third party. Lloyd's of London has been looking into ways to use blockchains to improve access to information and cut administrative costs.

Retail banking operations and money transfer businesses also face a clear risk. Blockchain could theoretically allow individuals to store money, bypassing the need for banks. Money transfer operators would also face a gradual erosion of their market share under such conditions.

Outside financial services

In branded goods or indeed any business that faces threats to intellectual property, blockchain as a reliable method of verification is a potential boon. The global trade in counterfeit goods and pirated products, estimated by the ICC to be worth as much as USD 1.77 trillion in 2015, stretches beyond faux-designer handbags and counterfeit medicines. "Tagging" the authentic goods with blockchain-enabled digital fingerprints will make a life-saving difference to those in need, – those who are often the most exposed to the dangers wrought by adulterated medicines, drugs, or baby food. The WHO estimates that more than 50% of medications purchased from online vendors where the doctor's name is concealed are counterfeit. Blockchain applications, such as BlockVerify used to track pharmaceuticals throughout the supply chain, improve the likelihood that consumers receive authentic products.

A demand for transparency was borne in part by a crisis of brand trust. Access to more information at rapid speed across the globe is a result of extreme connectivity. Using this extreme connectivity, consumers insist on knowing the origins of their staple goods—the coffee they drink (which farm did it come from?), the jeans they wear (is there chemical residue leftover from dyeing?), or the steak they eat (truly hormone free?).

Companies like Provenance are the first to tackle these issues by creating transparent supply chains for all types of products, versus those specialized in specific products like diamond and digital artwork in the cases of Everledger and Ascribe. Provenance was designed to track any type of product, throughout every part of its lifecycle – an example of key Fourth Industrial Revolution trends of extreme automation and connectivity.

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