Bell Labs Consulting

NOKIA

The rise of the new-collar worker

Reimagining work through human augmentation

White paper

Contents

Executive summary

The COVID-19 crisis has triggered an acceleration of digital transformation across nearly all industries in the world. This transformation has reignited the debate around the value of work today and what this means for future labor markets. With foreseen technology advancements over the next decade, we are set to witness the accelerated merger of the physical, digital and biological worlds, leading to reinvigorated economic growth, social inclusion and the rise of a new hyper-augmented working class. But first, it will require numerous changes to business activities and business models. And, more importantly, it will require workers to quickly adapt and acquire new skills.

The nature of work has evolved over the last two decades and many different industries have been impacted by automation. This impact has been felt across different job classes – including cognitive, physical and clerical. Although it is commonly believed that digital transformation and the subsequent automation of systems results in fewer jobs with workers being displaced by machines, Bell Labs Consulting has found the opposite to be true.

Bell Labs Consulting has analyzed different US industry sectors and different job classes and has determined that while digital transformation does require workers to adapt and develop new skills, the end result is a new type of worker. And in many cases, digital transformation and automation will result in higher productivity and higher wages.

We believe that this shift to automation and machine intelligence will transform modern society. Technologies such as 5G, extreme robotic automation, massive-scale sensing, augmented cognition and control tools, and human augmentation will result in as great a change to the world as we have witnessed in prior industrial revolutions. We have no doubt that every job as we know it today will have to change. While we acknowledge that some jobs will be replaced, we believe that many more jobs will be augmented, optimized and enhanced. And we believe that this digital transformation will lead to the creation of many new types of jobs as well.

This white paper will delve into Bell Labs Consulting's research and shed light on how current jobs will be impacted as machines replace humans. We will show how some jobs – particularly physical/blue-collar jobs – will see a renaissance through assisted automation and will actually become harder to replace in the future. At the same time, cognitive/white-collar jobs, which were the early benefactors of the rise of automation, have started to plateau in terms of growth rates. We believe that cognitive jobs have the opportunity to evolve to the next level with the introduction of the next generation of augmentation technologies.

The result will be a class of "new-collar" jobs handled by workers that blend human and machine skills and deliver a higher cognitive and physical performance. These new-collar workers will not be dependent upon a specific industry, but will be able to move across industries, making them and the economy much more resilient. Bell Labs Consulting predicts that new-collar jobs will represent 70% of all jobs and will dominate the labor markets by 2030.

Automation and digital transformation are accelerating

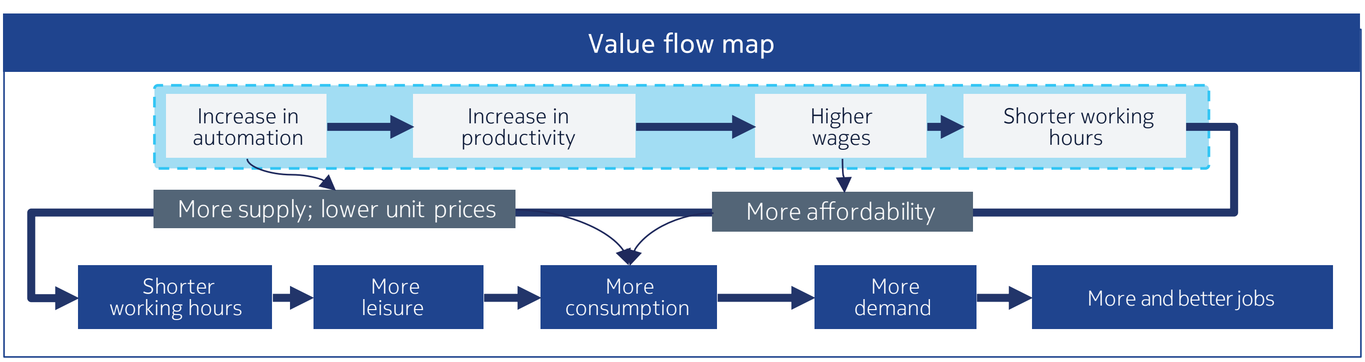
COVID-19 has made an indelible mark on industry transformation. On the one hand, the crisis has accelerated transformation that was already occurring. E-commerce experienced a 150% jump in transaction volume in the first three months of 2020 as e-tailers were able to meet the exceptional spike in demand by taking advantage of their existing underlying digital infrastructure, by making use of predictive analytics and by investing in warehouse robots [1][2]. Delivery companies were similarly able to ride the wave of demand by leveraging their investments in improved logistics systems and route optimization through geomapping [3].

On the other hand, COVID-19 exposed the latent inefficiencies in the global world order, and nowhere did that light shine brightest than on physical industries. The need for workers to be at their desks, in factories and on warehouse floors and the expectation that customers be physically present to receive goods or services stand in stark opposition to the need for social distancing.

The pandemic has forced every business to rethink its transformation strategy to a greater or lesser degree. Physical industries in particular have realized that they need to become augmented physical industries. But all industries must accelerate their move to automation using 5G, cloud, AI, machine learning (ML) and robotics. This hyper-digitalization coupled with distributed cloud will dramatically change the nature and value of work.

The essence of our thesis is that automation in most industries will result in more employment through a positive feedback loop or “virtuous cycle”: automation typically leads to increased productivity, and increased productivity will, in turn, lead to higher wages and shorter work hours. High productivity will result in lower unit prices, and those lower prices combined with higher wages will result in more consumption. That, in turn, will result in more employment (see Figure 1).

Figure 1: How will the augmented worker realize value?

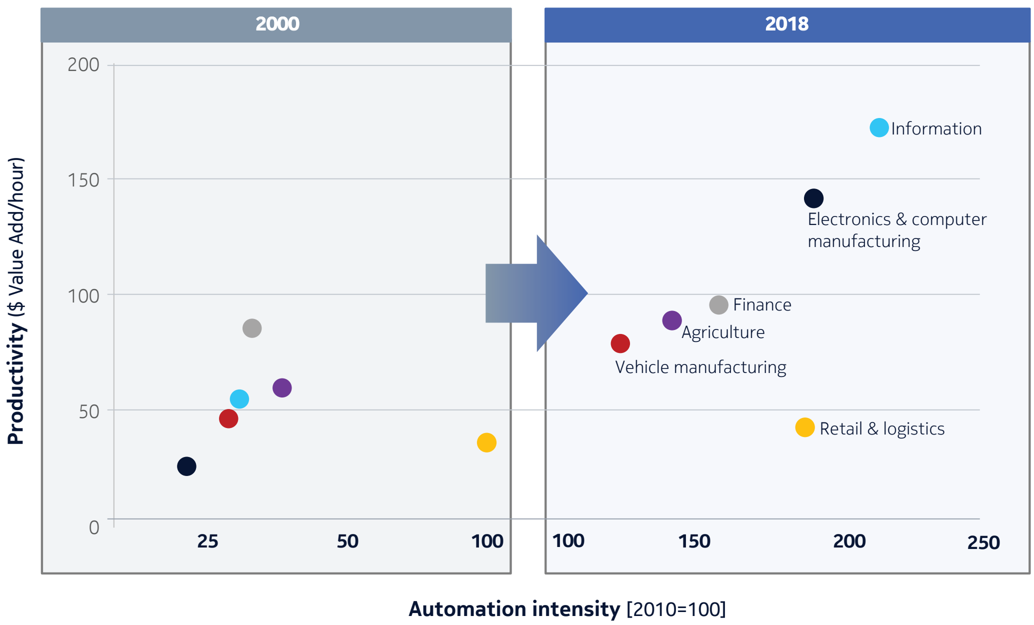


Our thesis, however, is subject to overall sector and regional economic conditions. During recessions and market demand contraction, increases in automation and productivity can lead to job losses. In general, if the rate of productivity increase is not met with equal or increasing demand, employment can be adversely impacted. However, even if demand in a sector does not grow, automation could still result in increased employment if the overall economy grows and other sectors are able to absorb the displaced workforce.

While automation has been taking place in all sectors since the start of the First Industrial Revolution in the mid-1700s, we are focusing on the last two decades, when most sectors embarked on their digital transformation journey. The notion of automation varies by sector. To analyze the impact of automation on productivity, we use automation intensity as a metric to quantify the level of automation and use different derivatives depending on the industry. For example, automation intensity in the manufacturing sector is defined as the number of robots per 1,000 employees. For other industries, we used machinery and ICT investment per employee as measures. Productivity in a sector is typically measured as the value added by sector (contribution to GDP) divided by total number of labor hours. Higher output and lower labor hours will result in higher productivity.

To track the change in productivity with change in automation intensity for different sectors across two decades, we plot the productivity and automation intensity of the different sectors for the years 2000 and 2018 in the two panels shown in Figure 2. We plot productivity along the y-axis and use normalized automation intensity along the x-axis, since the scale of automation intensity is different for different sectors. Normalization is done by dividing the automation intensity of the two years by the value of the year 2010.

Figure 2: Productivity vs. automation intensity



Productivity:
Real Value Add*/hour

* Real Value Add : Gross Output minus Inputs (adjusted for inflation) is a common measure of contribution to GDP and is used here for broad sectors with multiple types of outputs (products/ commodities/ services)

Automation intensity:
Robots/1000 employees for manufacturing; net fixed capital of automation enablers/employee for other sectors

Automation enablers:
Finance/Inf & Comm : ICT
Agriculture, Retail & Logistics
Industrial equipment + ICT

Sources: Bureau of Labor Statistics www.bls.gov; Bureau of Economic Analysis www.bea.gov; International Federation of Robotics

In our analysis we found that since the year 2000, most of the sectors saw increases in productivity as they increased their investment in automation.

For example, the electronics and computer manufacturing industry has very high growth in productivity along with increased automation. This dramatic increase can be attributed to the investment this sector has been making in automating their processes, and the shift to manufacturing of higher value-added products. Likewise, the information industry (which includes publishing, communications and broadcasting) also saw dramatic gains in both automation intensity and productivity due to the rapid adoption of digitalization. On the other hand, the finance and retail and logistics sectors saw much smaller increases in productivity.

These variations in productivity differ because some sectors might not have high demand for their services or products and therefore are not reaching full capacity. Another reason some sectors may not show significant gains is because they are at different levels of maturity with respect to deployment of automation technologies. Typically, automation is used to replace repetitive manual tasks. When those tasks have all been automated, there may be little productivity growth until further augmentation technologies are developed that can increase productivity once again.

Overall, we notice that accelerating automation and digital transformation across industries leads to higher productivity in those industries.

How the workplace and the nature of jobs are shifting

This rapid transformation has significant implications for the future of jobs and skills. We analyzed the data on employment and wages by occupational title for select "digital" and "physical" industries so we could better understand how automation and augmentation impact different job categories.

The US Bureau of Labor Statistics publishes survey-based employment and wages data on more than 700 occupation types for all sectors. We grouped these occupations into three categories:

- Cognitive jobs – jobs that have specialized skills and require cognitive and creative thinking.
- Clerical jobs – jobs that perform highly repetitive tasks and do not require high cognitive skills.
- Physical jobs – more manual-type jobs that require use of machinery and equipment.

Figure 3 shows the US Bureau of Labor Statistics breakdown of job classes in terms of these three categories.

Figure 3: US Bureau of Labor Statistics job classes and 2018 job category mix

Sources: Bureau of Labor Statistics www.bls.gov; Bell Labs Consulting analysis

Our analysis found that highly digitalized service industries that continue to invest in technology to augment their employees – for instance the information and finance sectors – are seeing increases in cognitive jobs. "Physical" industries involved in the production and distribution of goods – for instance the manufacturing, retail and logistics sectors – also saw growth in employment across all job categories since 2010.

We believe that the industries that will see the biggest benefits will be those that take advantage of work augmentation opportunities that promote mutual learning and collaboration between humans and machines. This will lead to the transformation of physical and cognitive job functions and give rise to a class of new-collar worker. These new-collar workers will be capable of superior creative and cognitive performance, which will in turn improve the physical productivity of their job tasks.

The augmented workplace

The augmented workplace can be characterized as an environment that is highly adaptive and can achieve significant improvements in critical safety, productivity and efficiency metrics.

Nokia's Conscious Factory, part of the World Economic Forum's Global Lighthouse Network project [4], is one such example of an augmented workplace. Recognizing that job classes – cognitive and physical – in future factories would radically change, Nokia leveraged some of its key technological capabilities to transform the factory itself and reimagine the worker's place within it. The Conscious Factory not only takes advantage of augmentation technologies, it also retrained its labor force with the new cognitive skills necessary to work on this transformed factory floor – for instance software automation, analytics and the use of IoT devices (see Figure 4).

Some of the key capabilities of the Nokia Conscious Factory augmented workplace are as follows:

- Extreme robotic automation – autonomous machinery that can accomplish predictable tasks without human intervention, autonomous vehicles that manage supply logistics, and software-definable and reprogrammable machines that can be dynamically orchestrated to accomplish various tasks and adapt to varying supply/demand conditions.
- Massive-scale sensing – multi-modal sensors that allow flexible placement, mobility and precision geolocation for safe positioning of equipment relative to workers to maximize safety, productivity and efficiency.
- Augmented cognition and control – high-fidelity digital representation within a hyper-local or wide-area context, enhanced with situational awareness that improves safety and detects anomalies in real time to respond effectively.
- Human augmentation – augmentation of workers with tools and capabilities designed to automate the most predictable tasks and enable the remote control of equipment. Augmented reality (AR) allows for access to the state of factory operations in the field; provides instructions for the operation, diagnostics or repair of equipment; and allows virtual inspections to ensure quality.

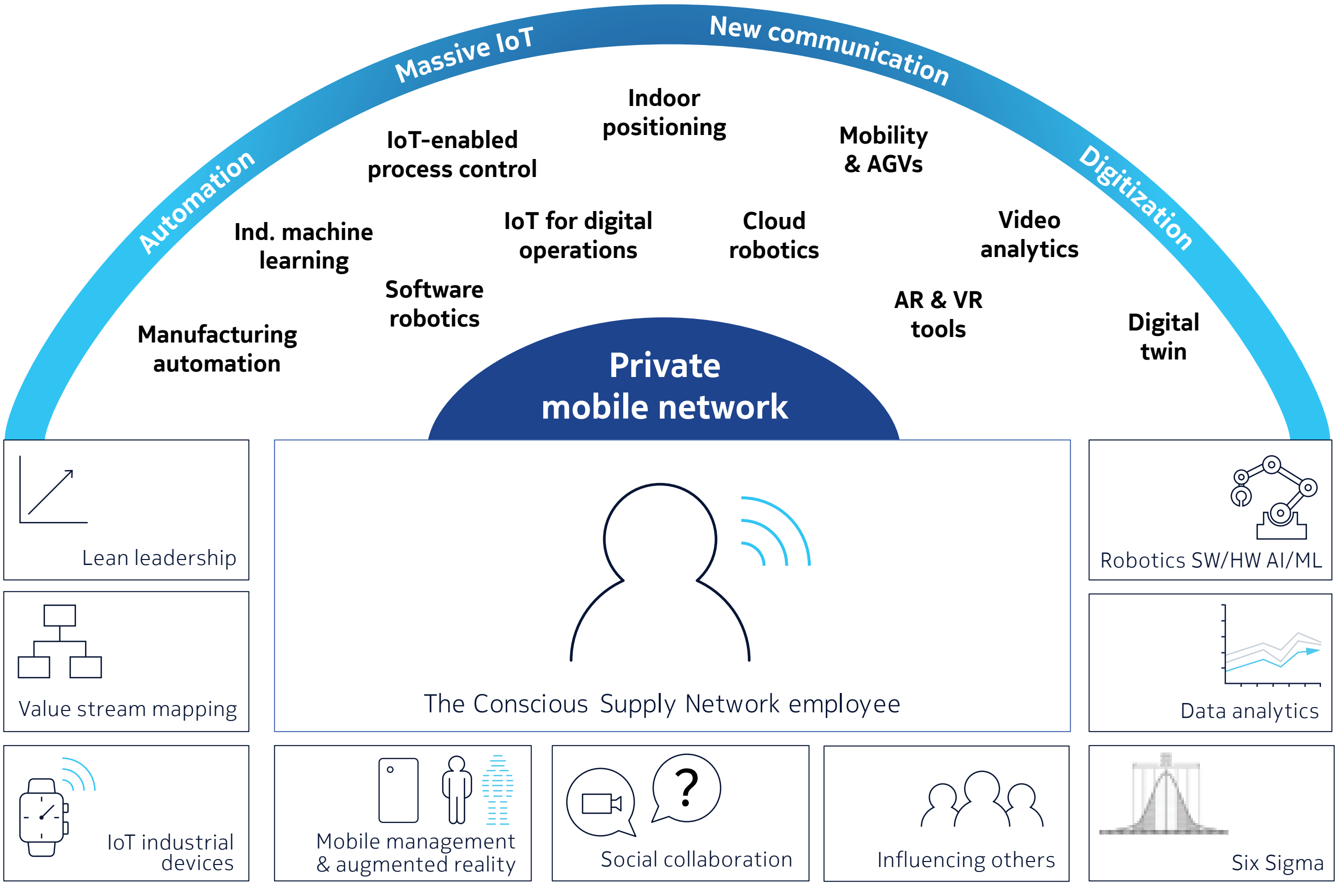
Capitalizing on some of these capabilities enabled the factory to realize its goals: the digitization and elimination of paper records in factories; the application of intelligent analytics to drive process efficiency; and increases in performance, transparency and security of data sharing between the factories and the supply chain. Furthermore, the use of robots delivered new benefits:

- Software robots helped in building automated scripts to replace manual data uploads and extraction between systems and teams.
- Hardware robots enabled investments in modular robot platforms that eliminated extremely repetitive tasks.
- Motion robots controlled remotely by workers assisted in moving heavy physical raw materials and finished goods in the factory, helping to avoid workplace injuries.

In addition to gaining significant productivity and improving time to market, the retraining of the workers is positively changing the diversity of skills in the workforce. We are seeing that these new augmented roles are attracting a broader community of workers and driving a positive attitude toward social inclusion.

An additional benefit of this kind of factory transformation is that, should a natural disaster hit an area where a factory is located (or should the facility be impacted by a pandemic such as COVID-19), the factory's operations could easily be relocated. The workload and manufacturing processes could be replicated by another facility in another place by just recreating the automated environment.

Figure 4: Nokia Conscious Factory is a testbed for the augmented workplace



Many industries across different sectors are beginning to see the value of augmenting jobs with advanced technologies. Below are examples of a few other companies that are part of the World Economic Forum's Global Lighthouse Network [4]:

- AGCO in Marktoberdorf, Germany, has deployed a smart and reconfigurable assembly line by combining digital solutions with intelligent line design. It is now able to manufacture nine series of tractors on a single assembly line with a batch size of one, resulting in a productivity increase of 24% and a cycle-time reduction of 60%.
- MODEC in Rio de Janeiro, Brazil, has leveraged advanced analytics for preventive maintenance, utilizing a digital twin of its offshore processing. This has reduced downtime by 65% in its first year of operation.
- Zymergen in Emeryville, US, is a digital-native bioengineering company that is augmenting its processes with robotics and AI, leading to a doubling of its innovation rate without any reduction in workforce.

This is just the start of a massive workforce revolution. As we continue down the path of augmentation, humans will be able to extend their capabilities and senses, allowing them to deliver superior workplace performance beyond what they are capable of today.

The future: a new hyper-augmented workforce

Nokia Bell Labs believes that workers in these future augmented workplaces will themselves become hyper-augmented, creating a new type of working class. By the time we reach the 6G era in 2030, the level of hyper-connectivity we see in the 5G era will also extend to the body, ushering in new advances in human augmentation technologies, which will in turn drive unprecedented levels of human and economic productivity.

Such augmentation of human workers will be in four categories (see Figure 5):

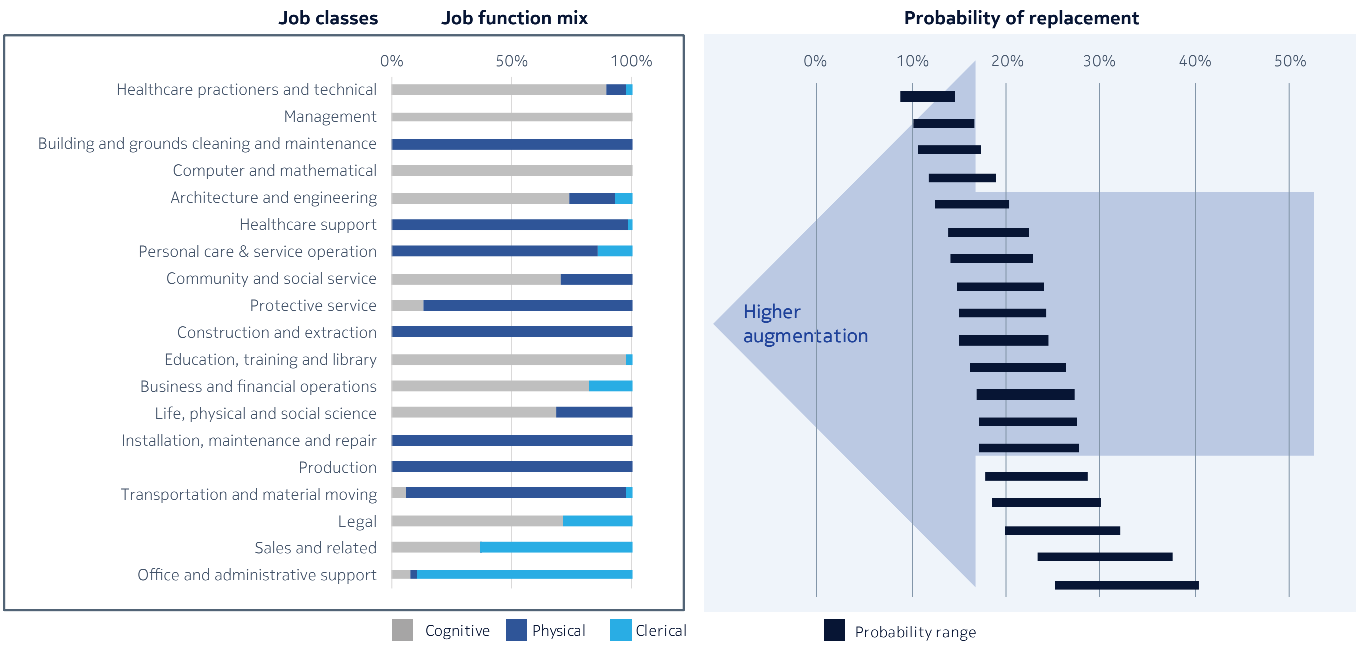
Figure 5: Types of future augmentation set to transform future work

Internal - Cognitive	External - Cognitive	Internal - Physical	External - Physical
• Enhances internal cognitive abilities while improving mental focus, expanding memory • Increases speed of decision making • Eases learning of new tasks, planning of our daily lives	• Extends the domain of control of our brain to control objects far outside our own bodies • Expands perception through external artificial sensors	• Repairs, monitors and enhances the workings of our inner bodies, replaces failing organs • Detects diseases, preemptively intervening • Tracks, prevents and manages epidemics	• From prosthetic limbs to exoskeletons, these technologies could make humans faster, stronger and more resilient
AI-physiological interfaces that can recall memories and assist in complex tasks	Interfaces that enable direct interaction with our environments at a distance	Embedded devices that provide continuous monitoring of our physiologies	Technologies, tools and machines that become direct extensions of our bodies

External augmentation has already begun to permeate the workforce as robotic automation and remote working become increasingly common. In the longer term, we not only expect the adoption of external augmentation to accelerate and augmentation technologies to grow more sophisticated, but also the adoption of internal augmentation technologies to increase, enhancing workers' mental acuity and physiology directly.

As cognitive and physical augmentation gain traction across industries, job functions that require certain cognitive or physical domain expertise will have a higher likelihood of transforming into new types of jobs that incorporate augmented skills. We call these types of jobs "new-collar" jobs because they combine human and machine skills. Meanwhile, jobs that include predictable, routine tasks – either cognitive or physical – will have a much higher probability of being automated and replaced. For any given job class, we looked at the proportion of time spent on repetitive tasks that could be automated, and then estimated the probability of the jobs being replaced. Job classes involving a higher proportion of unpredictable tasks that require special expertise are more likely to be augmented, while those with a higher proportion of repetitive tasks are likely to be eliminated as a result of automation, as shown in Figure 6. Jobs that are more likely to be augmented will emerge as new-collar jobs.

Figure 6: Likelihood of jobs being replaced



Sources: Bureau of Labor Statistics www.bls.gov; Bell Labs Consulting analysis

For example, healthcare jobs have a lower probability of being replaced because human skills are essential and many tasks are more difficult to automate. However, healthcare workers can benefit from augmentation. Internal cognitive augmentations could include monitoring tools that would allow nurses – no matter where they are in a hospital – to keep track of all their patients' vital signs, or AI/ML-based diagnostic tools could aid doctors in identifying medical conditions. External cognitive augmentations could give healthcare workers the ability to deliver medications remotely, while an external physical augmentation could help a medical technician isolate a vein when drawing blood or steady a surgeon's hand when making incisions.

Similarly, in the construction and extraction industry, workers often have to deal with different environments, making it harder to automate their jobs. These workers could benefit from numerous types of cognitive and physical augmentation. External physical augmentations could protect them from job hazards and perform feats beyond their normal physiological capabilities. Particularly dangerous worksites could be virtually reproduced as digital twins, which workers could then interact in, projecting their actions into the physical worksite via external cognitive augmentations. Internal cognitive augmentations could continuously monitor workers' physical states, immediately alerting safety officials if one becomes injured or is exposed to a toxic substance.

On the other hand, office and administrative jobs, which typically include many repetitive tasks, have a high likelihood of being automated and replaced.

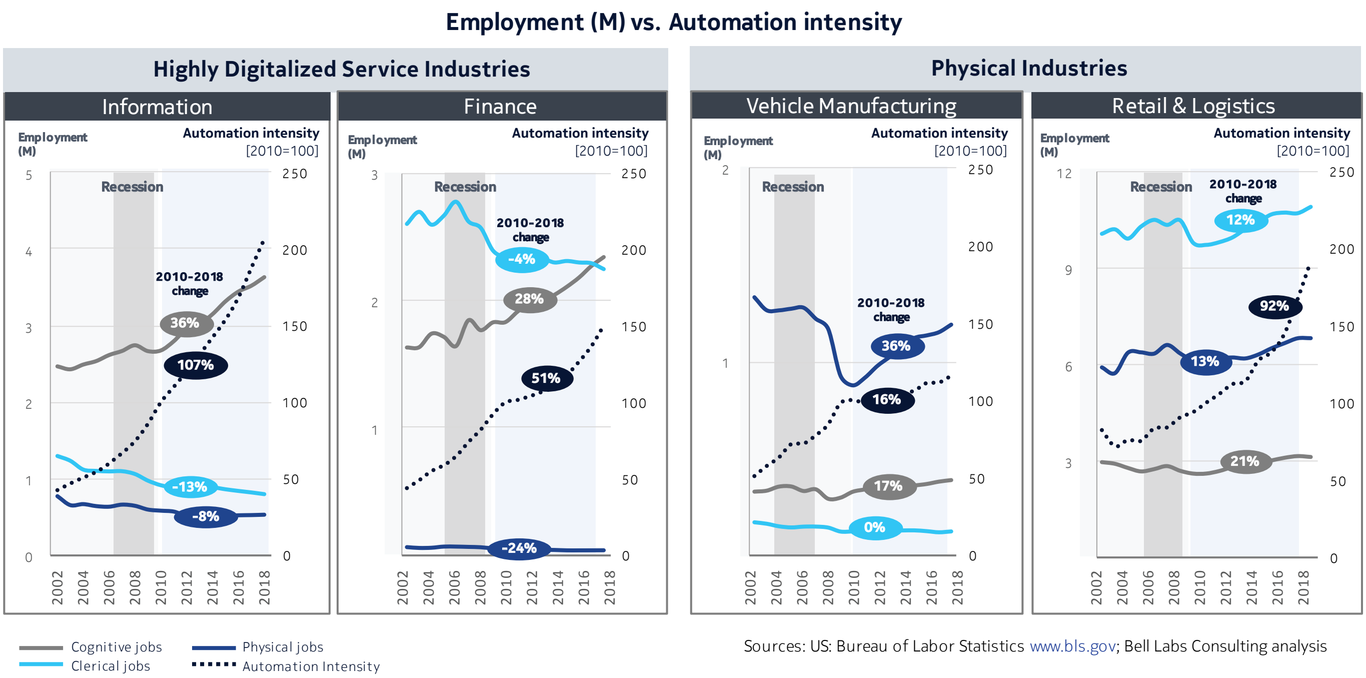
In the post-COVID era, we believe that we will see industry sectors reposition themselves to address new demands. Those businesses that automate at scale and successfully augment their workers will be more resilient and will be able to transcend COVID-19 and future pandemics as well as natural disasters that often lead to adverse economic impacts.

Why augmented workplaces and augmented workers will result in more and better jobs

More jobs

We have proposed that automation in an industry sector typically leads to productivity increases and therefore will lead to more jobs so long as growth in demand is faster than growth in productivity. To test this thesis, we have analyzed the data on employment and wages by occupational title for select digital and physical industries so we could better understand how automation and augmentation impact different job categories. In Figure 7 we show the employment numbers of different job categories and the automation intensity (shown in the secondary axis) of two highly digitalized sectors: finance and information, and of two physical industries: vehicle manufacturing and retail & logistics. The 2010–2018 change in employment and automation intensity are called out in the charts.

Figure 7: Employment (M) vs. automation intensity



Sources: US: Bureau of Labor Statistics www.bls.gov; Bell Labs Consulting analysis

Cognitive jobs have continually increased in both the digitalized industries since 2002 except for a small downturn during the 2007–2009 recession, while physical and clerical roles have declined steadily as the more repetitive jobs in these categories are replaced with automation.

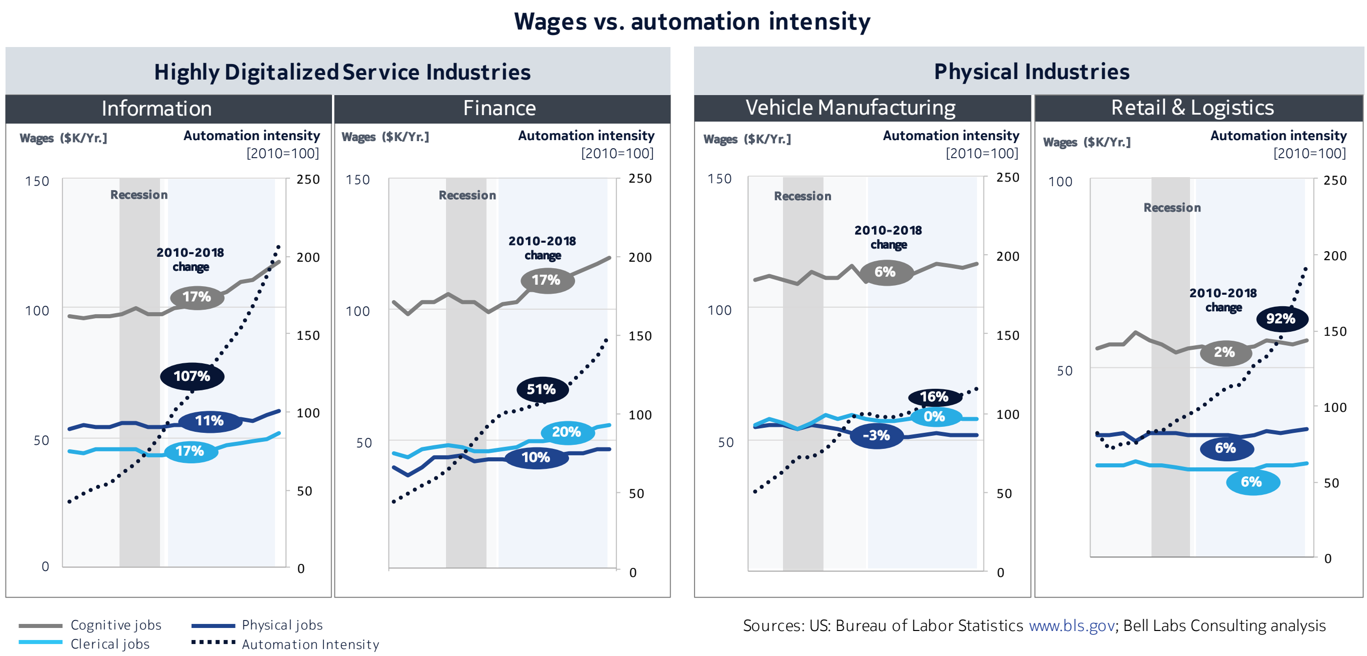
Physical industry employment trends, on the other hand, are mixed. While productivity continued to increase in the 2002–2010 timeframe because of increased automation, the employment trends were negative due to outsourcing in the vehicle manufacturing sector and depressed demand caused by the 2007–2009 recession. Productivity in the vehicle manufacturing sector increased by 62% between 2000 and 2010 while overall demand declined by 3%, resulting in jobs being eliminated because of increasing automation. However, in the 2010–2018 timeframe, demand grew by 46%, outpacing an automation intensity growth of 16% and a productivity growth of 5.3%. The net result is that overall employment in this sector grew during this time period, with more growth in physical and cognitive jobs.

In summary, historical data shows that if growth in demand outpaces productivity growth, there is an increase of jobs despite increasing automation. Moreover, even if automation results in loss of growth in a specific sector, overall employment can still increase as long as other sectors are growing and can absorb the displaced workers.

Better jobs

As far as wages are concerned, it is a tale of two decades. In Figure 8 we plot wage trends among the physical, cognitive and clerical job classes in the same four sectors we considered in the previous section, and then compare them against automation trends.

Figure 8: Wages vs. automation intensity



Sources: US: Bureau of Labor Statistics www.bls.gov; Bell Labs Consulting analysis

Prior to 2010, inflation-adjusted wages across all four sectors were more or less flat due to a combination of outsourcing and recession. After 2010, however, wages in most job classes increased in all sectors even with increased automation. The exception was the physical job class in the vehicle manufacturing sector, where wages stayed depressed. This is possibly due to the de-unionization trend in the auto industry.

Wages growth, in general, is a function of supply and demand. This is evident from the higher wage growth for cognitive jobs in the highly digitalized information and finance sectors, as they are dependent on highly skilled technology workers. In the future, as all sectors accelerate their digital transformations and demand for new-collar jobs increases, we can expect wage growth for new-collar jobs to outpace inflation.

We have seen that when the demand is growing, automation will lead to higher employment and wages. But what does automation mean for work hours? In the long run we believe that automation should lead to fewer work hours per worker. This will vary for different regions in the world. In the US, evidence shows that work hours per employee have not declined. However, in countries such as South Korea and Germany, there have been significant declines in work hours with increased automation [5].

Conclusion: The new-collar worker will be a superior worker

Our analysis of different industry sectors and different job classes has determined that while digital transformation and automation require workers to adapt and develop new skills, this does not equate to job losses. Instead, we believe that this shift to automation and machine intelligence and the utilization of new advances in human and workplace augmentation will end up benefiting society by creating a more resilient workforce that is more adaptable and untethered to a specific industry.

We believe that an automated workplace and a hyper-augmented workforce will shift industries' focus away from the workplace and onto the worker. In other words, once you have augmented the worker, the workplace will consequently respond and adapt dynamically. This will further benefit the labor market and the worker.

There are early indications that the current COVID-19 pandemic is accelerating the digital transformation of industries. We believe that this is a positive trend, because companies already leading in digital transformation will be able to weather or even benefit from the disruption caused by the recent pandemic (see Table 1).

Table 1: 2030+ COVID-19-induced accelerated transformation across industries

Type of company	Realm	Class of work	COVID impact	Success factors
Traditional				
Hospitality	Physical	Physical, Clerical	-	Basic digitization of CX, but requires new mechanisms to reset confidence.
Mining	Physical	Physical	-	Struggling but diminished productivity after first wave of automation and COVID.
Reimagined				
Food delivery	Physical + digital	Physical	+	Improved logistics through geo-mapping route optimization. Scaling.
Online retail	Physical + digital	Physical, Cognitive	+	Investment in warehouse robots and predictive analytics for improved CX.
Emerging				
Pharmaceutical	Physical + digital + biological	Cognitive, New Collar	+	Leveraging AI/ML, cloud computing for vaccine development.
Biotech	Physical + digital + biological	Cognitive, New Collar	+	ML/AI for molecules discovery, custom drugs, antibody development.
New communications infrastructure	Physical + digital + biological	Physical, Cognitive, New Collar	+	AR/MR/mirror of physical world in real-time 6G powered: man–machine interfaces, ubiquitous compute, precision sensing, new mixed reality experiences.

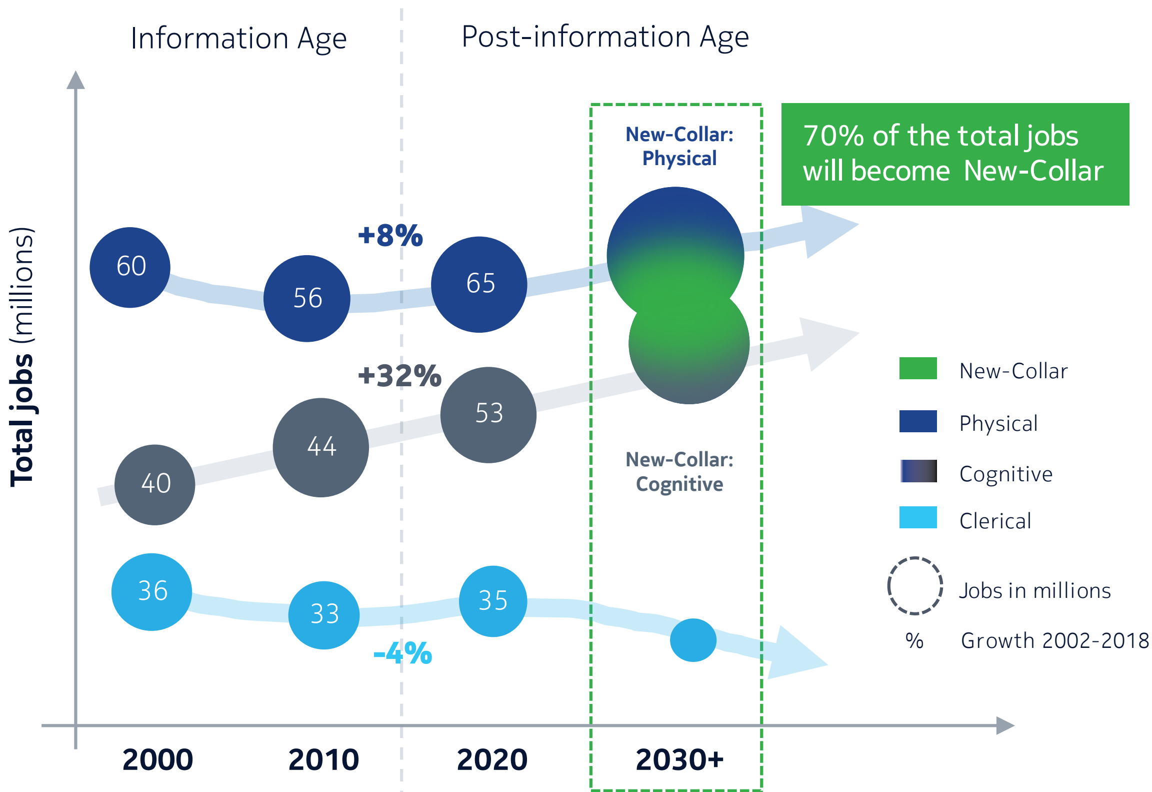
Source: Bell Labs Consulting analysis of company reports

New Collar · Physical · Cognitive · Clerical

Examples of this are pharmaceutical companies that are leveraging AI/ML and cloud computing for vaccine development, or telecommunications companies that are building 5G networks that will power new mixed reality services that provide a real-time mirror of the physical world [6][7].

Together with the shift in the communications infrastructure in the next few years to a more platform-based model and the early investments in 6G, we believe that the next decade will usher in unprecedented changes in worker augmentation, which will in turn lead to sizable boosts in overall industrial productivity. Our vision for 2030 and beyond is one where the new-collar worker becomes the new labor paradigm, accounting for 70% of all jobs in the labor force, as shown in Figure 9.

Figure 9: 2030+: Hyper-human augmentation era



Importantly, we further assert that, in the next decade, the businesses and industries that emerge as winners will be the ones that can integrate human systems with the physical and digital worlds in order to enable this new class of workers. These will be the companies that are resilient enough to transcend pandemics and other future crises.

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Abbreviations

5G	fifth generation mobile communication technology
6G	sixth generation mobile communication technology
AI	artificial intelligence
AR	augmented reality
ICT	information communications technology
IoT	Internet of Things
ML	machine learning
VR	virtual reality

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