Technology is not enough: Potential job displacement in an AI-driven future

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Abstract

Much has been made recently about the rise of artificial intelligence (AI) in the workplace — often accompanied by apocalyptic predictions about what that means for human jobs. This paper discusses job displacement in the face of advancing technology; technological advancement has always rendered certain jobs obsolete, but it has also always generated new jobs and industries in their place. For example, Henry Ford's Model T created the demand that led to an explosion of growth in the hospitality industry as cars became affordable. While AI is an extremely powerful tool, the fact is that humans possess certain indispensable attributes that robots and AI cannot match. Human attributes such as flexibility, soft skills, understanding of context and a moral compass, among others, are characteristics that are not likely to be offered by machines any time soon. People also have played a key role in a number of critical supply chain situations, such as major disruptions. To be used to their full potential, tools like AI will require human guidance and ingenuity — meaning that rather than job replacement, these technologies will enable job augmentation. AI is surely poised to fundamentally alter human work and jobs, but it is not likely to replace them outright.

Keywords

artificial intelligence, AI, automation, future of work, assistive technologies, supply chain management, logistics

INTRODUCTION

Much has been made recently about the rise of artificial intelligence (AI) in the workplace — often accompanied by apocalyptic predictions about what that means for human jobs. As I write in my most recent book, *The Magic Conveyor Belt: Supply Chains, A.I., and the Future of Work*, technological advancement has always rendered certain jobs obsolete, but it has also always generated new jobs and industries in their place. For example, Henry Ford's Model T created the demand that led to an explosion of growth in the hospitality industry.

The fact is that humans possess certain indispensable attributes that robots and AI cannot match. Flexibility, soft skills, understanding of context and a moral compass, among others, will always remain vital to business operations. To be used to their full potential, tools like AI will require human guidance and ingenuity — meaning that rather than job replacement, these technologies will enable job *augmentation*.

This paper is based on an excerpt from *The Magic Conveyor Belt* that details humans' unique skills and the roles we can expect them to play.

TECHNOLOGY IS NOT ENOUGH

In 2018, JD.com's aggressive development of automated warehousing and distribution led chief executive officer (CEO) Richard Liu to say, 'We have over 160,000 full-time jobs today. In the next 10 years, I hope we will have less than 80,000'.[1] Reality has proven otherwise. While JD.com's business grew by 70 per cent between 2018 and 2020,[2] instead of shrinking its workforce, JD.com nearly doubled it to 310,000 people in this period. Specifically, not only did the total number of people grow despite investments in automation, but the number of workers per dollar of revenue grew as well.

This and other similar examples paint a positive picture of job growth. In a comprehensive study, the management consultant Deloitte reported on the impact of technology, robotics and automation on the UK's economy. In the 15 years between 2001 and 2015, 800,000 jobs were lost, yet nearly 3.5 million jobs were created. These new jobs required higher skills and paid more.[3] More importantly, these examples indicate that people continue to be essential, even in jobs that could, in theory and in demonstration, be completely automated.

Overcoming rigidity

The quip 'To err is human, but to really foul things up you need a computer' first appeared in print in 1969.[4] The quote reflects the power of computers to rigidly and relentlessly do what they have been programmed to do even in the presence of programming mistakes, erroneous data or circuit board failures. Even if the hardware and software work as intended, the rigidity of computers creates shortcomings that only people can solve.

Some companies are aware of these shortcomings even as they work to use computers to their best advantage. For example, Moderna, the biotech company behind one of the leading COVID-19 vaccines, is a foresighted adopter of information systems. 'The strategy was', said Marcello Damiani, Moderna's chief digital and operational excellence officer, 'we have a platform [for mRNA-based vaccines and drugs]; we want to build multiple products; and let's build it from Day One as digitized as possible.' Damiani continued:

> What we focused on is how information technology is going to help

> Moderna improve its product, increase its scale, improve its efficiency, and improve drastically the quality [of products] that we're building, and how we're going to build a very data-centric company, and how we're going to use algorithms to help the company do all those improvements.[5]

Awareness of rigidity affected how Moderna implemented automation. 'If you automate too early, and your processes are not stable, you slow down the changes because automation becomes very rigid', Damiani said. To manage rigidity, he explained, 'We start with islands of automation. We can connect those islands as the processes mature.'[6]

This strategy of progressively automating more and more parts of the organisation as subsystems stabilise seems to imply that most, if not all, of the organisation will eventually become automated and have less need for people. That extrapolation assumes, however, that the company's product technologies, the outside world, supply chains, competitors and customers are themselves stable and unchanging. In reality, the world is changing faster and faster, in part because of the speed of change in digital technologies. In addition, the rate at which changes can spread is swift and growing ever faster due to the speed of communications and the utility of adopting various new digital sharing platforms. In a world of accelerating change, stability only occurs in short-term, limited environments (eg a factory dedicated to a specific product and using a specific production process).

This reasoning points to where digital systems are better than people and where they are not. As long as the environment is stable and operates within expected parameters (ie a 'normal' environment), the algorithms can function effectively and keep the systems going. Yet real-world environments are continuously changing, becoming more and more volatile. In these cases, the machines require supervision and manual control by highly skilled human operators.

Human robustness

An Internet image depicts a snapshot of a large sign above a Chinese hairdressing salon. Below the Chinese version of the sign's message is a supposed English translation that reads, 'Could not connect to translator service'. This amusing example illustrates the fact that if no human in an organisation has an idea of how the automated system is supposed to behave, then no one in the organisation will know when it misbehaves or produces inappropriate results.

There are other reasons why it may be risky to depend entirely on automation. A particular danger that faces systems is catastrophic failure. A service outage at Google, for example, could disrupt not only people looking for answers in Google's search function but also all users of Google Maps. In many cases, these users are automated systems that rely on a continuous flow of information; without it, they may all go down at once. Likewise, an enterprise supply chain software company, or a major cloud computing provider, such as Amazon Web Services (AWS) or Microsoft Azure, could go down. In fact, AWS has experienced several outages, including one lasting more than 24 hours in 2018. Other cloud services have also experienced occasional outages. The consequences can be severe. Such failures instantly paralyse numerous companies and disrupt their supply chains. And when too many companies depend on the same cloud functionality, software system or data flow, they all become vulnerable to a disruption at the same time, creating systemic and wide-ranging failures.

Another vulnerability of digital systems is their exposure to cyberattacks, which can utilise a common part of one company's system to bring others down. For instance, in June 2017, staffers at the mammoth container shipping company Maersk in Copenhagen, Denmark, saw their computer screens suddenly go black. Within a short time, the entire computer system that ran Maersk's operations at 76 ports and on 800 vessels was dead. But the attack was not directed at Maersk. It was a Russian cyberwarfare assault on Ukraine, leading to wanton destruction of Ukrainian government data and a power blackout throughout that country; however, the malware released by the Russian hackers was indiscriminately attacking computers around the world. In addition to Maersk, countless companies were brought to their knees, including hospitals in Pennsylvania, the pharmaceutical giant Merck, the food producer Mondelēz and FedEx's European subsidiary TNT, in addition to hundreds of others. The virus even spread back to Russia, striking the state oil company Rosneft. The damage spread across the world in only a few hours.[7]

In every one of the affected companies, people had to dust off old plans and, to the fullest extent possible, run operations manually until the damage could be repaired. Thus, the first lesson from the attack is that recovery depends on skilled people's knowledge of how the systems work. When the computers are down, people's abilities to understand, manage and operate the systems and processes can limit the damage and keep the enterprise going while others bring the computers back up. This knowledge is stored in physical documents and in people's memories and experience.

The second lesson is that, unlike connected computer networks, people-based systems seldom fail all at once. Very rarely do all workers in a given job function worldwide suddenly stop functioning. Humans are much more independent, robust and adaptable at the individual level, so human-based systems are collectively less susceptible to single-point failures.

Cyberattacks can bring down computer networks, robots, autonomous vehicles and Internet of Things (IoT) systems. Software-based supply chain disruptions, however, are not limited to cyber security breaches. Faults in software upgrades and operational settings can cause cascading failures, too.

In his masterpiece *Anna Karenina,* Leo Tolstoy famously wrote, 'Happy families are all alike; every unhappy family is unhappy in its own way'. One could, perhaps, say the same about supply chain disruptions: each comes from its own roster of causes, generating its own litany of misery and its own cascade of effects. No two are identical. When these disruptions take place, they create new global environments with new challenges that require knowledge, experience and empathy to understand and address.

Resilience in an uncertain world

Moderna's Damiani made the point that successful automation depends on stable processes.[8] Major disruptions, however, can destabilise an organisation's day-to-day operations and require exceptions in management actions far outside those typically handled by any automated system. For example, when the great Tōhoku earthquake struck Japan on 11th March, 2011, it wreaked havoc among Japanese suppliers to the global automotive industry, including US carmakers such as

General Motors (GM). The resulting shortages of parts threatened to shutter all 16 of GM's production plants in less than three weeks.

To tackle the disruption, GM needed to create a dedicated project organisation with the right people and processes required to create, coordinate and execute an effective response to this very threatening situation. The company marshalled a select group of people who had deep knowledge of the company's products, suppliers and production systems. This included seasoned professionals in the engineering and supply chain areas of the company. The resulting crisis team worked on five categories of tasks: identifying the disrupted parts, finding more existing supplies of those parts to delay a shutdown, finding ways to restart production at the affected suppliers, finding and validating alternative parts, and optimising production during the disruption.

To monitor the crisis, GM created a special visual tool it calls a *white space chart*. The chart was a room-spanning timeline for each of the automaker's main assembly plants. The near-term end of the chart showed when each production line might face some kind of parts shortage. The distant-future end of the chart showed when GM expected to restart production through one of three methods: the recovery of the original supplier, bringing alternative suppliers online, or finding an engineering work-around. In between was the dreaded 'white space' for each production line: the period when parts shortages would prevent production.

To help the crisis team and executives understand the white-space situation, GM created a graphic code of marks and colours to communicate the types of potential disruptions to each assembly line, such as a partial disruption of some vehicle options, a potential problem or a time when production might be forced to halt entirely. Furthermore, they used red–yellow–green colour coding for the production lines to indicate progress on creating and executing a plan. The time points, marks, colours and white space provided an invaluable overview of the situation and the team's progress in addressing it. GM staffers also used this same colour notation to talk about the status of different commodities: 'We are red on paint', or 'We are yellow on heated seat modules'.

The crisis grew worse and worse as the team uncovered the full extent of the problem. What started as a potential disruption to 390 parts (those made by GM's direct suppliers in Japan) grew to 5,830 parts (including those made by non-Japanese suppliers who depended on parts or materials from disrupted Japanese suppliers deep upstream in the supply chain). The crisis team made significant progress in finding additional hidden supplies of parts, however, thereby delaying the shutdown from the end of March to mid-April, and then to mid-May. Each delay in the shutdown gave more time to the sub-teams working on supplier recovery and alternatives. With the exception of a one-week shutdown of small-lorry production to reallocate scarce chips to production of more popular and profitable large trucks, GM was able to keep making vehicles, although some vehicle colours were unavailable for a time.[9]

It is during large-scale disruptions, such as a natural disaster that disrupts routine operations, that people must rise to the occasion and manage the crisis. Extraordinary events call for extraordinary actions, including complex but temporary changes in management, structure, priorities, processes and coordination of communications. This is particularly the case with large-scale/low-probability events where no past experience exists.

Understanding context

Possibly the main drawback of automated systems is that they do not understand context. Context is the environment, setting and circumstances in which something exists or happens. It is the 'bigger picture' that an automated system may not be able to take into account when taking action, because it may not be aware of the moral code, reasonable goals or common sense that may be obvious to humans.

Consider, for example, a no-name seller of second-hand books on Amazon that is competing with a branded seller. While the branded seller would like to charge more for a book, the no-name seller wants to price its books just below those of the branded seller: cheaper, but as profitable as possible. Both sellers might use automated pricing algorithms that embody their respective strategies. Just such a case in 2011 demonstrated how such automated algorithmic interactions can go awry.

In April 2011, two booksellers, Profnath and Bordeebook, were advertising their 'new' copies of the 1992 developmental biology reference book *The Making of a Fly*, by Peter Lawrence, on Amazon. Bordeebook's tactic, as a 'premium seller', was to set a price higher than Profnath's, whose approach was to set its price just below that of its competitor. As Profnath adjusted its price to just below that of Bordeebook, Bordeebook raised its price to stay above Profnath's. Then Profnath raised its price to be just below that of Bordeebook and Bordeebook again raised its price. This pattern of 'undercut and raise' using automatic adjustments kept repeating, with the price peaking at US$23,698,655.93 (plus US$3.99 shipping) on April 18th. At the time, other sellers were offering used copies of the same book for only US$35.[10] In this case, the interaction between two pricing algorithms, each representing a sensible, if different, strategy, had arrived at a nonsensical outcome.

Pricing dynamics, however, are only one example of unintended consequences from algorithmic decision making. An encounter between a bicyclist and an apparently polite self-driving vehicle at an intersection shows that safety algorithms can be overly sensitive to the actions of others. As both the cyclist and the car were trying to inch into the intersection, each was reluctant to challenge the other, and a full two-minute standoff ensued.[11] The predictable risk-averseness of self-driving vehicles might even be something that canny and aggressive human drivers could try to exploit.[12]

It is important to realise how amazing, yet taken for granted, is the human ability to apply context. Applying context is the basic process by which people understand other people, situations, ideas and challenges. People respond to stimuli based on the context of the issue at hand. It is difficult for AI to apply human context. Thus, tell a robot to bring a wrench from the machine shop and the robot will do it. Tell it to 'help with the stupid generator' and the robot will be at a loss. Understanding context is a key element of 'common sense'. And it is the context, or common sense, that allows people to look at a 'new' book's price, in the context of the price of competing 'used' books, to realise that the price shown makes no sense.

Applying context: Overriding the algorithms

Like most retailers, New England-based Shaw's Supermarkets uses computer-based forecasting models to predict demand over time and ensure that its stores carry the right quantities of the right goods at the right time. The grocer uses data on patterns of demand to understand what people will want and when they will want it. Shaw's uses the results of this system for ordering goods from suppliers. When the 2008 financial crisis struck, however, the computer models stopped making sense.

Overall, the retailer believed it was relatively recession-proof because people must eat; however, while total unit sales of food did not change, consumers' preferences shifted significantly as they embraced frugality and sought to stretch their constrained budgets. Previously robust sales of higher-priced (and higher-margin) items dropped, while sales of store brands and low-cost staples such as pasta and soup grew. Data collected from before the recession could not help Shaw's forecast sales during the recession, and the computer-based sales forecasts had to be adjusted manually to account for these abrupt shifts. The algorithms therefore were not able to recognise that the context had changed, and that the environment had shifted from stable to volatile, with consumers changing their preferences.[13]

Similarly, the COVID-19 pandemic in the early 2020s wreaked havoc on forecasting that relied on historical sales patterns by inducing surges in sales of some products (eg toilet paper, pasta, consumer electronics, home exercise equipment and recreational vehicles) and slumps in sales of other products (eg restaurant meals, cars, business clothing and cosmetics). To add insult to injury, sales data during the pandemic were not necessarily useful for predicting sales going forward, either. Less than a year after the surge in demand for toilet paper, sales of this essential product slumped below pre-pandemic levels.[14] Similarly, the drop in car sales reversed and led to a jump in sales, creating shortages and high prices.

It is important to realise that most forecasting models, whether based on tried-and-true statistical regression models or modern machine learning (ML) technology, rely to a large extent on historical data. This data is used to calibrate the model for product demand over time to reflect, for example, that just like in the past, the demand for flowers rises on Valentine's Day and people consume less soup in the summer. Yet the reliance on past data carries an important but dangerous assumption. Hidden in the entire big data/statistical forecasting/ML approach is the assumption that the future will be structurally like the past, and that patterns seen in the historical data will repeat themselves in the future. This is not always the case. In reality, structural patterns can change with changes in the economy, society, technology, and the effects of disruptions.

Another challenge around future predictions is that the Internet seems to be a very good amplifier of idiosyncratic trends and memes. Social media creates viral messages about fears (such as self-fulfilling prophecies about shortages of toilet paper) and influencer-promoted desires (sudden shifts in demand for coveted products like Birkenstock shoes, made popular on TikTok).[15] In short, the same high-speed digital technologies that enable better forecasting with ML can also disrupt it.

Supply chains are social networks

Supply chains are more than just faceless corporations and transactional flows. The people in supply chain organisations have agency to direct and modulate those flows.

When it comes to making decisions in a supply chain, such as managing exceptions or escalating problems, the personal relationships between the people in the companies and both their customers and suppliers matter. As Lynn Torrel, chief procurement and supply chain officer at Flex, explained about the company's operations during the COVID-19 pandemic:

> We've had a few escalation calls with suppliers, and you get on a call and there are critical needs. Often, it's someone I've known for many years. We had a hard negotiation and then had a really good dinner and spent time together, and we're always seeing each other at different events. I think that personal side is important, especially the relationships and trust that build over time.[16]

Person-to-person communications help provide unstructured information about what is happening and what each side is considering doing. It helps in negotiating a solution and obtaining mutual commitments to action. 'You can be as technically savvy as you want,' Torrel said, 'but at the end of the day, you've got to pick up the phone and see if you can get a solution.'[17]

Customer–supplier relationships in supply chains can be quite complex. Large organisations can have a web of personal relationships at supplier and customer organisations that span many levels or functions in each other's enterprises. Operational and administrative personnel might interact frequently to solve problems with purchase orders, shipments and payments. Engineers in both organisations interact when working on new products and implementation of new technologies. Managers and executives hold strategic discussions and negotiations.

Companies often maintain teams dedicated to specific high-profile customers, creating long-term person-to-person relationships. Good person-to-person relationships create a social bond that modulates how the companies treat each other. To this end, Procter & Gamble (P&G), for example, has an office in Bentonville, Arkansas, next to Walmart's offices. It is staffed with several hundred people, all dedicated to the P&G/Walmart relationship. So many other vendors have such offices around Walmart that the area has been dubbed 'Vendorville'.

In the cases of strategic customers and suppliers, the relationships can extend to the executive suite. For example, in dealing with shortages of pigments, Ignacio Pala, global sourcing director for colours at AkzoNobel, noted how relationships helped to address the shortage of a certain component: 'We eventually got it with the help of a dynamic cross-functional team, not to mention the support of our CEO, who kept the pressure on our suppliers to come through for us.'[18] Similarly, when GM faced chip shortages after the 2011 Tōhoku earthquake, CEO Dan Akerson used his position on the board of chipmaker Freescale to seek an alternative source of chips. 'I picked up the phone, I called the CEO of Freescale, and I said, "I know you make chips of this type". We came up with a solution', Akerson said.[19]

Collaborating for an industrywide response

The social networks implicit in supply chains can extend beyond direct supplier–customer connections, as the case of a disruption at Evonik Industries shows. On 31st March, 2012, a tank filled with highly flammable butadiene exploded in one of Evonik Industries' chemical factories in Marl, Germany. Intense flames and thick, black smoke billowed from the cyclododecatriene (CDT) plant at the 7,000-worker chemical complex in the heavily industrialised Ruhr River valley. Roughly 130 firefighters fought the blaze for 15 hours to prevent its spread to the rest of the facility and to ultimately extinguish it. The explosion and fire killed two workers and severely damaged the plant.[20]

CDT sounds like an obscure chemical, and the fact that it is used to synthesise cyclododecane, dodecanoic acid and laurolactam may mean nothing to most readers. But CDT is a key ingredient in making certain polyamides, which are high-strength plastics more commonly known as nylon. In particular, CDT goes into a high-tech type of nylon — PA-12 or nylon-12 — that is especially prized for its chemical resistance, abrasion resistance and fatigue resistance. This makes PA-12 a favourite of the auto industry, which uses this tough plastic for fuel lines, brake lines and plastic housings. And if that was not enough, using nylon and other plastic and polymer composites makes cars quieter and more fuel-efficient. The average light vehicle in 2021 included over 400 pounds of these materials, up from just 20 pounds in 1960.[21]

Nor were carmakers the only industry using these materials. PA-12 also goes into solar panels, athletic shoes, ski boots, optical fibres, cable conduits and flame-retardant insulation for copper wire. CDT is a key precursor for making many other chemicals, such as brominated flame retardants, fragrances, hot-melt adhesives and corrosion inhibitors. The March 2012 explosion and fire in Germany destroyed almost half the world's production capacity for CDT. Worse, at the time of the explosion, CDT supplies were already tight due to its use in the booming solar panel industry. For automotive companies, the potential impact of the Evonik fire was arguably similar to the potential impact of the 2011 Japanese earthquake. Every vehicle they made depended on PA-12 for a large number of parts, and the fire threatened a significant and prolonged disruption of car production.

When TI Automotive, a maker of fuel lines and brake lines, raised the alarm about the dire implications of the Evonik fire, the entire automotive industry sprang into action. The industry convened an emergency summit on 17th April in Troy, Michigan. The summit was moderated by a neutral third party, the Automotive Industry Action Group (AIAG). The AIAG is a volunteer-run, non-profit organisation that provides shared expertise, knowledge and standards on quality, corporate responsibility and supply chain management to about 4,000 member companies in the automotive industry. Two hundred people attended the summit, representing eight automakers and 50 suppliers. Companies from all tiers of the affected sectors of the automotive supply chain came, including the big original equipment manufacturers (OEMs), their Tier 1 suppliers, component makers, polymer resin makers and on down to chemical makers such as Evonik and BASF.[22]

The participants had three objectives that required the collective expertise of the entire industry. First, they wanted to understand and quantify the current state of global PA-12 inventories and production capacities throughout the automotive supply chain. Secondly, they wanted to brainstorm options to strategically extend current PA-12 capacities and/or identify alternative materials or designs to offset projected capacity shortfalls. Thirdly, they wanted to identify and recruit the necessary industry resources required to technically vet, test and approve the alternatives.

The group formed six committees to help quickly create action plans that would lessen any impact of shortages on component and vehicle production. Each committee tackled an assigned task, such as managing remaining inventories, boosting production at existing suppliers, identifying new firms to produce resins and finding replacement materials. The group hosted multiple technical follow-up meetings on this issue during the subsequent weeks.[23]

This multifaceted collaboration was key to overcoming the supply challenge. Within a week of the meeting, the top OEMs had jointly drafted a plan to expedite their validation processes for alternative parts.[24] Harmonised validation processes ensured that a supplier did not need to perform different validation processes for each customer OEM. Suppliers from other industries lent their capacity to automotive applications. For example, Kansas-based Invista Inc., the maker of Stainmaster brand carpets, released its contractual claims on capacity for production of CDT so more could be allocated to the automotive industry. In the end, cars continued to roll off the line even though the Evonik factory was offline until December 2012.[25]

Humanity's key qualities

The examples in this paper speak to the flexibility, robustness, creativity, critical thinking, communications, resilience and other qualities of people in contrast to machines. Such qualities are typically classified as 'soft skills'. Most of those qualities are part of what I have referred to as *understanding context*. While computers may be masters of the digital world, the fact that humans live in the physical and social world gives them a superiority in several areas applicable to supply chain operations and management. As mentioned above, whereas a piece of software dutifully executes its algorithms without exception, people can spot an exceptional change or a problem that requires implementing new processes.

Living in the physical and social world

A lifetime of experience in the physical world gives people the ability to detect changes or discrepancies between normal and abnormal situations. For example, during the financial crisis of 2008, companies worried about the financial health of their suppliers. Many companies asked for financial data from suppliers, but these numbers could be manipulated and only provided a lagging, infrequently updated view of conditions at the supplier. To augment the data, many companies sent people to spot-check key suppliers' production of parts or materials on behalf of the company. Simply by walking through a supplier's offices and factories, the visitor could gauge its financial health through observing the existence of too much or too little inventory, the bustle or silence of the facilities and the emotional states of the workers.

Moral code

Many work tasks involve value judgments and subjective elements based on the system designer's or manager's preferences. Even if such preferences are set by the user of the system, they may not be permanent. Objectives, moral understandings and preferences change over time and from one management team to the next. While in many cases machines may be able, if trained properly, to sift through large amounts of data and present options for actions, people may have to make the ultimate decisions in cases where the implications of decisions matter significantly.

This is especially true when context changes and decisions need to be made in a different environment. For example, when prioritising the response to a disaster, should preference be given to customers, employees, suppliers, shareholders or the community? People, embedded in the human experience of personal life, family, friends, co-workers, customers and communities, are likely to be better than machines at understanding and judging a response that is both economically viable and socially appropriate.

Adaptability and coordination

People are also more adaptable than are robots when faced with unstructured conditions and environments. Any given robot or software system is built and optimised for a specific set of tasks or a specific domain; however, change (disruptions, new knowledge, new products, competitors' actions, economic cycles and so forth) can render the machine's appropriateness moot, requiring a person to take over the task.

Moreover, in the social context of an organisation and supply chain, crisis management teams can create new organisational structures and new collaborations to deal with one-off challenges, as happened at GM after the 2011 earthquake in Japan, with C&S Wholesalers during the COVID-19 pandemic and through the AIAG collaboration after the Evonik fire. Whereas computers can and do collaborate, they do so through programmed protocols, while people can adaptively and quickly create new ways of collaboration when and as needed.

Creative drive

More importantly, change that requires adaptation is built into many consumer and technology supply chains, from fast fashion to fast chip-based hardware. These fast-moving supply chains search ceaselessly for differentiation that can spur demand for any new product or service. As such, these supply chains deliberately seek out novelty — new materials, new parts, new processes, new designs and new services — that can create a competitive advantage.

People, not machines, are embedded in a cultural milieu that establishes the shifting meanings and connotations of words, symbols, shapes and forms. Personal, human understanding of the delights (or frustrations) of everyday life then suggest opportunities for new products and services.

As new knowledge is created, it can be transferred to systems by collecting the large data sets required and training those systems. As they operate, the systems can improve by internalising the data streams they collect and use during operations. Making large step changes, however, whether due to the need to adapt to a new external environment or to an intentional redesign of the system, requires people. Unlike the narrow existence of machines and software built for a special purpose, people live in many worlds of experience, ideas and technology at the same time, engendering cross-fertilisation of ideas.

This description, however, should come with a caveat. A new category of

ML-infused programs — Generative AI (GenAI) — can simultaneously de-skill the creative process in many domains (thus reducing the need for designers, writers and artists) while *augmenting* the creative output of other workers who have ideas but not the skills or education of professional creative workers.[26]

Empathy and communication

While there are a growing number of AI applications used in healthcare, computers cannot show the empathy required of a nurse while treating a patient. A machine cannot replace the recognising smile of the cashier in the local supermarket and the exchange of gossip that follows. By the same token, few contract negotiations can be completed without both sides understanding each other, developing rapport and appreciating each other's point of view. The ability to create personal connections and communicate is one of the strongest differentiators of people from machines. Such qualities are evident in the cases in which systems fail and people need to overcome their difficulties by working together.

Yet, just like with creativity, AI-based programs are starting to surpass those limits and enter into the human territory of empathy and feelings. Programs like Replika and Woebot allow people to talk about their troubles and even get some counselling in return. As the programs get better, it may be more difficult to distinguish between a human and a machine. In hospitals, such chatbots may assist medical personnel in various tasks while also relieving them of repetitive explanations to patients about procedures and processes. These programs do not replace medical professionals or even de-skill their work; they just assist them. Of course, to the extent that medical professionals can become more productive, fewer of them may be needed to do the work.

A class of emotionally intelligent (EI) chatbots could help businesses improve their ability to share information, collaborate with internal and external resources and address the needs of consumers before they even speak. Programs like Affectiva can capture human cognitive states and emotions by analysing facial and vocal expressions. EI chatbots can gather the necessary data based on the emotional responses of consumers and come up with appropriate, unique answers. In particular, sales and support staff can use such chatbots to better understand customer requirements.

It is, however, difficult to imagine real acceptance of machine-generated, simulated emotions and empathy. Customers may well perceive it as the well-known 'your call is important to us' or 'thank you for your patience' meaningless lines of business-speak.

Risk tolerance

AI-based systems can, in many cases, offer a range of possible actions. Each one of the possible actions may come with a probability that a certain objective (maximum profit, safest outcome, minimum emissions, etc.) will be met. Even if there is only a single objective, and no social or moral considerations are present, a decision may still be a matter of judgment regarding risk. Should one take the high-risk/high-reward option or the safe one? Or maybe something in between: not totally safe, but potentially with a better-than-minimum reward? While rules can be programmed, based on the context the most appropriate choice may be different from what the rules suggest. For example, if the company suspects that a recession is on the horizon, it may prefer the safer alternative.

Risk tolerance is an example of a consideration that is context-dependent and is therefore something that people are likely to be involved in for the foreseeable future. So, while the machine crunches the numbers, final decisions are made by people. In general, the more consequential the decisions are, the more likely it is that people will call the shots. Other examples of context-dependent issues include business decisions regarding reshoring, new strategic business combinations, taking a political stand and so forth.

Change is coming. There is little doubt about this. Whether people will work in tandem with machines operating in various degrees of automation; whether they will have to operate the robots; whether they will design, build or explain how the robots work; whether they will have to share jobs with machines; or whether they will have to supervise a combined environment of machines and people — society has to prepare workers and companies for these changes.

CONCLUSIONS

Robots cannot convene emergency summits, they cannot blow off steam and heal divisions from negotiations over dinner, and they certainly cannot rely on years-long relationships built on mutual trust and respect. Given the US$24m pricing war over a biology book, how can we be sure that a business run by AI would not interpret a disaster befalling a competitor as a strategic advantage? How could you tell it not to? Or, perhaps more importantly, *who* could tell it not to? Offering assistance requires going beyond empathy to compassion and altruism — distinctly human qualities.

Supply chains, although made up of a vast number of nodes and entities (factories, warehouses, mines, etc.), are actually social networks; it is the connection *between* the nodes that really makes it all possible, which all rests on human understanding and cooperation. In effect, people are the glue that holds all the pieces together. As Moderna's Damiano alluded to earlier, AI or robots can automate any number of processes and even recommend process improvements to be more efficient and effective, but they operate all on their own. Bringing all those operations together — seamlessly and coherently with that human glue — is really what makes our global supply chains what they are.

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