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In an earlier paper entitled "Implications of an Aging Society", I discussed some of the challenges for our society caused by unprecedented demographic changes – specifically declining economic growth prospects. In his book, "Growth Makes You Happy", Peter De Keyzer, chief economist at BNP Paribas Fortis, developed a simplistic theory suggesting that economic wealth is determined by two factors: population growth and productivity growth. If one accepts the premise that demographic developments will reduce economic growth over time, then focusing on increasing productivity and/or the labor force become key policy concerns. There are several ways to address both issues.

To offset population decline and longevity issues, policy makers can literally encourage people to have more babies. Russia, for example, has a monetary incentive plan for having more kids. Another way is to allow increased immigration. Unfortunately, this has become a highly politicized topic and relaxed legal immigration reform is unlikely in the near term environment. In any case, both responses would seem to have long lead times.

Turning to productivity growth, one response is to maximize corporate output per worker, a common financial euphemism for firing people or slowing down hiring. Neither is particularly conducive to increasing aggregate demand. An alternative method is to make people more productive by giving them better tools, education, and training. This is why Japan and Germany are laser-focused on vastly increasing their productive capabilities by accelerating and investing in Automation, Robotics, and Artificial Intelligence.

In this paper, I will focus on the potential positive benefits to productivity that may come from what is being termed as The Fourth Industrial Revolution. In fact, this was the focus of the 2016 annual meeting in Davos of the World Economic Forum. Dr. Klaus Schwab, founder of the World Economic Forum, coined the term and wrote the following:

"The First Industrial Revolution used water and steam power to mechanize production. The Second used electric power to create mass production. The Third used electronics and information technology to automate production. Now a Fourth Industrial Revolution is building on the Third, the digital revolution that has been occurring since the middle of the last century, it is characterized by a fusion of technologies that is blurring the lines between the physical, digital, and biological spheres.

There are three reasons why today's transformations represent not merely a prolongation of the Third Industrial Revolution but rather the arrival of a Fourth and distinct one: velocity, scope, and systems impact. The speed of current breakthroughs has no historical precedent. When compared with previous industrial revolutions, the Fourth is evolving at an exponential rather than a linear pace. Moreover, it is 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.

The possibilities of billions of people connected by mobile devices, with unprecedented processing power, storage capacity, and access to knowledge, are unlimited. And these possibilities will be multiplied by emerging technology breakthroughs in fields such as artificial intelligence, robotics, the Internet of Things, autonomous vehicles, 3-D printing, nanotechnology, biotechnology, materials science, energy storage, and quantum computing."[1]

While researching this paper, I came across some astounding examples of advancing robotic technologies. Google's self-driving cars have driven more than 1.3 million miles since 2009. There is actually a company about to produce a flying car. The K5 robot is being used to patrol some malls in California. The Kiva robot, owned by Amazon, "is designed to scurry across large warehouses, fetching racks of ordered goods and delivering the products to humans who package the orders. A warehouse equipped with Kiva robots can handle up to four times as many orders as a similar unautomated warehouse…"[2] Another company is taking orders for its laundry-folding robot: it can steam and fold laundry in 30 seconds. There is a hotel in Japan that is run almost entirely by robots. Some companies are using 3D printing technology to make aircraft parts, and another teeth implants that are perfect replicas from a digital image. MIT has created an experimental robot that can bake cookies from scratch. There is a robot that can make and flip a gourmet hamburger in 10 seconds. According to Wired Magazine, "A manufacturing device from Universal Robots doesn't just solder, paint, screw, glue, and grasp—it builds new parts for itself on the fly when they wear out or bust."[3]

In terms of actual Artificial Intelligence, generally referred to as machine learning or deep learning, the computer capacity to access vast networks of information and weigh the probabilities of a particular answer being "right" are enormous. Look, for example, at IBM's supercomputer, Watson. Watson has instant access to 600,000 pieces of medical evidence and two million journal pages describing research and trials on lung cancer. Can any oncologist read and remember all that? And run a practice? Furthermore, Watson has the ability to utilize this cognitive computing – the ability to understand both words and numbers, to make lists of possible courses of treatment, assign levels of confidence or probability to each, and back them up with evidence for the recommendations it makes. It still is up to the doctors to weigh the recommendations, utilize

[1] Foreign Affairs, December 12, 2015, Science and Technology, The Fourth Industrial Revolution, What it Means and How to Respond, by Klaus Schwab

[2] MIT Technology Review, June 12, 2013, Business, How Technology is Destroying Jobs, by David Rotman

[3] Wired Magazine Online, Rise of The Machines: The Future Has Lots of Robots, Few Jobs For Humans, by Marguerite McNeal

their experience to add insights, and make the final decisions. The intent then, according to Harvard computer science experts, is " to create systems that let humans combine what they are good at – asking the right questions and interpreting the results – with what machines are good at: computation, analysis, and statistics using large datasets."[4] The point here is that this revolution is happening now. Just as smart phones have become ubiquitous in our society, these innovations will be part of our lives, and certainly our children and grandchildren's experience in the not so distant future. The requisite shift in education, orientation, and policy need to be addressed sooner rather than later.

Many people may view this pending revolution with trepidation. In his book, Rise of the Robots, Martin Ford conceives of a future in which humans live more productive and entrepreneurial lives, helped by guaranteed incomes generated by our robots. However, his vision contemplates robots replacing humans to the extent that there is a large scale worker revolt, prior to a better future. Science fiction movies and programming, in particular, have highlighted numerous possible dystopian societies where man is subservient or in opposition to robots. The Terminator series, 2001: A Space Odyssey, The Matrix Series, and Battlestar Galactica all come to mind as representative of the theme.

In their book, Race Against The Machine, Erik Brynjolfsson – professor at the MIT Sloan School of Management, and his colleague Arthur McAfee- Associate Director of the MIT Center for Digital Business, suggest that "Productivity is at record levels, innovation has never been faster, and yet at the same time, we have a falling median income and we have fewer jobs. People are falling behind because technology is advancing so fast and our skills and organizations aren't keeping up."[5] While ultimately optimistic about the productivity benefits of a combined human and robot workforce, they highlight concerns about how society needs to prepare for these potential long term changes.

One popular response today is the discussion about the viability of implementing a universal guaranteed basic income. Dr. James Albus, who had been writing on the subject for over 40 years, suggested that the government form an investment fund to finance private investment in these new technologies. The shares of the fund would be distributed to all in our society and incomes could be generated in the form of dividends and earnings. Of course, he espoused that in 1981. There is precedent for it in our society. In 1976 Alaska established the Alaska Permanent Fund, by a two to one majority vote, to take a portion of the state's oil revenues, deposit it into the fund, and then pay it out in the form of dividends to

[4] Harvard Business Review, November 17, 2014, Knowledge and Management, Artificial Intelligence Can't Replace Hard-Earned Knowledge – Yet, by Walter Swap and Dorothy Leonard

[5] MIT Technology Review, June 12, 2013, Business, How Technology Is Destroying Jobs, by David Rotman

all Alaskan residents. Ultimately, voters determine policy direction. If they get the chance to equally participate in future growth, I doubt they will need or want to go through anything close to civil revolt. Policy leadership can go a long way towards addressing potential negative outcomes, while supporting the foundation for future growth and prosperity.

In June of 2016, Robert Atkinson, founder of the Information Technology and Innovation Foundation, wrote,

"Although artificial intelligence has become commonplace—most smartphones contain some version of AI, such as speech recognition—the public still has a poor understanding of the technology. As a result, a diverse cast of critics, driven by fear of technology, opportunism, or ignorance, has jumped into the intellectual vacuum to warn policymakers that, sooner than we think, AI will produce a parade of horribles: mass unemployment, abuse from "algorithmic bias," the end of privacy, an atrophying of human agency, and even the destruction of humanity, as "Skynet"-like machines decide the world is better off without us. Indeed, these voices have grown so loud, espousing a message that a click hungry media eagerly amplifies, that we are very near the point where these narratives may be accepted as truth.

But AI is like a shovel or a tractor: It is a tool in the service of humans, making our lives vastly better. And given the promise that AI holds for economic growth and societal advancement, it is critical that policymakers actively support its further development and use. The cost of not developing artificial intelligence or developing it more slowly will be enormous: lower growth in per-capita incomes, slower progress in areas such as health and environment, and reduced improvement of quality of a wide array of public and private goods and services."[6]

While there are clearly risks involved with the advent of new technologies, history suggests that technology has improved our living standards and largely increased productivity in the aggregate. In the 1800's the US labor force was 80% concentrated in the agricultural sector of our economy. Today, that number is 2%, but it is hard to argue that our economy hasn't grown tremendously for the better over that timeframe. Food and other agricultural products are cheaper and more available today than at any time in our economic history. People can and do make the argument that just as the automobile supplanted the horse, we might one day be supplanted by robots ourselves. The difference is that we humans are the ones who are creating the machines and the policies that surround them. It will depend upon who is doing the programming and what the populace demands in terms of policy that will be the gatekeepers of technology. Clearly, the developers and policy makers are incentivized to minimize risks to ourselves and our society.

[6] Information Technology and Innovation Foundation, June 2016, "It's Going To Kill Us!" And Other Myths About The Future Of Artificial Intelligence, page 1, by Robert D. Atkinson.

Lastly, the projected rate of technological progress has historically been overly optimistic. The first AI conference was held at Dartmouth College in 1956. The view then was that strong AI could be attained in a summer's worth of work. In the 1960's and 1970's, computer scientists predicted that we would have machines capable of human thought within a decade. Today, despite the hype and outcry, the computer scientists recognize that they are a long way from any form of true intelligence. According to John Leonard, a professor of engineering at MIT and a member of its Computer Science and Artificial Intelligence Laboratory, ""Part of me sees accelerating progress; the other part of me sees the same old problems, I see how hard it is to do anything with robots. The big challenge is uncertainty. People and robots working together can happen much more quickly than robots simply replacing humans. That's not going to happen in my lifetime at a massive scale."[7] Guruduth S. Banavar, IBM's Vice President for Cognitive Computing, stated at the Nobel Week Dialogue that, "experts of the future will routinely work with learning and reasoning machines to do their day-to-day tasks in a very deep collaborative relationship between people and machines. This is nothing to be fearful of; it is an evolution, and I think it is going to be much better for the world."[8]

This Fourth Industrial Revolution has the capacity to greatly improve our lives and our economic futures. It can create vast new growth industries and reignite the economic growth which we are lacking. With intelligent policy decisions and implementation, we can invest in needed infrastructure and new technologies. We can create a more equal economic society by sharing the wealth that this creates. We can focus on improving and redirecting our educational system towards the needs of the future society. In the process, it can offset the growth concerns caused by the demographic shifts in the world today. None of this will happen overnight. You won't find a robot preparing your "breakfast in bed" anytime soon, but it is possible within the next decade or two.

In the interim, you can help your family by being well informed. You can direct your kids and grandkids towards growth fields with critical education and required skillsets. You can follow the policy debates and be part of the outcome. Leave the paranoia and the dystopian futures to the realm of science fiction for now. The reality is we're not close to creating truly intelligent machines. The age of malevolent phones and weapons-ready vacuum cleaners is not upon us. Instead, you

[7] MIT Technology Review, June 12, 2013, Business, How Technology Is Destroying Jobs, by David Rotman

[8] Guruduth S. Banavar, "The Future of Expertise" (remarks delivered at the Nobel Week Dialogue in Gothenburg, Sweden, December 9, 2015)

can start thinking about some really cool AI stuff that can be productive and enjoyable – like an autonomous flying car.

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