ARTIFICIAL INTELLIGENCE

AND THE JOB MARKET

For Those Who Follow

May they be Creative, Adaptable, Conscientious, Compassionate,

And above all, Confident

About the Author

Peter Farwell is a Chartered Professional Accountant and Certified Financial Analyst. He is a retired partner of Public Accounting Firm Ernst & Young. and was the leader of the Canadian Firm's services to the high technology industry for fourteen years.

Peter is a graduate of the University of Toronto in Mathematics and Physics and spent one year at Cambridge University in England studying Philosophy.

Peter has written articles and given speeches on aspects of Strategic Planning and Financing for High Technology companies.

Peter is the author of several books These include: IBM, Can It Survive, a study released in 2015 when IBM was in a period of difficulty; and The Personal Computer, Past, Present and Future, released in 2018 that studies the amazing growth in PC sales from 1975 to 2011, the drastic fall off of PC sales from 2011 to 2017 and speculates on new technologies that might lead to renewed growth in PC sales.

In 2012, Peter coauthored three studies of Research in Motion (Blackberry) that endeavored to determine its chances of survival and what changes management have to make to do so.

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Introducing the Debate

The thesis of this monograph is that Artificial Intelligence (AI) will create more jobs than it destroys.

The subject of Artificial Intelligence is producing a hive of activity among research analysts, particularly those generating new software applications that apply AI techniques. It has also been the subject of much debate.

The author of this paper provides a unique look at the implications of AI for the job market. He has drawn on his multidisciplined experience, which includes the study of mathematics and physics, the study of philosophy, the study of Financial Analysis and many years as a consultant to high technology clients in Canada. The author also owned a Heath Kit Robot, named Hero. Hero was a rolling-on-wheels, talking robot that was programmed in a very basic programming language and phonetic speech synthesizer.

There are many people on both sides of the important issue: *Will AI Create More Jobs than it*

Destroys. In a recent article, Jonathan Vanian at Fortune magazine wrote “If you ever want to start an argument, ask someone whether Artificial Intelligence (AI) will destroy jobs or create them.” Vanian reported that a Forester research study predicted that A.I. “would likely cause massive job losses in occupations that rely on repetitive tasks that software can animate.“ Since that publication, Vanian has received a number of comments on both sides of the question.[i]

It is not surprising that many people have a view that AI will destroy jobs. After all, this is often the most immediate effect of AI applications. Some examples are the loss of routine assembly line jobs, in the manufacturing and assembly industries, such as automobiles, electronics, and home appliances.

On the other hand, there are at least five good arguments supporting the position that AI will ultimately create many more jobs than it destroys.

1. The argument from the history of technology innovations.

2. The argument that computers will never have emotions, will never be happy or sad, will never show

empathy, and will therefore never be able to replace the mental capacity of the human being.

3. The argument that computers will never be conscious, and therefore similarly will not be able to match the creativity, flexibility and general capacity of the human mind.

4. The argument that the brain is too complex to be replicated in a machine, as described by Anthony Aguirre in his book: Cosmological Koans: A Journey to the Heart of Physical Reality[ii].

5. The argument that there is no such thing as a perfect system of logic. Therefore, we can never be sure that a self-learning, deep thinking, computer will be free of mistakes.

We will discuss each of these arguments in some detail. We will also discuss two counter arguments, and a number of examples in which AI is being applied today. But first a definition and a short history of Artificial Intelligence.

Definition and History

Artificial Intelligence is the term used to refer to the ability of computers to replicate human thinking. It also refers to the many different attempts to develop and apply software that would enable robots and other computers to replace tasks previously done by humans.

AI is also used to refer to Machine Learning, "the scientific study of algorithms and statistical models that computer systems use to perform a specific task without using explicit instructions, relying on patterns and inference instead". Machine Learning algorithms build a mathematical model based on increasingly large sample data in order to make predictions or decisions without being explicitly programmed to do so.[iii]

The creation of the term Artificial Intelligence (AI) is generally credited to a small group of mathematicians and scientists meeting at Dartmouth University in 1956. They were meeting to explore the possibilities of computer simulations of the human

brain and were the first to use the term Artificial Intelligence to describe the study of a computer system's ability to interpret correctly external data, to learn from such data and to use those learnings to achieve specific goals and tasks through flexible adaptation.[iv]

The seeds of Artificial Intelligence had been planted much earlier, by Alan Turing in 1936. Turing is often referred to as the founder of the Information Technology Revolution.[v]

In 1935, at Cambridge University, Max Newman, a fellow of St. John's college, gave lectures on The Foundations of Mathematics. One of the students there was Alan Turing. Newman expressed the view, based on research of David Hilbert, that mathematics was built on "Systematic Procedures", such as the procedures for long division. Newman went on to say that the basic feature of mathematical systems was that they could be performed by machines.

Turing took this to heart, and a year later, in 1936, produced a paper entitled "On Computable numbers" which included the hypothesis of a

"Universal Computing Machine". This was a machine that an operator could design to perform any procedure that a human "computer" could perform. This Universal Turing machine was a highly abstract idealization of a computer machine. Turing, himself, was unable to answer it definitively. Other researchers have been trying to prove that such a machine could be built ever since.[vi]

Turing was very familiar with the work of Kurt Gödel and with Gödel's "Mathematical Incompleteness theorem" which Gödel extended to cover all mathematical systems that included basic arithmetic. Eventually, working with Gödel, Turing was able to show that there were well defined mathematical problems that the Universal Computing Machine would be unable to solve. Specifically, Turing showed that" if the formulae that were being considered are permitted to come from regions beyond the simple calculus of propositions, it is impossible to build any finite computing machine for deciding whether the formulae are provable or not." Turing's discovery is one of the reasons for thinking that no computer operations can replicate the thinking of human beings. Later, Gödel added that

"Turing's result showed that the human mind will never be replaced by a computer."[vii]

The pursuit of the holy grail of a Universal Computing Machine continues to this day and is a principal driver of Artificial Intelligence research. So far, no one has been able to create the Universal Computing Machine.

The field of AI has exploded in the latter half of the 20th century with the developments of computing power (following Moore's law of exponential growth in the number of transistors that can be included in a microchip, causing increased speed of processing , reduced costs and greater capacity) and accompanying improvements in the speed of communications, and the size of memory banks. This has allowed the development of better training systems for machine learning and more widespread applications of AI.

The big AI breakthrough came not through the application of mathematical rules of logic, but by the simulation of a different learning system – "Neural Networks".

In the 21st century, developments led by Geoffrey Hinton of Toronto Canada, using synthetic replications of “Neural Networks” (as defined in the following paragraphs) have led to significant advances in the ability to train computers to perform human tasks.

The Neural Networks in humans and animals reach conclusions by optimizing patterns developed from examples. This is essentially how young children learn before their capacity for deductive reasoning has been developed. They learn from observing repeated examples and using their neural networks to deduce patterns in the examples and to learn that if a certain pattern is repeated often enough, they can generalize a conclusion.

For example, suppose a child is told repeatedly that eating broccoli is good for you because it is a green food, but eating cauliflower is not. After a sufficient number of iterations, the child will learn that it should eat broccoli, but not cauliflower, and store this conclusion in its memory. The process by which it reaches this conclusion is not deductive logic but the application of its neural networks. The neural networks allow the child to develop a conclusion from

the examples given to train it. This is different from the process of deductive reasoning used by adults. Of course, adults use both systems of reasoning to develop their own library of conclusions.

Geoffrey Hinton first heard of neural networks in 1972, when studying AI at the University of Edinburgh.[viii] He recognized that neural nets offered the prospect of computers learning the way children do, from experience rather than logic.

In 1958, Frank Rosenblatt at Cornell, built a prototype neural net called the Perceptron. “After 50 trials it learned to distinguish between cards marked on the left and cards marked on the right.” Obviously, it was limited, but had only one layer of neuron-like nodes. Researchers believed more could be accomplished with multilayer -or deep- neural networks.

Hinton explains the approach this way:

“Suppose a neural net is interpreting pictures some of which show birds. So, the input would come in pixels, and the first layer would detect little edges. The next level, analyzing data sent from the first layer, would learn to detect things like corners where two

edges come together. The next level of neurons might find more complicated configurations, like a bunch of edges arranged in a circle.

At a still higher level, a neuron might detect the recurring juxtaposition of beaklike angles near head like circles. That's a pretty good clue that it might be a bird.

The neurons of each higher level respond to concepts of greater complexity and abstraction, until one at the top level corresponds to our concept of a bird."[ix]

The neuron net also needed a way to determine if it was getting the correct results. This is where the learning would occur.[x]

In 1986, Hinton and two colleagues wrote a seminal paper offering an algorithmic solution to the error correction problem.[xi]

Despite all the strides neural networks fell into disfavour in the 1990's, because of the inability to access large enough input data.[xii]

"The field of Artificial Intelligence received a boost in the 2000's, with the continued increases in power of the computer and the development of access to Big Data sets, facilitated by such developments as the growth of Cloud Computing. These developments allow the accessing of large samples of data, thousands and millions of data, and the processing of these data sets by powerful computers. This capability permits the use of simulations of the brain's neural networks to construct more and more reliable and accurate conclusions, just as the human brain does."[xiii]

Currently, Hinton is exploring an advance using an alternative mathematical technique that he calls a Capsule Network. The neural network that he developed has limitations: " if a neural network is trained on images that show a coffee cup from only one side,- it is unlikely to recognize a coffee cup turned upside down."[xivxv] Hinton's new system will use a different mathematical technique that will operate in three dimensions, not just two. This will allow many more complex conclusions to be developed from masses of examples. Hinton hopes that this new approach will allow computers to "deliver the kinds of

autonomous tools that will improve the efficiency of voice recognition instruments and improve such projects as driverless cars”.

The Arguments in Favour of our Thesis

(1) Technology innovation creates more jobs than it destroys

The long history of technology innovation is full of examples of the fact that new technologies create more growth and jobs than they destroy.

Perhaps the most dramatic example of new technology job creation is the development of the automobile. This development put the buggy whip business out to lunch, not to mention the horse and carriage business. But it created whole new industries.

The automobile revolutionized the business of travel, making it cheaper, more convenient, increasing distances, improving the speed of travel. This made travel more attractive and more accessible to more and more people. As a result the travel business grew like topsy and many more jobs were created as new car companies were created and flourished, as the car leasing and financing businesses were developed, as

service station networks proliferated, and as the demand for gasoline blossomed, creating a primary market for the oil and gas industry. The list of jobs created by the automobile innovation is long. It far out strips the loss of jobs in the horse and carriage business.

This is but one striking example of how a new technology created more jobs than it destroyed.

Turning to modern computer technology, we can focus on the personal computer. The story of this technology is told in my book on the history of the personal computer.[xvi] It is the story of how a series of technology innovations in software destroyed jobs but created many times more new jobs.

For example, the development of word processing software for the personal computer led to a decrease in demand for secretarial work as authors learned to type their own work, proofread and publish it. While the process took over ten years to play out, the effect was a large increase in the demand for personal computers and a proliferation in the creation of documents, the communication of documents and the reading of documents; all much more cheaply,

more easily and more conveniently than had previously been the case. Again, the result was an immense increase in production and distribution of documents, papers, books, records that incidentally produced far more new jobs than the drop in secretarial work.

And now, we will turn to the Internet. The public Internet was the product of a number of innovations (see my book; The Personal Computer, Past Present and Future, 2018). This collection of innovations totally remade the way we communicate. The result has seen a large increase in the volume of communications, a buildup of communication networks, and a large increase in the demand for personal computers which were in the 1990's the primary means of accessing the internet communications facilities. Later, in 2007, the smartphone was introduced and took over the internet communications from the personal computer. The smartphone spawned a new industry, which outsold the personal computers by a factor of 4 to 1.

These technology innovations changed the way we communicate, making it cheaper, more convenient

and much faster, as well as other improvements. These changes not only spawned the new smartphone industry and the software employed in it, but substantially increased the volume of communications, creating a whole array of new jobs to deliver the new communication systems.

Just as these technology innovations of the past created many more new jobs than they destroyed, so too with Artificial Intelligence. Later in this monograph we will look at a number of the areas in which AI is being used today to see how likely this argument holds up in practice.

We will now look at four arguments that support the thesis that computer intelligence cannot replicate human intelligence.

(1**) Lack of emotions**- It seems unlikely that a robot will ever have emotions, will ever feel sad or glad or mad, will ever be anxious or pleased. While robots may be programmed to look like they have emotions, like Braezeal's Kismet (see below), it is hard to imagine that they will ever feel emotions. It follows that they will lack the creative abilities, the flexibility and the adaptability of humans. This is a major reason

why the most effective use of AI robotics today requires a combination of robotic and human cooperation.

"Companies that excel at implementing AI throughout an organization will find themselves at a great advantage in a world where humans and machines working together outperform either humans or machines working on their own." [xvii]

(2) **Lack of a sense of consciousness**- Machines are unlikely to develop consciousness, a sense of self-awareness. This is a puzzle that intrigued Alan Turing in the 1940's and 1950's. He was not able to solve this before he died in 1952.[xviii] This lack of consciousness is a serious limitation for the applications of AI. Many AI researchers have grappled with this puzzle, but none have solved it. Without this sense of self-awareness, it seems unlikely that AI will duplicate the creativity of the human brain.

(3) The complexity of the human mind-A further argument that AI will never be able to match the capacity of the human brain comes from a book by Anthony Aguirre entitled Cosmological Koans: A

journey to the Heart of Physical Reality. Here is a relevant quote from the book:

"On a physical level, biological creatures are so much more complex in a functional way than current artifacts of our technology that there is almost no comparison. The most elaborate and sophisticated machines of human design, while quite impressive, are utter child's play compared with the workings of a cell: a cell contains on the order of 100 trillion atoms, and probably billions of quite complex molecules working with amazing precision. The most complex engineered machines have several million parts. Thus, perhaps all the jetliners in the world could compete in functional complexity with a lowly bacterium."

"Researchers in artificial intelligence have long been acutely aware of how monstrously difficult it is for computers to compete with biological minds on their own territory, not for numbers of bits, but of perception, prediction, and action. Perhaps even harder is to operate comparably on the level of contextual understanding to conform perceptions, predictions, and actions to the vast standing repository of concepts, understandings and

constraints that make up the biological and social world."[xix]

The implication of this line of thought is that the workings of the human brain is so complex that it will be a long time, if ever, before Artificial Intelligence can replicate the human brain.

(4) Philosophical limitation of logical systems-To these three arguments that Artificial Intelligence will not be able to replicate the human brain, we add a fourth from the field of philosophy. Kurt Gödel astounded the philosophical world in 1931 when he developed his Incompleteness Theorem. This theorem proved that it is not possible to have a logical system that is complete in the sense that any statement in the system can be proved or disproved. Gödel went on to show that if a logical system was complete, in the above sense, it would be possible to deduce a contradiction in the system. One can infer from this astounding result that there is no such thing as a perfect system of logic, and hence that any system of Artificial Intelligence founded on logic would be prone to error.

Later Turing became familiar with Gödel's work and developed his theory of the Universal Computing Machine, a machine that "an operator could make carry out any procedure that a human computer could carry out." This was a hypothetical construction, and Turing spent much of the rest of his life investigating whether such a machine could be constructed in reality. Later still, "by reasoning about the behavior of the Universal Computing Machine, Turing was able to show that there are well defined mathematical problems that the universal machine cannot solve." This work reinforced the conclusion from Gödel's theorem, that there could be no such thing as a perfect system of logic. Gödel went on to show that it would not be possible to construct a Universal Computing Machine.[xx]

We can apply the collection of these four arguments to conclude that no system of Artificial Intelligence is likely to match the human brain. As a result, it is most likely that the best uses of Artificial Intelligence systems will be those that are used in collaboration with humans, to obtain the best results from the advantages of both; on the one hand, the ability of computers endowed with artificial

Intelligence to subject masses of data to elaborate analysis, and on the other hand, the human brains' creativity, adaptability, flexibility and variability.

This collaboration is what many are finding produces the best results. This is the finding of a study referenced in the Harvard Business Review publication: The AI-Powered Organization.

"Companies that excel at implementing AI throughout the organization will find themselves at a great advantage in a world where humans and machines working together outperform either humans or machines working on their own."

"Our research shows that the majority of workers will need to adapt to AI rather than being replaced by It.[xxi]"

While these four arguments do not address directly the question of whether AI will create more jobs than it destroys, they do make a strong case that there are serious limits to the types of jobs that AI will displace. From this it seems reasonably clear that AI will fulfill the traditional role of new technology: reducing costs, improving efficiency and speeding delivery of products and services. Historically, these

improvements have led to more profits and expanding volumes for existing businesses and the creation of new businesses with competitive advantages. All of this suggests strongly that AI will create many, more new jobs than it destroys.

A quote from "The four waves of AI" by Kai-fu Lee in Fortune issue on AI

"Because AI can be programmed to maximize profitability or replace human labour, it adds immediate value to the economy. AI is fast, accurate, tireless, doesn't complain and can be applied to many tasks, with substantial economic benefit. How substantial? PwC estimates that the new AI technology will contribute about $16 trillion to worldwide GDP by 2030."

This statistic supports our general thesis that AI will create more jobs than it eliminates.

Two more quotes from the Fortune article on 25 ways AI is Changing Business are relevant:

"AI's eventual uses will be determined largely by market forces."

We can test this statement, by asking ourselves the following questions: Would you rather have a knowledgeable salesperson or a robot help you select a new dress? a new tie? A new refrigerator or a convection oven? A new car? a used car? A house? If you are in hospital would you prefer to be looked after by an empathetic doctor or nurse, or a fleet of robots? Your answers to questions like these will help determine the extent to which Artificial Intelligence will proceed to replace human intelligence.

"AI will be used by companies for countless purposes and the cumulative effect can't be foreseen." We examine some of the applications of Artificial Intelligence today to illustrate this point.

Job Destruction Consequences

As bullish as we are on the results of AI applications to create jobs, we can't ignore the fact that many routine jobs will be destroyed. This destruction has and will cause serious social dislocation, attendant costs and human hardship.

It will be essential that businesses, react sensibly and with compassion. A good example of the right behaviour has been given by AT&T. With the rapid growth of Internet communications, AT&T found it necessary to upgrade its communications network. The jobs on the old network disappeared. AT&T reacted positively by identifying the new jobs, retraining its employees, and informing its employees how to find the new jobs. It was reported to be spending $100 million a year on this initiative.

Governments and education institutions will also have to respond positively. Examples of what we have in mind are already in play. A Saturday, February 22, 2020 New York Times article notes several places where AI assistance is being used to bring education innovations to the fore, under the heading: How Technology is Changing the Future of Higher Education.[xxii]

(1) The Georgia Institute of Technology is one of the places mulling a subscription model, said Richard DeMillo, director of its Center for 21st Century Universities. It would include access to a worldwide network of mentors and advisers and “whatever someone needs to do to improve their professional

situation or acquire a new skill or get feedback on how things are going."

(2) Georgia Tech has been experimenting with a virtual teaching assistant named Jill Watson, built on the Jeopardy-winning IBM Watson supercomputer platform. This A.I. answers questions in a discussion forum alongside human teaching assistants; students often can't distinguish among them, their professor says. More Jill Watsons could help students get over hurdles they encounter in large or online courses.

(3) At Arizona State University, A.I. is being used to watch for signs that Arizona State University Online students might be struggling, and to alert their academic advisers.

(4) The way these kinds of learning get documented is also about to change. A race is underway to create a lifelong transcript.

"The learner, the learning provider and the employer all are speaking different languages that don't interconnect," said Michelle Weise, Chief innovation officer at the Strada Institute for the Future of Learning.

A proposed solution is the “interoperable learning record,” or I.L.R. The I.L.R. would list the specific skills that people have learned — customer service, say, or project management — as opposed to which courses they passed and majors they declared. And it would include other life experiences they accumulated. Not only could prospective employees use them to look for jobs requiring the skills they have; employers could comb through them to find prospective hires with the skills they need.[xxiii]

These are very encouraging academic innovations to meet the displacement of jobs caused by AI.

A Counter Argument

A strong counter argument can be found in the work of Yuval Noah Harari. In his book, the third in a series, 21 Lessons for the 21st Century, Harari presents a powerful argument to the contrary.[xxiv]

“Some believe that within a mere decade or two, billions of people will become economically redundant. Others maintain that even in the long run

automation will keep generating new jobs and greater prosperity for all."

"Fears that automation will create massive unemployment go back to the 19th century, and so far, they have never materialized. Since the beginning of the industrial revolution, for every job lost to a machine at least one new job was created. Yet there are good reasons to think that **this time it is different."**

Harari notes "as manual jobs in agriculture and industry were automated, new service jobs emerged that required the kind of cognitive skills only humans possessed; learning, analyzing, communicating and above all understanding human emotions. However, AI is now beginning to outperform humans in more and more of these skills."

Harari goes on to observe that the AI revolution is not just about computers getting faster and smarter. It is fueled by breakthroughs in the life sciences and social sciences as well."

The better we understand the biochemical mechanisms that underpin human emotions, desires, and choices, the better computers can become in

analyzing human behavior, predicting human decisions, and replacing human drivers, bankers, and lawyers."

Commented [PF1]:

Harari goes on to suggest that research in neuroscience and behavioral economics is allowing scientists to get a much better understanding of how humans make decisions. (It is interesting to note that this is a subject that was being pursued by Alan Turing in the 1940's and 50's, in his attempt to understand how the human brain worked. Turing was unable to complete his investigations before he died.) Harari states "that our choices of everything (may) result not from some mysterious free will but rather from billions of neurons calculating probabilities."

"If these emotions and desires are in fact no more than biochemical algorithms, there is no reason computers cannot decipher these algorithms and do so far better than any HOMO SAPIENS."

Harari concludes the combination of progress in the life sciences (neurosciences) and in development of computer algorithms could lead to the replacement of many jobs without any offsetting creation of new jobs.[xxv]

This is not a guarantee that this will happen at some time in the future, but a speculation that it could happen. In our view, because of the 4 arguments set out above, this is very unlikely.

The Discussion by Economists.

The macro economic implications of AI have been the subject of many works by economists.

One set of these studies has been carried out by McKinsey and Company, Management Consultants. We will look at two McKinsey papers: the first is a study of the general economic implications of AI: The AI Frontier; and the second is a study entitled: Jobs Lost, Jobs Gained: Workforce Transitions in a Time of Automation.

1. Notes from the paper: The AI Frontier: Modeling the Impact of AI on the World Economy.

The study notes “AI has the potential to contribute to global economic activity”. “In the aggregate, and netting out competition effects and transition costs, AI could potentially deliver additional economic output of around $13 trillion by 2030, boosting global GNP by about 1.2% each year.”

“For individual workers, too, demand and wages may grow for those with digital and cognitive skills and with expertise in tasks that are hard to automate but shrink for workers performing repetitive tasks.”

“In all cases, there are trade-offs that need to be understood and managed”[xxvi].

The suggestion here is that if the allocation of income among the factors of production is fairly constant, the aggregate number of jobs will increase as world GNP increases.

2. Notes from the paper: Jobs Lost; Jobs Gained: Workforce Transitions in a Time of Automation.

In this paper, McKinsey “examines work that can be automated through 2030 and jobs that may be created in the same period.”

Key findings include:

"Automation technologies including Artificial Intelligence and Robotics will generate significant benefits.... lifting productivity and economic growth."

"Even as it causes declines in some occupations, automation will change many more."

"It will also create new occupations that do not exist today, much as technologies of the past have done."

"Our scenarios across 46 countries suggest that between almost zero and one third of work activities could be displaced by 2030."

"Even with automation, the demand for work and workers could increase as economies grow, partly fueled by productivity growth enabled by technological progress."[xxvii]

The suggestion here is that if countries and companies react positively to identifying changing jobs and job training requirements and to enabling the transition of displaced works to new jobs, the demand for work and workers could increase as economies grow.

An example that illustrates this point can be found in the Opinion Piece by David Olive in the February 8 Toronto Star newspaper. Olive notes that the Greater Toronto Area already suffers from a shortage of skilled workers that is going to worsen as the GTA "adds an estimated 1.2 million people in need of services by 2030"[xxviii]. One of his suggested solutions is "A reform in worker training." "Digitization, computer automation and Artificial Intelligence will demand that workers be upskilled to master rapid changes in their fields, or to be retrained to succeed in New Economy vocations in which they have no background."

While the conclusions of the McKinsey studies are indefinite, the inference is that new jobs will flow and could more than offset the loss from displacement of existing workers. For the reasons set out elsewhere in this paper, we believe that this will happen.

A World Without Work

Another economic analysis of our question is provided by Daniel Susskind in his book: A World

Without Work: Technology Automation, and How We Should Respond. As the title indicates Susskind is on the other side of our thesis. Will there be enough work for everyone in the 21st century? His answer is no.

Susskind sums up his position in the book's introduction.

He notes that the anxiety about work displacement is not new, but centuries old. He observes the shift from farming to factories during the Industrial Revolution, the shift from manufacturing to service during the Information Revolution, and currently the shift from old services to new services in the Technological Revolution; each in turn, causing many people to raise concerns about a loss of jobs. In each case, more new jobs have been created than destroyed. But he notes "**this time it is different".**

"The future of work raises exciting and troubling questions questions about the nature of intelligence, about inequality and why it matters, about the political power of large technology companies, about what it means to lead a meaningful life, about how we

might live together in a world that looks very different from the one in which we have grown up.[xxix]"

"Machines will not do everything in the future, but they will do more. And as they slowly but relentlessly, take on more and more tasks, human beings will be forced to retreat to an ever-shrinking set of activities." "There is no reason to imagine there will be enough demand for it to employ all those who are indeed able to do it."[xxx]

We will take issue with several of Susskind's positions, but principally the idea that technology advances, in particular in the field of AI, will not create enough new jobs for human workers to employ all those who want to be employed.

Susskind raises four important supplementary concerns stemming from Technological Unemployment, as John Maynard Keynes termed it in the 1930's. These are important and need to be addressed. They are: (1) the disruption in the lives of those who lose jobs because of technological innovations, (2) the growth in inequality, (3) the power of Big Tech and (4) the occupation and sense of

purpose of those who are out of the working class. We will deal; with each in turn.

The growth of new jobs from Technological Innovation

A starting point of the argument that Technology Innovation is creating more jobs than it destroys is the growth of global GNP. Steven Pinker in his book: Enlightenment Now: The case for Reason, Science, Humanism and Progress,[xxxi] has summarized the factual statistics that document the growth in global GNP. Pinker shows a 2000-year graph of global GNP in U.S.$ adjusted for inflation and Purchase Power Parity, from Our World In Data.

The graph shows that after many centuries of little GNP growth, GNP growth has taken off exponentially in the last 200 years. A major contributor to this growth has been technology innovation. Thus, the economic Pie is getting bigger. With it we surmise that the demand for work is growing and therefore the number of jobs should be growing as well. We will look at some other checks on this supposition.

The Unemployment rate. The unemployment rate in The Unites States has never been lower than it is

today, at around 3.6% in 2020. This indicates that those human beings that want work today are finding it at faster rates than ever.

Well what about the Participation Rate. Susskind has argued that participation rates are shrinking as a result of human beings leaving the work force, and therefore falling out of unemployment statistics, because they are discouraged by the lack of jobs available to them. We believe that a more important contributor to a falling participation rate is the aging of the population. Statistics show that humans are living longer, healthier and more prosperously. More people, a higher % of the population, are reaching retirement age and dropping off the participation rates for this reason. Japan is just the canary in the mine on this point.

The U.S. Bureau of Statistics provides data on the Participation Rate in the U.S. over time. In January 2020, 259,392 thousand were in the Civilian noninstitutional population. Of these,164,606 thousand (63.4%) were employed and 5,892 thousand (3.6%) were unemployed. The number of discouraged workers was 337 thousand, (only slightly more than 0.2% of the total labour force). The primary factors

contributing to the decrease in The Participation Rate over the last 20 Years, from 67.3% in 2020 to 63.4% in 2020, may be attributed to an aging population, the recession of 2001 and the financial crisis of 2008.[xxxii] Susskind's argument that Participation rates are falling because workers are leaving the work force because they are discouraged is not borne out by these statistics.

These statistics provide strong support for our thesis that AI will create more jobs than it destroys.

The Disruption in the lives of workers who lose their jobs

This is a serious and immediate problem. The case of coal mine workers in Alberta today, as reported in The Toronto Star newspaper, is a good example. This displacement is not due to technology innovation, but to initiatives to produce a greener climate. The crisis is similar. The Canadian government is pushing hard to become a low carbon economy. Coal mining and coal-fired electricity are being phased out. Despite significant efforts by three levels of government to provide the displaced workers help with retraining,

support and new opportunities, there is serious suffering in the coal mining communities. Much more help is needed to bridge the gap. (See one of the suggestions of David Olive in the February 8 Toronto Star newspaper, referenced above.)

The Growth in Inequality

Income and wealth inequality have been on the rise in the last 50 years. The Gini coefficients are a measure of inequality. The Gini income coefficient measure the dispersion of income in a population. A Gini of 0 means all incomes are equal, while a Gini of 1 means only one person receives all the income. The Gini Income coefficient for the U.S. has risen from about 0.34% in the 1980's to about 0.40% in 2017.[xxxiii]

In his analysis of Inequality, Susskind focuses on the top end. Since 1970, he notes, the share of wage income of the top 1% has doubled to 2017; the share of the top 0.1% has more than doubled, and the share of the top 0.01% has more than tripled. He notes that the CEO's of Americas largest firms, forty years ago earned 28 times the average worker; by 2000, the

rate climbed to 376 times the income of the average worker. This focus on the top income earners strongly suggest income inequality is a serious problem and is getting worse. Susskind attributes much of this inequality to technological innovations.

Steven Pinker takes a different look at income inequality in his book: The Enlightenment Now. To see how we have progressed, Pinker looks at the bottom tiers of income earners. In 200 years, he finds, that the percentage of the global population in extreme poverty has dropped from 90% to 10% with almost half of that decline occurring in the years from 1980 to 2015.

“Extreme poverty has been eradicated and the world is becoming middle class.” stated a UN report in 2015.

Pinker attributes the diminution in the level of poverty to a combination of Science (technology), Growing Global Markets, Good Government and Modern Institutions.

From Pinker’s perspective, we are making significant progress in reducing the most harmful effects of inequality. From this analysis, we conclude

that the consequences of income inequality are not as serious as Susskind makes them out to be. That having been said, it is still a concern for reasons that we discuss in the next section.

The Power of Big Tech

Susskind raises the issue posed by Big Tech companies. Currently these are Microsoft, Amazon, Apple, Google and Facebook. They have grown so dominant in their field that they can exert Monopoly Power to gain control of their markets. Susskind also points out that in addition to this economic power they can also gain political power. This is clearly dangerous to society. But the building of monopoly power is not new. In the middle ages and earlier monopoly power was created through the land holdings of the aristocracy. In the industrial age it was held by the railroad barons. And later still it was possessed by the Oil kings. A good example of how monopolies can be dealt with is the action of the U.S. Federal Trade Commission that broke up the Standard Oil Monopoly created by John D, Rockefeller.

Standard Oil was broken up into 34 separate companies.

The problem with a monopoly is primarily that it constitutes a flaw in the free market system that forms the backbone of traditional economic theory. In the free market system, any given market is made up of many willing buyers and sellers, each acting rationally and fully informed to produce a price at which the goods or services in question will satisfy the optimum number of buyers and sellers. A major advantage of such systems is that they achieve the optimum use of resources, the use that maximizes economic growth. Any distortion of the markets will cause a suboptimal allocation of resources. Monopolies, and indeed, Oligopolies, constitute serious distortions.

The author had a personal acquaintance with the creation of monopolies. At Ernst & Young, Chartered Accountants, he was sent on an executive MBA course at North Western University, near Chicago. As part of the course, the students were organized into teams to compete in a market game of 8 rounds, in a simulated environment. For each round, each team chose from 6 or 7 business variables such

as marketing and sales budgets, amount of investment in plant and equipment and so on, and the selling price of their product. The organizers calculated for each round how much the teams sold and the financial results of their decisions. One of the teams was made up of representatives from Phillips Petroleum. For the first 6 rounds, that team adopted a strategy of underpricing their product and as a result garnered more offers than they could fill. But they took market share away from the other teams. They earned very little profit in those rounds. In rounds 7 and 8 they bumped up their prices and in round 8 achieved the largest profit of all the teams to win the match. Lesson learned!

A few years later the author was advising Canadian High-Tech entrepreneurs on their strategic plans. One of the key recommended points was to ensure that each business had a Distinctive Competence in their target market, something that would enable them to attract customers and to fend off the competition. Little did we know we were contributing to the growth of future Monopolists!

Monopolies are just one of many features that distort and produce sub optimal markets. The author

agrees with Susskind that it is incumbent on governments to use their taxation and regulation policies to fight monopoly power to minimize the distortions of free and open markets. However, these policies must be used carefully to avoid stifling markets and discouraging businesses from productive operating and planning decisions.

The Erosion of the Meaning of Life

What are retired people to do**?**

Susskind raises a concern that they will not find things to do and lose their purpose. Our experience is much different.

Retired people have many alternatives to keep them busy and with a sense of purpose. Some may do some consulting in their field of expertise. Others may focus on charitable and other not-for profit activities, that are proliferating these days. Some may pursue sports activities, or hobbies such as music, cooking, writing, reading and playing bridge. Still others may take up the travel opportunities they didn't have time

for when they were working. The list is long and growing. We don't see this as a significant problem.

Summary on Susskind's book

Susskind has raised important issues that need to be addressed continually. However, on the subject of the Impact of Technology Innovation, and AI Innovation in particular, the author of this paper disagrees with his primary position. Technology Innovation will follow the path of history and produce more jobs than it destroys. While it is early days in the development of AI applications, history and global GNP statistics, progress in relieving poverty, in health care and longevity support this conclusion.

AI in Practice Today

We will now look at some of the applications of Artificial Intelligence in its relatively early days to see how the effect on job quantity is playing out already. These examples have been extracted from 25 Ways Artificial Intelligence Is Changing Business, Fortune Magazine, 2018 and other sources

Medical Applications

AI is being used in many medical applications. Using the computer's ability to access very large databases, to analyze the data and to predict outcomes, researchers are developing systems to

improve diagnoses, to prescribe more accurate treatments, to understand side effects of drugs, and to predict outcomes.

In Toronto, Doctors Igor Jurisica and Christian Veillette are applying AI to create efficiencies to help patients get better faster. Their examination of large data sets and powerful analytic tools are helping them to understand better and more quickly a complex spectrum of diseases, to look for new treatments of arthritis, such as repurposing existing drugs for other diseases and modifying lifestyle factors specific to each patient to increase their response to treatments. They are using the data and analytic capabilities to predict a novel treatment for osteoarthritis. The AI tools permit them to integrate data from many sources to help identify novel, previously missed connections and to help them to identify more accurate prognostic and predictive biomarkers, to determine who will respond to what therapy, and to find new drug targets for developing new therapies. One thing they have discovered is that integration across the research team to combine the clinical knowledge of doctors and nurses, with technical analytic knowledge derived from AI applications is key

to mitigating the risks of incorrect decisions and predictions. This is a clear example of how AI, rather than replacing jobs, is being combined with clinical knowledge in collaboration to produce better and better conclusions.[xxxiv]

In this area, AI does not seem to be destroying jobs but enhancing them by making them easier to do, more accurate and more speedily delivered. In the result, this work will make good deliveries of diagnosis, treatment and prediction of outcomes more readily available. One might predict that this will not only improve treatment of arthritis but make better treatment more widely available, thus increasing the demand for doctors and nurses.

Manufacturing examples

It is not surprising that AI will displace many manufacturing jobs. When Henry Ford developed the assembly line method of manufacturing cars, the advantage he foresaw was that each employee on the assembly line would be performing the same task over and over. So, each employee would be able to specialize in his place on the assembly line and would quickly become efficient, more accurate and speedier.

The sum would be the production of cars at lower costs, higher speeds and fewer faults. But this amazing discovery now has another consequence. Each position on the assembly line is ideal for replacement with AI infused robots. The result is, inter alia, a large loss of jobs on the assembly lines of manufacturers. But what is the effect on the manufacturer?

The use of robots will improve the efficiency of the assembly line, improve quality, lower the costs of producing the cars and increase the volume. These factors should increase both sales and profits of car companies, allow them to sell cars more cheaply, and therefore offer them to a larger group of buyers. The businesses will expand, profits will grow, and more jobs will be created elsewhere in the businesses.

Further, there will be a large increase in the jobs required by the design, manufacturing, programming, servicing, repair and replacement of robots. This will be a separate and new source of jobs in those industries where robots are introduced. Already, there are strong indications of a large demand for people with AI design and application skills.

The overall effect of using robots in these industries will be, other things being equal, to increase the number of jobs in them.

A more specific example of what happens when robots replace routine tasks previously performed by employees is this example of what is happening at Walmart, as reported in the Toronto Star newspaper.

Wall-E is one of 350 restocking robots now operating in Walmart stores across the U.S. Wall-E rolls through the warehouse aisles, scanning the shelves, looking for items that need restocking. It can take pictures which it transmits to its human colleagues' handheld devices, so they know which items need restocking. The result is that these stores can respond immediately to customers' needs for lower prices and convenience. But the stores have found that the resulting increased volume and profitability require more sales and service staff. The Walmart store in Phillipsburg reports that as a result, it has hired 22 employees and is looking to hire 25 more. More jobs are being created than destroyed.

Self-driving cars

The case of self-driving cars is an interesting one. It is difficult at this stage to predict whether the result of introducing self-driving vehicles will destroy or create more jobs.

On the one hand, it is appealing to have a self-driving car take one home from a late party. No need to worry about impaired driving. It will also be convenient to use self-driving cars in busy traffic situations, and for long trips. One could imagine fleets of delivery trucks that are self-driving.

On the other hand, many drivers enjoy driving and would not welcome being displaced by a self-driving vehicle for most drives.

Many articles on self driving cars (SDC) focus on the evolution of SDC as a service. People could subscribe to the service without owning a vehicle. They could simply call when needed and return when finished. This development could reduce the number of vehicles, parking requirements, open market service facilities, private financing and insurance. This might reduce the number of vehicles on the road but would boost the businesses of owning and renting of vehicles, with all the incumbent features of existing

vehicles -parking requirements, service facilities, private financing and insurance.

Looking down the line, it is possible to imagine an influx of self-driving vehicles could lower the costs of driving, increase the safety of driving and be more convenient in many situations. It certainly will increase the volume of self-driving vehicles, let alone increase the total volume of vehicles. (General Motors is reported to be converting its closed plant in Detroit, U. S. to transition to make self driving cars) If so the number of employees selling and servicing vehicles should grow, perhaps enough to overcome the loss of human driving time.

Smart homes.

There are many uses of AI in our homes. One of the most significant is the development of the "Roombas". The Roombas will automatically clean carpeted floors, even maneuvering around obstacles like chairs and chesterfields. The latest versions also have the ability to seek out a recharging station for their batteries. Still we wonder who will look after the hardwood floors, who will empty the dust collector,

who will change the bed linen, who will clean the chandeliers and wipe the cobwebs off the ceiling.

There are a number of other AI gadgets in the home; Siri and Alexa can take voice commands to turn the lights off and on, to change the thermostat, or to monitor security.

As interesting and creative as these gadgets are, they are toys for the curious rather than job displacers. We think it will be a long time if ever before these home AI applications replace the cleaning personnel.

AI in Japan

The adoption of AI in Japan has an interesting twist. The Japanese have been using Robots in Auto manufacturing since the 1970's. Today, the Japanese are looking to increased applications of AI, not to displace workers, but to solve a labor shortage resulting from a birth rate that is at its lowest level in decades causing a declining population. Thus, applications of AI in Japan are meeting needs in a declining work force.

The Japanese are applying AI in many fields, from removing potato eyes in potato salad plants, to peeling pumpkins, from programs to build self-driving buses to package delivery drones to robots that look after residents in nursing homes. In many of these applications, they are finding robots lack the flexibility, lack the judgment, lack the creativity of humans.

"A hotel staffed by androids in southern Japan ended up laying off some of its robots after some of its customers complained that they were not as good at hospitality as people." (Toronto Star, January 4, 2020.)

Still, many of these shortcomings of today should be overcome as progress is made in the capabilities of Robots.

An example of the kind of progress that seems possible is the robot Kismet, as reported in Jack Copeland's biography of Alan Turing. Kismet was an experiment in human-machine interaction built by Cynthia Breazeal, a pupil of Rod Brooks, working in the MIT AI lab in the 1960's. Kismet could express annoyance both vocally and facially. Kismet could bob

up and down and make excited noises in response to a visitor's inquiries of how it was feeling.

With the greatly increased power of today's computers it is not hard to imagine that many of the shortcomings reported by the Japanese will be overcome. Nevertheless, the Japanese experience is indicative of the differences between the capabilities of the human mind and AI equipped robots.

AI in Construction

The construction of buildings is a complex business, requiring the application of many different disciplines. It starts with Design. "Industrial design, transport needs and thoughts to patterns to manufacturing processes to delivering the final product. One of the widest applications of AI is in building design, where multiple disciplines must unite with coordinated design that fits together like a complex jigsaw puzzle. Software packages are available for single disciplines or in fully integrated multidiscipline packages. Various packages can design and size engineering solutions, solve complex shape construction challenges, provide material and

quantity take-offs for pricing, and manage complex construction schedules and trades integration.[xxxv]"

A remarkable set of construction initiatives is being provided by the Broad Group in China under the leadership of Zhang Yue, a modern-day Thomas Edison. The Broad Group has recently completed the construction of a brand new 57 story building. The 57-storey building was constructed in 19 days, as shown in a Utube video which can be accessed at: http//en.broad.com. This is but one example among many of the construction achievements of the Broad Group.

The Broad group has been motivated under its owner's leadership to meet 6 standards in its "sustainable building development" business. These are:

Build to sustain 9 magnitude earthquake resistance,

Maximize energy efficiency,

Maintain much longer lifespans,

Produce cleaner air environment,

Use stainless steel structural components to minimize rusting, and

To minimize waste.

On top of these a drive to minimize costs has been critical.[xxxvi]

The steel and copper honeycomb structure, labelled B-Core Slab technology, took 7 years of research to develop. It arose out of a visit by Zhang Yue to a Lear jet plant where he noticed a piece of material lying on the side. When asking what it was, he was told it was a sample of the honeycomb structure used in the construction of spacecraft. It was light, strong and durable but very expensive. Zhang Yue went home and developed the same structure at a fraction of the price. It became the fundamental structural building material, known as B-Core Slab, for the Broad Group's building construction system. The B core Slab construction system incorporates several other innovations that make it a disruptive technology.

This technology and construction system speeds the on-site construction process, produces energy efficient, longer lasting, more environmentally friendly

structures in much less disruptive time and is claimed to achieve these results at a fraction of the cost of existing systems.

What jobs are created by this technology? We look at two sides of this development.

On the supply side, one can imagine increases in the demand for stainless steel and copper and other components, increasing the volume of production of these elements. A major component is the software developments required to build and modify the basic system, increasing the demand for workers with the skill to do this work.

On the customer side, the production of energy efficient, longer lasting, environmentally more friendly and much cheaper structures should increase the volume of the structures. To take the system for building new hospitals as an example, this will meet a shortage that is global. New hospitals will require more doctors, more nurses and service personnel, increasing the demand for these people, resulting eventually in better service for more patients. Similarly, the ability to construct more residential buildings, condominiums, will meet an increasing

need as populations around the world continue to move into urban centres. More buildings mean more satisfied users and more work for building operators. All in all, an encouraging story.

New travel companion

"A bot in the computer field is an autonomous program on a network that can interact with computer systems or people. A social bot is a bot which lives in social media such as Facebook or Twitter. They are programmed to autonomously create posts or tweets. An internet bot, also known as a web robot, robot or simply bot, is a software application that runs automated tasks over the Internet. Typically, bots perform tasks that are both simple and structurally repetitive, at a much higher rate than would be possible for a human.[xxxvii]" Wikipedia. Based on this definition, a bot is an application of AI.

Airlines have discovered social media bots as an effective, real-time way to reach passengers. "Once that happened," says Rob Harles, Accenture

Interactive's head of social media and emerging channels, that mode of communication "was an unstoppable force." Since then, the number of air travellers has ballooned, with 1.26 billion arrivals in 2016. "Human-powered social media interaction on that scale is impossible." according to Harles.[xxxviii]

The development of the airlines usage of social media chatbots in this way has clearly stimulated an increase in the volume of travellers and boosted the airline business, expanding air travel and creating more jobs in that and related industries.

The Call Centre Case

"IBM estimates that by 2020, 85% of customer service interactions will be handled without a human agent. Machine learning and natural language processing make it possible for Chatbots, enhanced phone support and self-service interfaces to perform most of the functions of human representatives.

As for the 2.7 million Americans who are employed as customer service representatives, some may be redeployed to tasks that bots can't do. Companies relying on this AI say it can help eliminate human error, drastically increase speed in data retrieval, and remove bias from customer service interactions."

Hard to say whether these applications will create more jobs than they destroy.

Advertising

Marketers are increasingly leaning on Artificial Intelligence to improve the effectiveness of ads.

Affectiva, uses AI to assess the emotions of viewers. Affectiva's system has been trained on images of 7 million faces in 87 countries. It decodes the facial expressions of viewers and identifies 20 different expressions and 8 emotions. Media research giant Kantar has used Affectiva's product for 8 years. Among other things it found Nike's ads using Colin Kaepernick's message about sacrifice and dreams triggered significant positive responses. The application has not only helped clients sharpen their campaigns, but also given them insights that benefit

all clients. By making ads more effective, AI has reduced the cost of ads, improved their effectiveness. This must lead to increased sales, generating an expanded work force.

AI in Retail

The global AI in the retail market attained a value of $720 million in 2018 and is predicted to achieve a compound annual growth rate of 35.4% in the nest five years.[xxxix]

"With AI, retailers have been able to automate their work processes, study consumer behavior, and capture relevant data through the adoption of numerous advanced technologies, such as machine learning, natural language processing, and computer vision."[xl]

Retailers have been using AI applications in "supply chain management, visual search, price optimization, customer relationship management and others."[xli]

One example is the Wallmart use of robots to scan warehouse inventories to identify the needs for restocking, as referred to earlier. We saw that this

application led to greater sales and the need to hire more customer relationship and other staff.

A more striking example is a current launch of Amazon's "cashier-less stores". Their new system allows shoppers to select their goods and walk out without waiting in line to check out or ever getting out their credit cards. In a Seattle store, Amazon shoppers scan a smart phone App to enter the store. Then cameras and sensors track what they take off the shelves and charge the sale price to the shopper's Amazon account. Amazon says the AI technology has to be tweaked to account for how customers squeeze tomatoes, or rummage through other items to find the right one to purchase. Other retailers are exploring similar technology.

Clearly, implementations of this technology will do to cashiers what the automobile did to the horse and carriage drivers, put them out of business. How this change will meet with approval of shoppers remains to be seen. Retail analysts note that shoppers decide where to shop based on other factors besides how easily they can get in and out of the stores.[xlii]
If the history of Technology innovation is followed here, the improved shopping experience should lower

costs and increase the markets for retail goods, leading to an increase in sales and profits and expansion of the businesses , thus requiring more employees in other areas of the business, such as supply management, warehousing and administration, as well as more employees to provide services to shoppers.

Making Health Care Human again

“The current U.S. health care picture is pretty bleak: more than 12 million diagnostic errors a year, a third of the $3.6 trillion spent attributed to waste, reductions in life expectancy for three years in a row,” and many overtaxed physicians, nurses and hospitals. Deep learning AI is being used to address these problems, “helping to accurately read scans,” and “by providing a virtual medical coach to better manage or even prevent diseases.” AI will use the wealth of data available to reduce errors and waste and improve many aspects of medical services. This will reduce costs, improve efficiency and effectiveness of medical services. Good medical services will become available

to more people. Rather than replace jobs these applications will relieve medical service shortages.[xliii]

"Using another AI application, Virta Health uses "AI to prevent patients at risk for diabetes from developing the full blown disease, and in early trials, even reversing Type 2 Diabetes."[xliv] While this application may hurt the producers of Metformin, it will preserve lives, and increase longevity for significant numbers of people. In the long run, this must increase economic growth and create more jobs."[xlv]

Hiring Smarter

Unilever uses several AI pieces in its hiring practices. AI software designed by Pymetrics measures cognitive and emotional responses with algorithms designed to minimize racial, gender, or other biases. Another algorithm sifts candidates based on not just what they said in an interview, but how quickly they responded and what emotional clues

they revealed in their facial expressions. Candidates who pass these tests are then interviewed by human recruiters.

The process generates a higher rate of acceptance than previously.

This is a good example of how the combination of AI and human recruiters can produce better results than either acting separately. AI is not replacing human recruiters but aiding them to make better decisions. This will make the recruiting process more reliable, more efficient and faster. It is hard to see that this AI will destroy jobs., rather than allow existing recruiters to be better at their jobs.

The New Mortgage Lender

40% of U.S. mortgage banks have used AI to automate the document heavy loan application process, to detect fraud, and to predict the likelihood of defaults. Banks are not yet relying on AI for approval decisions but have already observed a secondary benefit of making home loans accessible to a broader swath of American Consumers, in the lower income brackets. One result should be an increase in

the mortgage lending business, creating more jobs for the lending staff.

Financial markets

There are many opportunities for the application of AI in the Investment Business.

One of the most striking is on the stock and bond exchange trading floors. “Machines took the easier and loudest jobs first. In the 1970’s floor traders bellowing to each other in an exchange started to be replaced by electronic execution.” “The execution of orders on the stock market is now dominated by algorithmic (computer) traders.”[xlvi]

AI has been intruding extensively in other phases of the investment business.

One of the most interesting is the use of AI techniques to supplement or replace Quantitative Analysis to determine investment buy and sell transactions. Quantitative Analysis of stock prices uses the history of the prices of a stock to predict buy and sell opportunities.

Typically, the analysis tracks price performance patterns to deduce whether the stock's current price is above or below the analyst's estimate of its true value. For example, if the stock price history shows what is referred to as a head and shoulders pattern, this could indicate that the price is likely to fall. Hence this pattern identifies a possible selling opportunity.

There are many different Quantitative Analysis systems that can be used in isolation or in combination. Part of the fun and expertise of the Quantitative Analyst is selecting those that are likely to give the best results. The analyst is usually on the lookout for new approaches that will be better predictors of stock prices. Once the Quantitative indicators are chosen, the application of them to trading activity can be automated. In fact, this is what some investment funds do. But Quantitative analysts have yet to find a method of selecting and applying Quantitative analytic indicators that consistently produce good results. Trading practices that are based on a particular set of Quantitative indicators may produce good results for a time but are unlikely to do so for an extended period.

An extreme example of what happens when over reliance is placed on one of these systems occurred when a number of robotic traders were using the same one and it triggered a sell signal. The volume of automated trades overwhelmed the market for the stock and brought the market operations to an abrupt halt.

In the case of Quantitative Analysis of stock prices, AI techniques could help in the analysis of data, but could not replace the judgment of the Quantitative analysts. This is a good example of a situation in which AI can be used in collaboration with humans to get better results than either working alone.

AI has many other applications in the world of finance. For example, many investment analysts today are using AI to unearth quickly, insights that are helpful in valuing stocks and bonds. Bloomberg was a pioneer in using sentiment analysis, in which machine learning techniques are used to assign sentiment scores to stocks. Investment groups have more than quadrupled their number of “alternative data” analysts in the last 5 years, as wealth managers scramble to unlock the potential of trading signals

contained in websites, language analysis, credit card purchases and satellite data. This application is creating more jobs, not eliminating them.

Another intrusion into the investment advisory business is the growth of Robo Investment Advisors. A Robo advisor creates an investment portfolio for a client by following a simple set of rules. For example, the Robo advisor may simply mirror the shares underlying a major stock index such as the S&P 500. The Robo advisor software changes the share holdings of the customer's portfolio to match well publicized changes in the make up of the index. The Robo advisor can as a result charge fees that are significantly less than those of a human advisor.

Other Robo advisors may invest in an Exchange Traded Funds (ETF's). An ETF is an investment fund that holds a portfolio of stocks or bonds, and the shares of the fund itself are traded on stock exchanges much like stocks. ETF's are often run by computers and have a much lower fee structure than human advisors.

In spite of the cost advantage of Robo Advisors, they have so far been unable to attract enough investors to make profitable businesses.

“In 2015, A.T. Kearney projected that American Robo advisors would have $2.2 trillion under management by 2020.The latest figure suggest total assets are just more than one-tenth of that.”

“Matthias Memminger, of Bain & Company in Frankfurt, said of Robo Advisors: “trusting an algorithm is a leap of faith very few people are willing to make.” “most individual investors still crave human interaction (inter alia, for the soft skills to advise and comfort a client)” “Across Canada, the United States and Britain there simply aren’t enough assets flowing into Robo advisors” reports the Toronto Globe and Mail on February 8, 2020.

Mr. Menninger predicts “The winning model will leverage the strength of the digital service and the strength of the human advisor”. It does not appear that Robo advisors are yet displacing the jobs of the human investment advisors.

Nevertheless, AI driven computers are making serious inroads into all aspects of the investment

business, “The Russell 3000 index of U.S. stocks measures the total value of American Public equities to be $31 trillion, in 2019. The three types of computer managed funds-Index funds, ETF’s and Quant funds- run around 35% of this. Human managers, such as traditional hedge fund and other mutual funds, manage just 24% The rest, some 40%, is harder to measure and consists of other kinds of owners.”[xlvii]

There are many sceptics about the advance of AI driven computers into the investment business. “Brian Kelly of Yale University ... says its fund has found purely machine-derived factors that appeared to outperform for a while. But in the end, they turn out to be spurious.” Mr. Dalio, Founder of Bridgewater Associates, now the world’s largest hedge fund, points out: “Markets evolve, not least because people learn, and what they learn becomes incorporated in prices.” “There is no guarantee that strategies that worked before will work again.”[xlviii]

The investment business is an area where IA is making significant strides. While the displacement of human investment advisors seems to have been limited so far because of the human capacities for

creativity, adaptability and compassion required by the business, the onslaught seems relentless. This will be a good testbed to see how far AI driven computers can go. The jury is still out.

Design Improvements

A new program from Autodesk called Dreamcatcher uses AI techniques to assist human designers.

A designer inputs requirements, limitations, and other qualities; the software then generates thousands of options for the human designer to choose from. Airbus used the software to redesign an interior partition in the A320 and produced a design that was 45% lighter. This is another example of the fact that collaboration between AI and human designers produces better results than either operating separately.

AI in the World of Real Estate

"Technology and data are finally shaking up the world of commercial real estate, allowing the industry to make more informed decisions, respond quicker to consumer trends, and take on more complex projects, says consultancy Altus Group.[xlix]

"The change is stark at the executive level, where 80% of firms surveyed now say they have a chief data officer or equivalent executive, compared with 44% four years ago."[l]

Leasing software provider VTS, automated door hardware provider Latch, and contractor software provider Build Connect are examples of the many young companies targeting this space.

"Early entrants were focused more on efficiencies like lower energy costs or automating repetitive tasks, but with the wealth of data available there's the potential to improve future planning" said Altus CEO Bob Courteau.

While these developments have created jobs in the real estate software arena, they do not appear to be displacing the jobs of the real estate agents whose experience, training and judgment and personal touch are still the keys to good advice.

Conclusion

This paper addresses a significant debate: Will Artificial Intelligence create or destroy jobs. We have argued that it will create more jobs than it destroys

The subject of Artificial Intelligence is complex. We have started our discussion with a definition and history of Artificial Intelligence going back to the work of Alan Turing, in the 1930's,and reaching to the present work of Geoffrey Hinton as he and other researchers explore deep learning, the use of computer simulations of the human neural network system of learning.

We have set out 5 arguments in favour of our thesis that AI will in the long run create more jobs than it destroys. A strong argument is provided by a brief review of the history of technology innovations. This review shows overwhelmingly that technology innovations, such as the invention of the automobile, have created more jobs than they destroy. In large part this follows from the fact that the innovations typically lower costs, improve speed and efficiency

and promote increased profits and expansion of businesses. Beyond that, most technology innovations, create new businesses that greatly outweigh the businesses that suffer job reductions.

We have also presented 4 arguments that each show a limitation of the ability of AI to replicate the human mind. In turn we argue that these limitations will limit the number of jobs that will be destroyed by new applications of AI, and through collaborative initiatives will increase the effectiveness of existing human tasks, lower the costs of these tasks and ultimately lead to expansions in the economy and affected businesses and the creation of more jobs.

We have included a significant argument to the contrary, one of several. However, this argument presented by Yuval Harari is a supposition. It supposes that advances in computer science and neuroscience could allow researchers to achieve what is referred to as the Singularity, the replication of the human brain by computers. Harari goes on to suggest that this will allow AI based computers to destroy more and more human jobs. Harari's argument is however hypothetical. Because of the strong arguments we

have presented, we believe that Harari's supposition will not be realized.

We have also discussed the views of economists about AI and Jobs. In particular, we have discussed the views of Daniel Susskind presented in his book: A World Without Work. We agree that AI is raising important issues that need to be dealt with as Susskind suggests: the problem of job displacement, the contribution of AI to income inequality, the problem of the economic and political power of Big Tech monopolies and the problem of activities of the people who have left the workforce. We disagree with Susskind's main position that AI will destroy more jobs than it creates and explain why we disagree.

Finally, we have presented a number of examples of AI applications today. These examples have been extracted from a Fortune magazine article: 25 Ways Artificial Intelligence Is Changing Business and other sources. While the examples are by no means conclusive, since it is still early days, they are suggestive that our thesis is correct:

Artificial Intelligence will create more jobs than it destroys.

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