

What if employment as we know it today disappears tomorrow?

A forward-looking view of the
workplace in Germany, Switzerland
and Austria in 2030



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Glossary

Artificial intelligence	The ability for artificial neural networks to perform tasks normally associated with requiring human intelligence, such as decision-making, visual perception and speech recognition.
Automation	The ability of computers or computer-directed machines to perform repetitive tasks.
Automotive manufacturing	Within the country scenarios, the “automotive manufacturing industry” is modeled and discussed. Working from the data included within the EU-KLEMS database for the sector, the auto-wholesale and retail industries are not included in the figures discussed.
Digital connectivity	The availability, use and cost of broadband and mobile internet by private and public sectors, as well as devices via the Internet of Things (IoT).
Digital human capital	A term that quantifies the presence of digital skills and their development within the labor market.
Digital public services	The availability and use of electronic government services.
Digital skills	The knowledge and capability to use advanced technology to improve existing processes and ways of working, as well as to create new innovative solutions.
Digitalization	Broadly indicative of shifts in workflows and businesses due to the greater use of the computer, big data, data-driven decision-making and artificial intelligence.
Fourth Industrial Revolution	The broad term used to describe the current technological revolution that is blurring the lines between physical, digital and biological processes.
Industry 4.0	Describing the ability for “smart machines” to operate in factories with minimal human interaction. Often used to describe processes by which machines can maintain and optimize themselves, rather than being assigned solely to perform repetitive tasks.
Machine learning	The ability for computer systems to learn and adapt new skills.
Machine superintelligence	When machine intelligence surpasses that of human intelligence.
MINT	Science, Technology, Engineering and Mathematics in German.
Small and medium-sized enterprises (SMEs)	Companies with less than 250 staff and have an annual turnover of less than €50m or an annual balance sheet below €43m ¹ .
STEM	Science, Technology, Engineering and Mathematics. Also known as MINT.

What if ...

Foreword

... employment as we know it today disappears tomorrow?

Industry 4.0 is changing the nature and shape of both our economy and our lives. Today, the scope for transformation seems endless, from cars that drive and park themselves, to on-location production through 3D printing and wearable technology that is controlled by our thoughts to name a few.

But while there is consensus that dramatic changes are happening in economies and societies, there is considerable debate over their impacts on labor markets.

By examining the prospects for Germany, Switzerland and Austria (GSA) to 2030 in relation to Industry 4.0 we can better understand what economic shifts are likely to occur and how great those shifts will be. In many ways, these countries are well placed for the transition to a more digital economy.

All three have well-educated populations, are home to world-class universities and possess the prosperity to invest in new technology. In this study we have drawn from insights shared in interviews, through scenario planning, and econometric analysis to model possible outcomes and impacts on the size, shape and skillsets of future workforces in each country. Those insights are key to defining our response to forces transforming the way we work.

Of course, none of the suggestions incorporated in the study are necessarily quick or simple fixes to the scaling challenges that our workplace faces. They offer a constructive starting point for richer ongoing conversations regarding the transition to a brighter future for the GSA region through shaping a long-term sustainable future, harnessing human values and long-term value in business and government.

Join the conversation [#FutureWorkNow](#)



Silvia Hernandez



Silvia Hernandez
Future of Work Now Leader in EY GSA

At EY we have a strong sense of purpose - everything we do contributes to *building a better working world*. We believe that in a better working world, a number of positive things happen: trust increases, capital flows smoothly, investors make informed decisions, businesses grow sustainably, employment rises, consumers spend and governments invest in their citizens.

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Study

A forward-looking view of the workplace

A study of the adoption and economic consequences of Industry 4.0 for Germany, Switzerland and Austria to 2030.

To clarify and quantify the economic changes likely to occur within the region, our scenario planning methodology, combines the macro drivers listed below and interviews with business and academic leaders to distill key findings about how each country may respond to the Fourth Industrial Revolution by 2030.

Germany	Switzerland	Austria
Machine learning: transformative or hype?	Automation vs. augmentation: where does the future lie?	Clustering: urban/rural divide or national growth?
SMEs: nimble adopters or underfunded laggards?	Government support: engaged or distant?	Digital skills: can supply meet demand?

Key findings

Germany

Where are the professionals?

The German labor force is expected to decline by approximately 3.5 million professionals between 2015 and 2030; unemployment considerations are at risk of being overlooked in the short-term search to bridge the skills gap.

Decline of the auto sector

There are dramatic declines in the automotive manufacturing sector across all scenarios, recording a drop of at least 50% in employment in every instance.

Support for hidden champions (Small and medium-sized enterprises or SMEs)

In a country with an expected tight labor market, SMEs that do not adopt new technologies will find it extremely challenging to meet customer demand.

Austria

The Germany effect

Germany is the country's largest trading partner, accounting for more than 35% of imports and less than 30% of exports; this will tie Austria's performance to Germany's future digital infrastructure.

Clustering outweighs access to talent

Chemicals and life sciences sectors respond positively to a clustering effect, even in a scenario where the right skillsets are assumed to be scarce.

To Vienna go the spoils

Vienna and the surrounding regions in Lower Austria will undoubtedly be the biggest beneficiaries of Industry 4.0. The capital is poised to become an even larger economic region within the country.

Switzerland

Bright future for Swiss chemicals

Even using the most conservative estimates, the chemicals industry, which includes the Swiss life science and pharmaceutical sectors, will experience 30% growth in GDP between now and 2030.

Banks continue to grow

While there are concerns that some jobs will fall away or be replaced by machine learning, our econometric scenarios show that the finance industry is set to grow as a result of digitalization.

Governments cannot remain idle

Currently, the Swiss Government is providing funding streams for Industry 4.0 technologies, but has not yet brought together public and private sector executives to discuss appropriate policy responses. This could slow development of the country's technological infrastructure.

Dystopia or utopia?

Finding our way to the Future of Work



Individuals

The Future of Work is often portrayed as a choice between two extremes: a dystopia of unemployable, incorrectly-skilled citizens unable to find a job, or a utopia of universal basic income built on a foundation of artificial intelligence doing all necessary work. This study is not based on the premise that there will be such a stark shift between now and 2030.

However, it does outline rapid changes. In Germany, we expect employment in automotive manufacturing to shrink by up to two-thirds, in Switzerland we expect there will be at least 30% growth in the GDP share contributed by the life sciences and chemicals industries.

The idea of work needs to be reimagined. Professionals can no longer regard education as a phase of life that occurs before entering the workforce. Continuous education and the ability to adapt to new tasks and processes will be crucial.

Individuals should also expect that a job on the market today may no longer exist tomorrow; preparing for a new work path should be a constant quest. Millennials and people entering the workforce should explore different careers, in order to gain exposure to diverse fields of work.

Perhaps most importantly, employees and employers should not see themselves solely as someone who just does a job, or performs a task - tasks can be automated. Individuals must focus on human competencies that cannot be replaced, such as empathy, creativity, interlaced thinking and the ability to inspire.



Companies

Technology allows skills to be linked to jobs. This creates a more diverse workforce that can work wherever and whenever it is convenient in order to drive a project forward. At the same time it facilitates the unlocking of silos, empowering employees to input into a broader range of projects that become correspondingly dynamic and consultative with the introduction of new and diverse perspectives. It will be crucial for companies to shift to a culture of permanent learning to ensure that professionals are able to make best use of the latest technology in their work.

Established firms may struggle to overcome the hurdles of legacy systems and those who tackle the problem early on are most likely to succeed. In Central Europe, a fragmented landscape of technology architectures and IT systems makes it very difficult to adapt and transform with agility. This landscape lends itself to short-term optimization, rather than more fundamental transformation, and has allowed disruptors to gain market share at the expense of slow incumbents.

Existing businesses must give employees the space to simulate the start-up environment in order to prevent them from being trapped in legacy business models. This must include the ability to fail in a safe, repercussion-free, way in order to support the spirit of innovation.

However, SMEs will also face hurdles in more broadly adjusting to the impacts of the Fourth Industrial Revolution. Access to either technology itself or the capital to invest in technology is crucial to enable to adoption of new systems. SMEs with tight margins will have little room for error in picking which technological wave is the one to ride but an overly risk-averse perspective will lead to companies missing out on the opportunities that these technologies bring. Firms must invest in creating a process for scaling new technologies, in order to maximize the value from their investment and protect productivity gains.

At the sector level, the Future of Work will create winners and losers. The automotive manufacturing, through the introduction of self-driving cars, may lose as much as 70% of total demand by



Countries

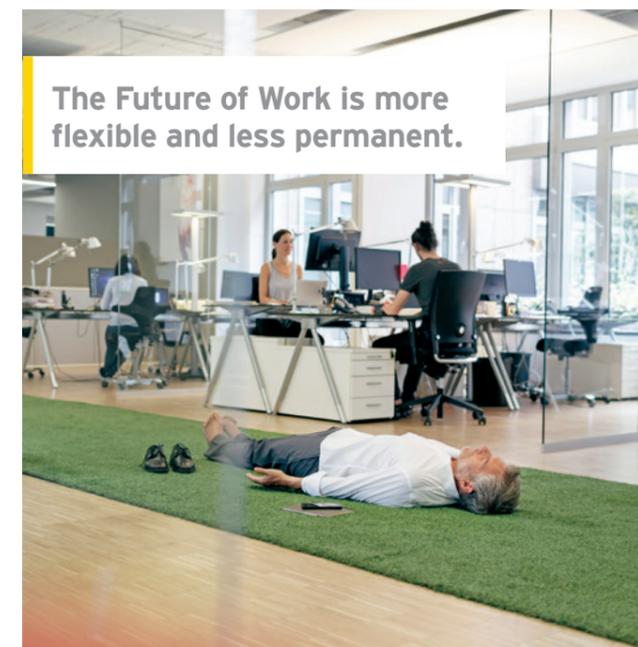
2030. Retail and manufacturing are also likely to see disruption and job losses. Health, finance and IT are sectors that are likely to expand.

Even if businesses fully and proactively embrace technology, there are still considerable perils to future operations. Algorithmic discrimination and data leaks, for example, have already caused embarrassing situations requiring both apology and testimony to governments. Nevertheless, businesses must tackle these consequences and be willing to grapple with fundamental challenges internally before a malfunction, leak or scandal requires a far more costly reconsideration. Where organizations and their workforce engage with technology head-on, ownership will belong to everyone involved, leading to a more committed and responsive workforce.

In all three countries, the technology facilitating the Future of Work will require the active participation of civil society and government executives. While there is an understandable tendency to look for new solutions to the challenges posed by today's market environment, a more effective strategy is to adjust existing processes and institutions, such as unemployment and social security, to equip professionals with additional skills and direct them where their skills are most needed.

Education at all levels, too, must be brought into the digital age, right through to continuous professional education. Regulations must be enacted to address new problems - data privacy being one of the most important. Access to large data sets is critical for the application of current digital technologies to create and commercialize new products. Being unable to capture this data could prevent the emergence of a self-driving car sector or hold back the development of artificial intelligence-enabled medical diagnostic programs. Yet not protecting this data adequately could expose citizens' most sensitive information to hackers and criminals.

As each country responds to the challenges of the Future of Work and balances all that it must consider in its decision-making processes, its economy will be developing in reaction to those changes, with sectoral shifts likely to develop in each of the three national economies. The IT industry is set to become an important economic sector and a driver of future growth. This brings with it new demands, particularly in terms of infrastructure and skills. The total number of medium-skilled jobs will drop as the total number of highly skilled jobs rise. This means that there will be an essential transformation of society, creating new demands. Countries able to meet those demands in the fastest and most efficient manner, will be able to leverage the industry's benefits for more growth in other sectors.



4.0

Employment

While there is agreement that dramatic changes are happening in economies and societies, there is considerable debate over the significance and speed of their impacts on labor markets.

Technologies, including automation and artificial intelligence, that enable workers to be profitably replaced by machines are accelerating in both sophistication and adoption. These new tools are contributing to a change in how work is done, reducing the need for labor in traditional economic sectors such as heavy industry, for example.

The new technical workplace in Central Europe

Manufacturing, one of the sectors most vulnerable to automation plays a significant part in the German, Austrian and Swiss economies. Consequently, divides between urban and rural prosperity may only grow and there is a risk that regulatory mismatch between national and EU levels will hurt European firms when competing with locally based firms from other regions.

Pathways to the Future of Work

While new technologies are shaping the socioeconomic landscape of Central Europe, the contours of that shape are still to be determined. It is against this backdrop that this study examines the most likely strategic pathways that Germany, Switzerland and Austria may follow to 2030. It draws insights from those who work in the fields of technology and employment and explores ways that individuals, companies and countries can nudge the future in a more positive direction.

While new technologies are shaping the socioeconomic landscape of Central Europe, the contours of that shape are still to be determined.



Change

How does technology change the way we work?

Technology is the hallmark of the modern world and the most important driver behind the exponential economic growth seen over the past two centuries.

Digitalization in Germany

Within its manufacturing sector, Germany is a global leader in incorporating digital skills and implementing automation. The country boasts 7.6 robots per thousand industrial workers, significantly more than the European average of 2.7.² The high number of robots within the manufacturing supply chain indicates that the process of automation within Germany has been ongoing for some time, which may mitigate the negative impacts of increased automation and robots as Industry 4.0 progresses.

German companies are also European leaders in the use and sharing of electronic information, a key indicator for the amount of connectivity within an economy.³ German industry, and manufacturing in particular, has benefitted from the rapid adoption of digital technologies. Even outside of industry, Germany has fostered the widespread development of strong digital skills. This investment is being further supported by a new funding program from the Federal Ministry of Education and Research, which is investing an additional €5b until 2021 to improve digital equipment and infrastructure within schools.⁴

Despite its high average age, Germany is also well positioned in terms of digital skills. While it is relatively average within the EU in terms of its rate of producing STEM graduates (known as MINT in Germany) - ranking 11th out of the 28 EU Member States in the EU's 2017 Digital Economy and Society Index (DESI) - in a survey conducted by the OECD in 2015, Germany scored well above the OECD average, demonstrating a high level of problem-solving skills in complex technology environments.^{5,6}

Access to modern internet infrastructure remains the largest hurdle to further digitalization within Germany, as broadband subscription rates are artificially depressed due to a lack of sufficient infrastructure.⁷ German firms also seem unable to capture consumer demand for online shopping: e-commerce as a percentage of revenues for German SMEs is among the lowest in Europe and continues to fall, despite Germany having one of the highest rates of internet shopping in Europe.⁸ This limits the incentive for German SMEs to invest in more advanced e-commerce platforms or to partner with existing online retailers. This potentially delays their use of new digital technologies in this space, which would lower growth in worker productivity and slow changes in employment brought about by technological shifts.

The progression of technological change is often referred to as digitalization. Though definitions differ, the general consensus is that digitalization is the process by which digital technologies are used to completely change the way in which work is done. Examples of this include enabling businesses to store their data electronically (in the cloud); to be in constant communication with suppliers and customers (B2B and B2C communication); monitor operations remotely (e.g., drones in agriculture) and even enable machinery to increase productivity (sensors and data analytics optimizing a warehouse or assembly line).

Businesses adopting an 'Industry 4.0 approach' require digital infrastructure, digitally skilled workforces and government regulations that have been evolved to suit the needs and threats of a digital workplace. Consequently, any country-specific evaluation of the Future of Work requires insight into what kinds of technologies are possible, and an informed understanding of the likelihood of their full utilization.

How new technologies have already affected the workforce

As advanced economies, Germany, Switzerland and Austria already have relatively high rates of digitalization. Within each country, technology has already been integrated into public and private services. Applications such as Qando in Vienna (provides users with real-time information for public transportation) and UBS' online banking platform in Switzerland (allows for the international transfer of money from a handheld device), are just two of the digital technologies already present within their respective economies. These tools, and others, use existing digital technologies to create labor efficiencies, reducing the need for traditional roles such as bank tellers and information kiosks.

When looking at the use of those types of technologies and the overall level of integration of digital skills, Germany and Austria are slightly above the EU average, while Switzerland is a front runner within Europe and globally in fields such as connectivity and digital integration.

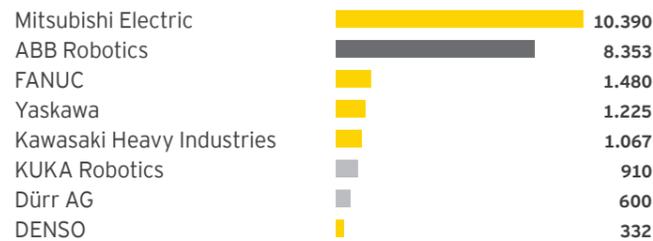
Digitalization in Switzerland

Switzerland is currently the most digitally advanced of the three countries, lagging only behind Scandinavia in terms of information and communication technology (ICT) infrastructure and its use within the economy and Japan in digital connectivity.⁹ Switzerland is particularly strong in terms of integration, as the country is integrating new technologies faster than any other country in Europe.¹⁰ Swiss industry has been particularly active in using digital technologies to increase production efficiency and create the necessary front-end tools to more seamlessly interact with customers.

While currently a leader in digitalization, Switzerland's rate of digitalization is improving slower than its peers.¹¹ The Swiss Government has been less active in efforts to promote Industry 4.0 and has invested less in digitizing its own services. As a result, Switzerland has relatively limited electronic interaction between businesses and the public sector.¹² If Government efforts are not improved in this area, the gap between Switzerland and the leading EU countries is likely to widen as other governments invest more heavily.

Nevertheless, Switzerland has a solid base in automation to build from, as it is home to the second largest robotics company in the world by revenue. The presence of German companies as the only other non-Japanese firms in the global 'top 10 robotics companies by installed robots' shows the potential strength of a German-Swiss automation cluster.

Figure 1. Revenues of leading global robotics companies 2015 (billion euro)



Legend: Japan (yellow), Switzerland (dark grey), Germany (light grey)
Source: Statista.com

Digitalization in Austria

Austria's current level of digitalization is only marginally better than Germany's, with roughly comparable numbers (Austria received an overall DESI score of 0.57 compared to Germany's 0.56, placing it one position higher in the rankings).¹³

However, while Austria is relatively average in terms of digital connectivity and in the integration of digital technologies within the EU, it is a leader in other areas. Austria has placed a growing emphasis on the provision of digital public services, ranking fifth within the EU in this category.¹⁴ The country is also making great strides in raising the number of STEM graduates, which has helped it improve its digital human capital in the DESI.¹⁵

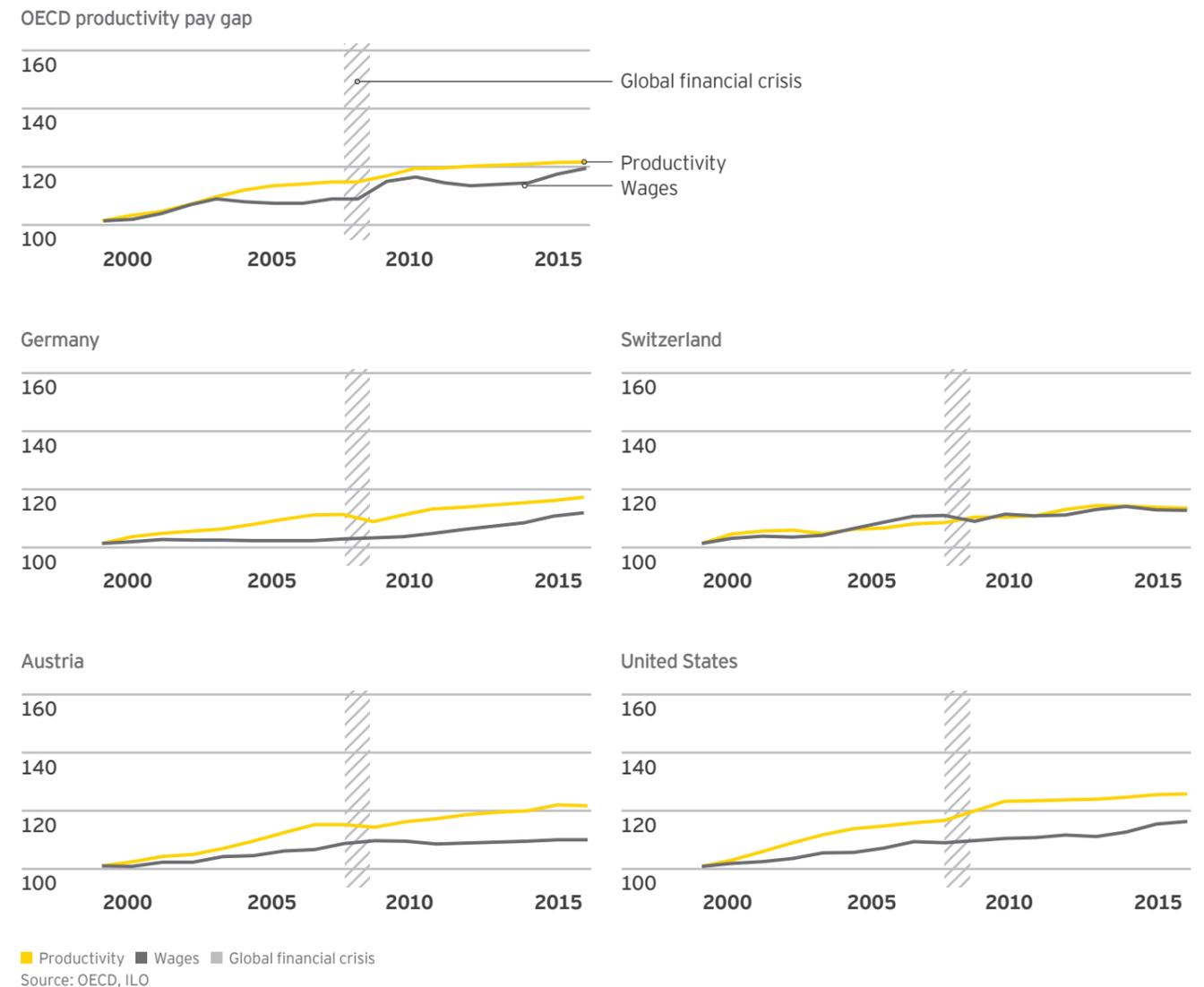
The biggest impediment to digitalization in Austria to date has been an overall lack of digital utilization, coupled with insufficient access to ICT technologies.¹⁶ While Austrian businesses have used digital technologies well for internal processes, they have not taken advantage of cloud technologies or electronic tools to better connect themselves with their customer base.¹⁷ Few Austrian SMEs sell online, though those that do see high turnover. Access to high-speed broad-band remains below EU and OECD averages, and well below the levels in Switzerland and Germany, restricting any growth that these services could have in the private sector.¹⁸

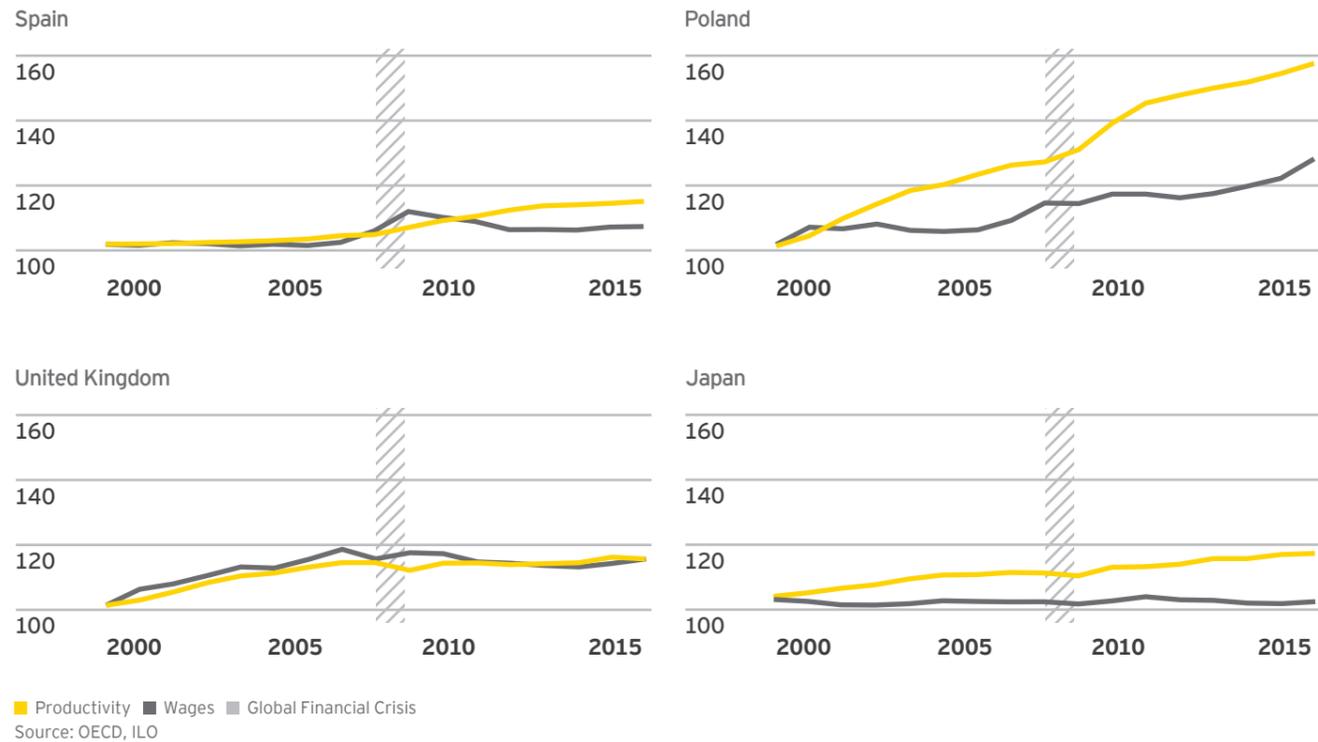
Government support

In order for the impact of digitalization to be managed and the growing demand for digital technologies and skills to be met, collective action by public and private stakeholders is needed.

Both Germany and Austria already have government-supported initiatives under 'Industry 4.0', to help the public sector connect with industry, labor unions and the scientific community.

Figure 2. Productivity pay gap
GDP per hour worked and average annual wages





In Germany, the Industry 4.0 group, a strategic government initiative, is geared towards trend identification and forming a common understanding of the Fourth Industrial Revolution.¹⁹ While it is only a forum for communication, Industry 4.0 is the means through which the government can educate firms, by funding research and pilot projects. Austria has followed the German model and created its publicly supported group, Industry 4.0 Austria, as a government platform to encourage knowledge transfer and creating a consensus on socially acceptable uses for technology.²⁰ The country has also published *Digital Roadmap for Austria*, which outlines planned future digitalization initiatives, such as broadband infrastructure works and vocational training programs for digital skills.²¹

Switzerland has yet to adopt this model of government support, with the private sector currently relying on its own resources to highlight the coming changes of digitalization. Swiss industry associations have band together to form Industrie2025, a new industry group that aims to help member firms develop digital business models, strategies for automation and knowledge on

how to use data effectively.²² The lack of an official public-sector forum to support Swiss enterprises encountering changes associated with Industry 4.0 represents, along with the relative lack of digital public services, a more limited level of public-sector activity than in Germany and Austria in regards to digitalization.

Both Germany and Austria have government-led initiatives to support Industry 4.0.

Government actions will be critical to smooth the adoption process of Industry 4.0 technologies and digitalization as a whole. Many of these technologies have deep social implications and finding the correct path forward will be critical to determining the environment in which businesses and employees will find themselves by 2030. Programs that complement new digital technologies will be a key component of this and will require strong support from the government in order to be implemented.

This support will be crucial in responding to any possible backlash against a productivity pay gap, where productivity consistently outstrips wage increases. This gap has been a feature of most developed countries in the first phase of digitalization. This may

be particularly important for Austria, where the average worker only sees 43% of real output reflected in wages, compared to around 70% for German and Swiss workers.



Our suggested government actions will be critical for the adoption process of Industry 4.0 and digitalization as a whole.

Unlocking value in a digital world

Can SMEs compete in human capital investment against larger firms with greater resources?

"Companies looking to invest in human capital should look to technology, leveraging it to do things differently. Also Industry 4.0 helps businesses to create flexibility in how their employees are able to work, while implementing programs that support the development of the technical skills employees need. Companies are starting to realize the importance of incentivizing employees to be creative, and there are now many different options that add to the employee experience beyond compensation."

In Germany and Austria there are strong labor unions and work councils. How are these countries thinking about this transition at the moment?

"I was recently part of a panel here in Germany with representatives from the largest work councils. They are starting to look at technological advancement more closely, but their policies are not that aggressive yet, and certainly not as flexible as they could be. It will most likely be hard for them to be nimble and flexible in the future. As digitalization takes hold and we see technological advancement, I expect that there will be some more

flexibility from the work councils as a result of external pressure, and as some of the big industrials might be at risk, I imagine hard expectations might soften as the realities come into focus."

Do you feel that we are not investing enough in human capital? Not many OECD countries have seen a large uptick in this area since the financial crisis.

"We are not investing enough in human capital. In my view, there is a huge risk that we miss the opportunity to create the platforms necessary to help individuals develop a life-long love of learning. Technology is changing the face of the human resources function as well. In Central Europe, I have seen human resources act as an administrative body and an execution body, but not fulfill its role as a partner to the CEO. This Fourth Industrial Revolution is giving human resources executives the opportunity to really think strategically and become a critical partner in the execution of business strategy."

What positive examples have you seen of how businesses have developed ways of working with technology to attract talent?

"There are a lot of interesting examples of companies that effectively use technology to attract talent or match individuals to tasks. In my view these are relatively young companies and start-ups. Legacy companies or the industrials are starting to talk about this and are introducing initiatives to attract new competencies. I think a good number of these organizations are redefining their employee value proposition to tap into the newest skills that are different from what they currently have in their workforce. What should be understood is that we are currently far from best practice in

this field. In my view we should think about the entire value proposition we offer our employees. We need to adopt a holistic view of this issue to create a well-articulated and compelling employee experience (that is differentiated for our employee groups). This applies to recruiting, on-boarding talent, giving them the ability to contribute and keeping them infused with the spirit of what the company does for as long as they are with the company, right through to staying connected once they move on."

Can EY help firms develop leading practices in this regard?

"We work with a significant number of companies in developing and executing their digital strategies. Once there is a vision for this future model, we help them think through the workforce implications of that strategy, collaborating to define a transformation road map that may include: elements of the organization (for example by defining a culture and change framework that accelerates workforce transformation through the alignment of the organization around a common, inspirational purpose); teaming elements (by drawing from the technology infrastructure and tools to activate multiple types of technology experiences, customized to both individuals and digital teams, designed to influence engagement, adoption and productivity) and the individual (by creating digital leadership development programs).

We often get asked to think about ways in which companies or departments can become agile. And a lot of thinking has been done by a lot of EY clients in creating supposedly ideal frameworks. This has created immense hype around what the workspace is supposed to look like, or how we should act. In my view, in isolation these initiatives result in the appearance of agility, without actually establishing the groundwork to be agile.

Internal functions continue to operate as before, just with different window dressing. We need to be authentic with how we go about thinking about our transformations as modeling ourselves after something that we are not just simply isn't working."

What skills do you feel will be critical for people to have by 2030?

"Creativity, empathy and the ability to inspire are skills that will be critical in 2030. These are some of the traits that will be needed in order to lead in a connected world. There are conditions in being human that are going to be fundamental in defining some of the things we do, as it is about combining human skills with what machines can be most effective at doing. It's how we as humans, interact with those technologies to create new opportunities to add value that will influence how we progress.

One thing that I think is starting to be discussed is that the curriculum of current leaders does not include these traits. We work with Oxford's Saïd Business School, and we have discussed working topics such as philosophy, which does not fit into the traditional business education, into the curricula, as it could provide a perspective for students that will be critical for business leaders going forward. EY's *Global Leadership Forecast* highlights how much more can be done in developing current leaders digital skills; this is a situation that should be addressed as quickly as possible.

I think it is important that business leaders are capable of thinking about the big questions such as issues within capitalism, climate change, radicalization, and the ongoing challenge to democracy. Private sector organizations will have a huge role to play in managing these issues, as they are too big for government alone. We are already beginning to see this happen

- for instance, the Coalition for Inclusive Capitalism has established a number of initiatives that bring together leaders from some of the world's most powerful companies to begin addressing these issues."

Have you seen any evidence of a trend toward cross-sector employment, where one sector will employ individuals from another, with a non-traditional skillset?

"There are a lot of opportunities to use talent in different environments, particularly as technology creates a platform for us to connect skills with jobs. These types of informal platforms also create work opportunities for older members of our society that might not be able to work otherwise. There is a huge opportunity at the moment for organizations to think about talent in new ways and to really connect people with tasks. I think we will certainly see growth in this area, as technology enables people with skills to be further connect to those who are in demand of their services."



Silvia Hernandez
Future of Work Now Leader EY GSA

Technology creates a platform for us to connect skills with jobs.



Scenarios

The Future of Work

Making predictions about the Future of Work - indeed, making predictions about the future at all - is a highly uncertain task. Unforeseen variables or slight shifts in trends can mean the difference between a prediction being highly accurate or wildly off-base. In regard to the Future of Work, all projections are highly volatile, as long-term growth rates post-recession must be accounted for, as well as yet-unseen productivity gains from technology, and coming demographic shifts.

Scenario planning gives corporations and governments insights into the future without lending too much credence to a single set of assumptions. The group managing director for Royal Dutch Shell, André Bernard, is one of the pioneers of scenario planning and wrote in the *Harvard Business Review* in 1980 that: "... Experience has taught us that the scenario technique is much more conducive to forcing people to think about the future than the forecasting techniques we formerly used."²³

In this and in following sections, we present a series of scenarios designed to address the specific circumstances of Germany, Switzerland and Austria, and to analyze how key trends and uncertainties may combine to affect each country.

Building scenarios

This report uses a methodology for scenario planning that is based on the work of Herman Kahn for RAND and Pierre Wack for Royal Dutch Shell.

First, a working group examined the existing literature on Industry 4.0 and digitalization to identify the top trends and uncertainties that may affect Germany, Switzerland, and Austria. The major trends for each country were identified and research conducted to determine how each trend may affect the key variables of economic growth: sectoral size; productivity growth and overall macroeconomic performance.

In a workshop, this group debated which trends had the highest level of combined impact and variability. This allowed us to build alternative scenarios around macro drivers that are important enough to affect an entire country and uncertain enough to require multiple scenarios. For example, geographic location would not be a macro driver, because though it is important for a country, it will not change in the next decade.

Upon identifying macro drivers that could be combined to form scenarios, further research was conducted to isolate the plausible range of impact of each driver. The inputs of an econometric model trained on historic data for advanced economies were adjusted to simulate the effect of the macro drivers and then re-run again. Further research was conducted on the most probable effects of these underlying quantitative changes and narratives developed for each scenario.

Empathy, the ability to inspire and cultural awareness are certainly skills that will be critical.



Top trends for the Future of Work

Demographic change

The UN projects that the population of Germany will shrink between 2017 and 2030, while Austria's population is projected to remain at its current level. The Swiss population is projected to grow by 10% from 2015 to 2030. In all countries the dependency ratio will increase from 61 to 64 dependents per 100 people aged 61 to 64 and 76 to 81. Workers are to work longer in countries with expected populations.

Machine learning

The rate of change in occupations has been relatively constant over the past 50 years, with routine production-related jobs consistently losing employees to service-related, non-routine, cognitive tasks. However, if machine learning and the development of artificial intelligence advances rapidly, it could drastically accelerate productivity in areas ranging from transportation to manufacturing and increase the pace of technological adoption.

Size of firms

There is some evidence that large firms spend more on technological improvements compared to SMEs, as they can better afford the capital expenditure and benefit more from the economies of scale of internal improvements. However, larger firms may be slower to adjust to new trends, and smaller firms in aggregate may adopt new technologies faster, due to lower structural barriers.

Rise in services

As digital tools have been introduced, developed economies have seen a steady increase in the size of services sectors at the expense of traditional manufacturing roles. This transition is likely to continue as automation further penetrates the workforce. The pace of digitalization will thus be reflected in the growth of the tertiary economic sector. Service business models, such as software as a service (SaaS), will also be replicated as additional industries use new technologies to replicate a service offering.

Government support

Governments are beginning to identify Industry 4.0 as an economic differentiator and are viewing digitalization, and its human capital requirements, as avenues for government support. As the rate of digitalization increases, governments will compete more openly to support the creation of digital technologies, through direct funding and favorable regulatory environments, and through digital technology education programs. The use of public funds to finance improvements in infrastructure is one such outlet for government support, as is investment in IT classes for schools.

Demand for digital skills

The advancement of digital technologies has increased the burden on individuals to learn new skills. As the pace of digitalization increases, the importance of digital skills will grow accordingly and will force educational systems to offer curricula aligned with the demand for new skills. This will influence the ability of firms to find skilled workers who are able to harness new technologies.

Job loss

According to Dr. Michael A. Osborne from Oxford University's Department of Engineering Science and Dr. Carl Benedikt Frey of the Oxford Martin School, 42% of professions within Germany have a high (more than 70%) possibility of being automated within the next 20 years. Other studies have hypothesized that only 12% of jobs will be automated within Germany and Austria, with augmentation of human skills from use of technology more likely. The wide range of projections stem from the uncertainty about how many jobs will be fully eliminated, how many will adapt and how many will be created by the rise of new sectors. Net job losses linked to the arrival of new business models are difficult to quantify due to their volatility, but will preoccupy both workers and politicians - particularly as politics tends to focus more on those who have lost jobs in highly visible sectors than those who are gaining jobs in rising sectors. The use of different methodologies to quantify 'job loss', also leads to volatility in the projections.

Connectivity

The Internet of Things (IoT), the network of devices that can communicate, is quickly growing, with estimates ranging from 26 to 50 billion devices that will be electronically connected by 2020. The number of devices able to be connected digitally will drive business and consumer demand for further digitalization.

Clustering

Industries are known to cluster in order to share knowledge and lower production costs, giving rise to areas such as Silicon Valley. Rapid development of additional clusters in urban areas could accelerate the pace of technological adoption, while also spreading the effects of digitalization unevenly within a state or industry.

Top uncertainties for the Future of Work

Immigration

The working-age demographics of these countries in 2030 are highly contingent on the levels of immigrants accepted. If immigration is high, the dependency ratio will be less than projected. If low, the reverse. Yet immigration is dependent on push factors in the surrounding areas, such as conflicts or economic collapses. The competition for attracting skilled immigrants will also increase.

Regulatory harmonization

Since regulations involving new technologies are still being developed, there is still a question about whether they will be similar across the EU, Europe or the developed world. Separate regulatory environments between Europe, the United States and Asia could lead to a fragmented technology sector with higher costs.

Speed of regulation

Governments are beginning to adjust to Industry 4.0 and digitalization, introducing regulations concerning new business models, blockchain technologies, employee rights, privacy and security. However, it is still highly uncertain when they will be adopted by both national governments and international bodies, such as the EU.

Digital education

While digitalization has given rise to digital natives, it has also increased the learning burden on individuals who are less technologically adept. If firms and governments are unable to properly educate their workforce, digital technologies will not be able to be fully implemented. Conversely, the successful implementation of training programs could help attract business and increase the speed of digitalization.

Access to capital

Adopting digital technologies is expensive. For SMEs in Germany and Austria, the process of digitalization will require either public support or significant private investment. The availability of publicly financed or inexpensive capital will impact the pace at which new technologies are adopted.

Access to technology

While it is widely assumed that technology is developed in a linear fashion without delays, this is not the case. Roll-outs of new technology platforms are often delayed. Patent issues, lack of capacity for delivery and technological failure can all contribute to a lack of access to new technologies.

Cost of labor

The price of a unit of labor will impact firms' appetites to invest in increased automation. An increase in the cost of labor, brought about from a higher minimum wage, would accelerate the development of automation. A further influx of labor from abroad or growth in atypical employment could keep the cost of labor low and reduce incentives to automate.

Societal acceptance

The pace of digitalization is highly contingent on the demand by society for greater connectivity and automation. If communities and unions decide to oppose the increased presence of automation or robotics within the workplace, the process will stall while widespread public support for new technologies will lower barriers to adoption. The development of artificial intelligence, and discussions surrounding its morality and dangers, are an example of this.

Cyber security

Increased use of digital tools, such as internet platforms and wirelessly connected devices, creates additional opportunities for data loss, tampering or interruptions of service. If the security of digital technologies can be increased to a level where businesses feel secure, digitalization is likely to occur quickly. If not, concerns about cyber security could reduce the use of robotics and connected systems within the workplace.

Attitude toward trade

Digitalization is in part driven by a growing demand for individualized products and services from international firms. A further deterioration in the global attitude toward trade would lower the need to adopt new technologies and limit the capital available to purchase them. However, if previous attitudes toward trade are readopted, demand for automation and electronic integration of services could increase.

Human vulnerability in relation to artificial intelligence (AI)

What do you see as the focus in the development of AI today, the replacement of human employees or the improvement of quality of life?

“Within the academic community, the focus tends to exist around a basic research interest, and a curiosity about how to make machines smarter and what machine intelligence can tell us about the nature of thinking. Then there are companies that research AI with specific aims in mind, and the end goal of using the technology for some sort of purpose. That purpose could be in some instances the replacement of workers with digital processes.”

Which jobs or careers do you expect being completely replaced by robots and AI between now and 2030?

“The transportation industry, through the advancement of self-driving cars, appears to be the most obvious answer. While it is unclear just how far the technology will advance by 2030, the current signs are very promising.

Another sector where automation seems poised to disrupt the status quo is in retail. Experiments such as Amazon Go, where automation and robotics have been brought into a traditional retail setting are very interesting, and their success will dictate how far that technology can

advance over the next 15 years. Online commerce might have a bigger impact on the retail sector over the short term than experiments to physically automate retail locations.”

How far away are we, technologically, from being able to automate work that is cognitive and performed by highly educated and specialized professionals?

“This depends on our definition of complex. Examining a chest X-ray is a good example of this. A doctor studies for years in order to properly interpret the exam, making it a high-skilled task, but it is fairly easy to automate, as it is entirely down to pattern recognition. These types of tasks are where we see automation and machine learning more capable of making an impact in the short-term.

In the long-term, we are likely to see the automation of highly cognitive and complex tasks when we reach the stage known as ‘AI complete’. That is to say, when everything can be automatable. This means that when the technology reaches a point where it can be used to solve a complex task, and the ability to solve that task demonstrates the ability of the machine to solve a larger and more general class of problems. This stage would represent a sudden jump in AI capabilities, from a stage where only some tasks can be completed, to a stage where all tasks can be completed this way.

What type of government involvement in the deployment of work-related new technologies would allow for safer and better outcomes?

“In the short-term, the focus for governments should be to create formal processes by which new automated technologies can be trialed and brought to market. It is important to have a regulatory process for this rather than doing it in a vacuum.

In the longer-term, we need a society-wide conversation about how if there is large worker displacement from automation, how those workers can be supported economically despite not producing value within the economy. The real aim should be to decide as a society how to distribute value created by artificial means.”

What are the pitfalls businesses need to avoid when considering how to develop and implement AI in the workforce?

“Within a business context, issues such as algorithmic discrimination come to mind. Even today we see embarrassing malfunctions of algorithms that companies are forced to apologize for. But going forward, making sure that when technologies are implemented they do not contain means of discrimination. Social media platforms provide another example of potential negative consequences in a business environment, specifically what type of criteria can you use for ads. You have these algorithms, and if you maximize them for predicative accuracy, they take into account factors that we as a society would probably not want included.

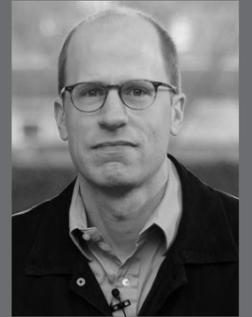
We need businesses to engage with the idea of how algorithms impact social outcomes, and this also requires the constant involvement of civil society in order to influence the discussion and identify what society thinks of as the right balance.”

How will the greater German emphasis on digital privacy affect how AI develops in that country?

“For current applications of digital technologies, access to large data sets is critical for a product to become commercially useful. This will also be the same for developing technologies such as self-driving cars, as businesses will need to be able to collect lots of road data on the car’s performances in order to not only prove their safety, but also to improve handling and efficiency. So, if laws were constructed so that you were unable to get that information from within Germany, businesses will be forced to get that information from somewhere else.

This also applies to the health care industry which, through personalized medicine, is using patient data in order to construct better health outcomes: this requires access to large data sets of patient information.

If German firms cannot develop the technology because of such laws, or develop ways around them through international activities or subsidiary firms in other jurisdictions, then this could hamper technological development within Germany.”



Nick Bostrom
Professor, University of Oxford and
Director, Future of Humanity Institute

In the long-term, we are likely to see the automation of highly cognitive and complex tasks when we reach the stage known as ‘AI complete’.



Germany

Scenarios on the Future of Work

Germany



The German labor force is expected to decline by approximately 3.5 million professionals between 2015 and 2030.

There are several factors that will shape how the global trends surrounding the Future of Work are realized in Germany. The country has a high-tech manufacturing sector, an educated workforce, and the largest trade surplus in the world. It also has one of the oldest populations in the world (with an average age of 46.8 years, just below Japan at 46.9 years), a position at the heart of the EU and an economy shaped by the large presence of SMEs, which employ 61% of workers but account for only 17% of exports as of 2013.²⁴ Germany's economy is also differentiated by its 'Mittelstand', known colloquially as 'hidden champions'. These are global leaders in the provision of intermediate goods and are a dominant force in the structure of the German economy.²⁵

Germany has sector-wide collective bargaining and strong unions. This same study suggests that the unions have worked to blunt the impact of automation in terms of jobs lost by negotiating lower wages in order to maintain levels of employment.²⁸

Automation in the manufacturing sector in Germany has already contributed to the reduction of middle-skill wages, while productivity gains have been realized by corporations and high-skill employees. As automation increases and unions come under additional pressure to protect their members, this trend is likely to grow in importance.

Current expectations of the Future of Work

In nearly every comparative international study, Germany has one of the highest percentages of jobs at risk to automation, this is thanks in large part to its sizeable manufacturing sector. Under a baseline scenario of linear productivity growth, Germany will continue to adopt automated practices in its manufacturing sector and its economy will accelerate its rebalancing toward services.

Individuals involved in atypical employment are also at a high risk of being replaced as the automation of manual tasks will reduce the overall need for part-time workers. This represents an area of potentially significant job loss, as atypical employment remains at an elevated level within Germany, with 20.7% of the labor force involved in those activities.²⁹

High exposure to digitalization means that the current literature on Future of Work forecasts large changes for Germany. The Federal Ministry of Labour and Social Affairs predicts that 750,000 jobs will be lost to digitalization by 2030, though these will be offset by one million new jobs in sectors that grow thanks to the creation and implementation of new digital technologies.³⁰ A study for the Federal Ministry of Labour and Social Affairs suggests that the losses will be seen in sectors such as public administration, mechanical engineering and retail, while gains will be made in business services, the social sector and IT services.

Foundations of the Future of Work

Germany's manufacturing sector is one of the sectors being disrupted most by digitalization, both positively and negatively. Industry accounted for 27.7% of total employment share in 2015.²⁶ This is considerably higher than the OECD average (22.5%), and that of similar European countries, such as France (20.1%), the United Kingdom (18.5%) and the Netherlands (15.2%). This shows that Germany is not only a country with a large manufacturing sector, but that the EU has enabled it to be the location for many of the continent's manufacturing clusters, giving it a higher degree of exposure as a country to any continent-wide changes in manufacturing.

Germany's industrial sector's employment share is expected to be 5.2 percentage points greater than the OECD average, increasing its vulnerability to automation.

Already, the impact of robotics in manufacturing has been substantial. According to a study by Dauth et al, each industrial robot replaces two manufacturing jobs.²⁷ From 1994 to 2014, about 275,000 manufacturing jobs in Germany were lost to automation. A similar number of jobs were created elsewhere, and in many ways the trend of a shrinking share of employment in industry mirrors global trends - with the major difference being that Germany began the current era with a large manufacturing sector, meaning that the shift has been more pronounced than the OECD average.

Interestingly, the same study finds that under a baseline scenario, Germany will gain 26,000 financial services jobs by 2030, but will lose 19,000 financial services jobs by that time in an accelerated digitalization scenario.³¹ That projection does not account for any additional gains in the financial services that Germany may see from jobs migrating to Frankfurt as a result of Brexit, which is so recent and uncertain that it has not been accounted for in the study and as such, is not factored into our analysis.

The German public tend to see themselves more as 'winners' of digitalization, creating space for pro-digital reforms.

There are no immediate major political or social threats to the ongoing digitalization of the German economy. An opinion poll found that the 54% of respondents in Germany saw themselves as 'winners' of digitalization, while only 16% saw themselves as 'losers'. That may indicate greater leeway for the Government to pass reforms to adjust to the Future of Work, as these would be seen as ensuring that the 'winners' gains are protected, rather than capturing wealth that should be distributed.³²

The German Government has adopted the Industry 4.0 initiative with business associations for development of the Government's high-tech strategy for industry. The strategy calls for a rethink of much of the current labor to account for digitalization, such as ensuring that employee data is protected, assessing whether employees should be obligated to undergo continuing education programs, and determining how the employment status of gig economy workers should be legally defined.

In addition to work on digital skills and ICT adoption, the German strategy has placed significant emphasis on data protection and the work environment. While this is not to say that there is no consideration of these issues elsewhere, Germany does seem to give these issues greater prominence and can be expected to raise them earlier in the process of digitalization than other countries might.³³ German concerns over data privacy in particular could impact this baseline scenario, as strict legislation that limits the usefulness of the Internet of Things could have far-reaching impacts for the pace of technological adoption within Germany.

Key macro drivers

With a government keenly invested in maintaining regulatory and social pace with the evolution of technology, the most important and uncertain trends for Germany are in the impact that such technology would have directly on the German economy. We have chosen to build our scenarios around three key trends that will Germany's socioeconomic outlook to 2030.

Machine learning: transformative or hype?

Machine learning, the process by which machines can improve their own operations, could radically increase productivity. Even in the most technically advanced business, people are still needed to monitor and upgrade machines. Through widely adopted and realized machine learning, Germany's annual growth rates may increase to 3.0% and the productivity of labor may grow 29%.³⁴

SMEs: nimble adopters or underfunded laggards?

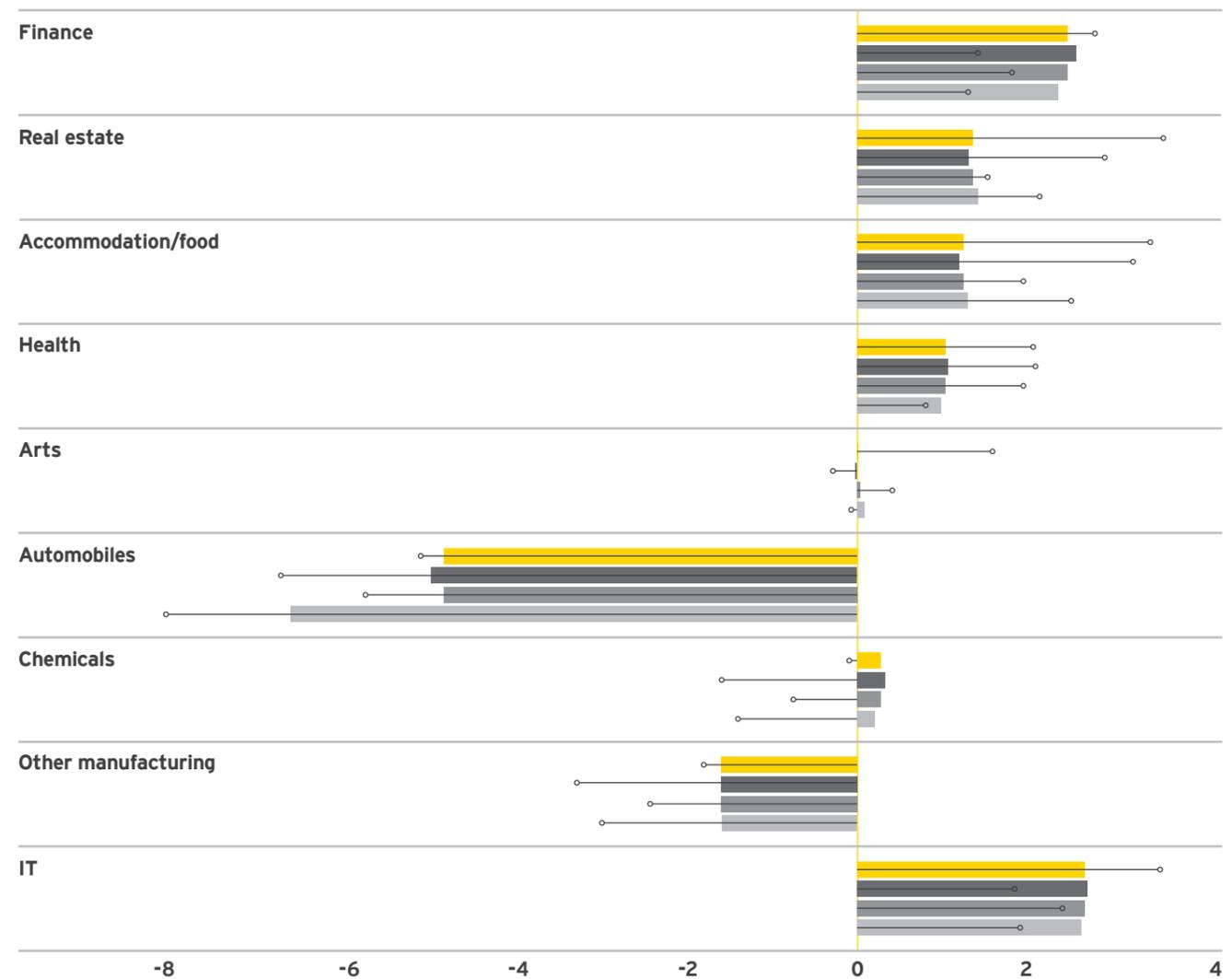
Technical upgrades require large capital expenditures and are most effective when used to create large economies of scale. This would suggest that SMEs would lose ground to larger firms, which have greater capital reserves and incentive to invest. Yet the act of transforming a large firm to fully embrace the Future of Work is itself an obstacle, with the presence of strong labor unions another challenge for large-scale adoption of technology. Therefore smaller firms, as a category, may be more able to take advantage of the latest technologies. In Germany, sectors with a high percentage of SMEs would suffer in the first scenario, and flourish in the second.

Self-driving cars

According to a report from a California think tank, self-driving cars could reduce demand for new vehicles by 70% in 2030 in the United States, with similar projections for other developed markets.³⁵ The German automotive sector in 2015 accounted for 20% of revenue for German industry and employed 983,000 people. If this sector were to see a global collapse in demand -

especially for its high-quality products which are exported to markets that would be among the first to adopt a self-driving model - the consequences would be extensive. Electric cars are also less labor intensive to produce. A rapid shift to non-fossil fuel vehicles could also create a sharp decline in employment.

Figure 3. Germany scenario comparisons for selected sector share of GDP and employment
Germany: Sector share annual change and employment annual change from 2015 to 2030 (%)



■ Baseline ■ 1: Big business boom ■ 2: Silicon Mittelstand ■ 3: Automatic autobahn □ Sector share ○ Employment
Source: Oxford Analytica

Baseline scenario

While the scenario planning process was designed to give greater breadth to the possible futures considered, it does not invalidate the importance of a baseline scenario. By determining what is likely to result from a continuation of the status quo with no major disruptions, we create a likely future and establish context for how other scenarios differ.

The baseline for the Future of Work in Germany sees the continuation of technological adaptation follow a similar pace as the previous 20 years, matched with predictions about the long-term overall economic growth and population change of these countries. In this model, we assume that Germany will have an average annual growth rate of 2.4% to 2030 and a total labor force 8.37% lower than in 2015.

German workforce will see a 8.37% decline by 2030.

In this scenario, we will see significant shifts in the size of sectors, as technological gains affect productivity differently across industries. Aside from major shifts in the macroeconomic environment, such as a collapse in demand for a certain product or particular export markets (which are not included in the baseline scenario), productivity is the best proxy variable for sectoral size and employment. It predicts how much value will be added by each sector and the number of workers that will be needed to create that much output.

Figure 4. Baseline: Selected sectors' share of German economy

Sector	2015	2030	Annual growth rate
Finance	4.1%	5.8%	2.4%
Health and social work	7.7%	8.9%	1.0%
Automotive manufacturing	4.7%	2.3%	-4.6%
Other manufacturing	1.5%	1.2%	-1.5%
IT	2.7%	3.9%	2.5%

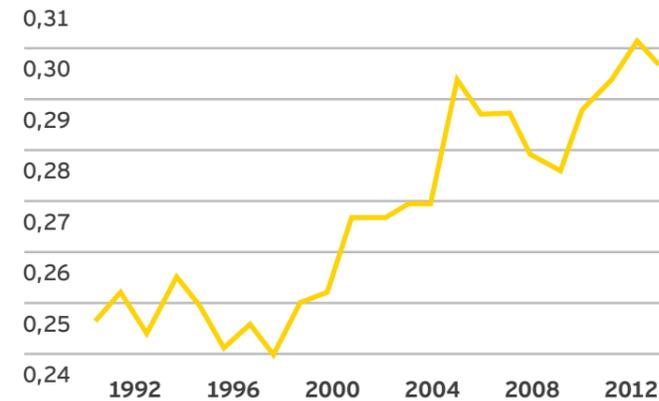
Figure 5. Baseline: Employees (thousands) in selected sectors

Sector	2015	2030	Annual growth rate	Net job gain/loss
Finance	1,187	1,754	2.6%	+567
Health and social work	5,518	7,373	2.0%	+1,855
Automotive manufacturing	983	465	-4.9%	-518
Other manufacturing	654	507	-1.7%	-148
IT	730	1,200	3.4%	+470

In the baseline scenario, existing trends continue, demonstrating a shift away from manufacturing to the service sector. Automotive manufacturing shrinks by half as a percentage of the economy and by number of employees, losing 518,200 jobs. The other manufacturing industry also sees a significant decrease in employment, losing 147,600 jobs.

The number of health and social workers increase. However, it should be noted that a key uncertainty for this sector is the amount of inequality in Germany. The Gini coefficient, which measures the income distribution within a country, is a mechanism by which that inequality can be measured. The above numbers reflect an extension of current levels of inequality to 2030, although recent history suggests that inequality in Germany may move on an upward trend. By lowering the Gini coefficient by 1 standard deviation, which implies a lower level of inequality within Germany, the number of jobs in the health and social work field increases by about one million, whereas an increase in inequality via the Gini coefficient lowers projected employment by 900,000, as people will be less able to afford those services. It is important to note that, even in a baseline scenario on the technological trends relating to the Future of Work, societal factors have a high influence on where that work will be performed.

Figure 6. Inequality measurement for Germany: Germany: Gini coefficient (net household income)



Scenario 1: Big business boom

In this scenario, machine learning has elevated productivity to levels significantly higher than they are currently, in fact, one standard deviation above current trends. This productivity is, however, largely the province of big business. Many Industry 4.0 technologies, from automated factories to just-in-time deliveries enabled by technologically-enabled supply chains, require large capital expenditures so the next decade sees larger firms gain much of the technology advancements.

These trends lead to rising world trade, as large firms are more likely to export and large firms represent about three-quarters of German goods and services exports to the rest of the world. This increase in exports creates a slight increase in the annual growth rate of the German economy from an estimated 2.4% to 2.5%.³⁶ This projection is, however, dependent on attitudes to trade both in Germany and in its major trading partners. Because Germany can only export to willing importers, and because many German products depend on international value chains, a growing global shift away from current trading standards would hurt the large firms dependent on foreign markets.

Figure 7. Big business boom: Selected sectors' share of German economy

Sector	2015	2030	Annual growth rate
Finance	4.1%	5.9%	2.4%
Accommodation and food service	1.6%	1.9%	1.1%
Health and social work	7.7%	9.0%	1.0%
Automotive manufacturing	4.7%	2.3%	-4.8%
Other manufacturing	1.5%	1.2%	-1.5%
IT	2.7%	3.9%	2.6%

Figure 8. Big business boom: Employees (thousands) in selected sectors

Sector	2015	2030	Annual growth rate	Net job gain/loss
Finance	1,187	1,754	2.6%	+567
Accommodation and food service	1,837	2,890	3.1%	+1053
Health and social work	5,518	7,373	2.0%	+1855
Automotive manufacturing	983	465	-4.9%	-518
Other manufacturing	654	507	-1.7%	-148
IT	730	1,200	3.4%	+470

In this scenario, finance and IT both see tremendous growth, increasing their share of the overall economy by more than 40% each from 2015 to 2030, while manufacturing shrinks as a share of the economy, following current trends.

This scenario sees a move away from employment in manufacturing (with a nearly two-thirds total drop in the automotive sector, equivalent to 620,000 jobs) towards real estate, accommodation and food and IT and information services. The chemicals sector sees the largest job losses in this scenario; the sector is expected to be about the same size, as a share of the economy as in 2015, but increasing productivity means that fewer workers will be required for the same amount of output.

The automotive manufacturing sector is expected to shed about two-thirds of its current number of jobs by 2030.

Given that the German labor force is expected to shrink by 2030, this will put heavy pressure on Germany to find workers for areas such as health and social work (1.88 million additional workers needed by 2030) and accommodation and food service (1.1 million additional workers needed by 2030),³⁷ creating strong incentives for Germany to adopt flexible working policies to increase the potential workforce and offer retraining programs for manufacturing workers who lose their jobs. A key uncertainty will be the levels of immigration to Germany to 2030, and how well immigrants are integrated into the German workforce to fill openings in service jobs that may require, like social work, a high level of cultural understanding.

Scenario 2: Silicon Mittelstand

In this scenario, technology dramatically boosts the productivity of SMEs (the German "Mittelstand"), but larger firms are overly cautious about deploying technology and capturing the gains of change. This leads to considerable productivity boosts in fields with a high share of output represented by SMEs, such as construction and real estate. It is also likely that the products that lead to considerably higher productivity for smaller firms, such as cloud computing, also apply to the health sector, permitting fewer workers to manage Germany's aging population than is needed in the baseline scenario.

Figure 9. Silicon Mittelstand: Selected sectors' share of German economy

Sector	2015	2030	Annual growth rate
Finance	4.1%	5.8%	2.4%
Real estate activities	10.9%	13.2%	1.3%
Health and social work	7.7%	8.9%	1.0%
Arts, entertainment and recreation	1.4%	1.4%	0.0%
Automotive manufacturing	4.7%	2.3%	-4.6%
Other manufacturing	2.7%	1.2%	-1.5%
IT	2.7%	3.9%	2.5%

Figure 10. Silicon Mittelstand: Employees (thousands) in selected sectors

Sector	2015	2030	Annual growth rate	Net job gain/loss
Finance and insurance	1,187	1,532	1.7%	+345
Real estate activities	467	580	1.5%	+113
Health and social work	5,518	7,259	1.8%	+1,741
Arts, entertainment and recreation	669	708	0.4%	+39
Automotive manufacturing	983	423	-5.5%	-560
Other manufacturing	654	462	-2.3%	192
IT	730	1,025	2.3%	+295

In this scenario, finance and IT see the largest employment gains of any of the non-baseline scenarios. This makes sense, as the adoption of advanced technology by SMEs will require considerable financial support followed by technical assistance to ensure that non-specialized workers at smaller firms understand how to use the new technology. This scenario is therefore highly dependent on SMEs having access to capital and on workers having a broad base of technical skills. A period of persistently low interest rates and increased government or business support for continuing education favor this scenario.

Access to capital for SMEs is a critical component in the wider adoption of new technologies.

Scenario 2 sees some productivity gains in the health sector, as efficient electronic records streamline the administration of health work, and artificial intelligence diagnostic systems enable doctors to see patients more efficiently. However, all productivity gains using electronic records is dependent on developing sufficient regulatory and cybersecurity protections, as health information is some of society's most sensitive data. Germany will have to grapple with the implications of protecting patient information in an environment where machine learning could help manage the strains of an aging population.

Scenario 3: Automatic autobahn

In this scenario, the self-driving car revolution has truly arrived. Demand for cars within Germany has dropped by 70% and world trade has fallen slightly as the auto sector stalls. While Germany is still holding onto some of its foreign export markets, its dominance in the premium automotive sector has proven to be a weakness, as its customers are the first to switch to a subscription service for their transportation needs, severely disrupting the expectations for the size of the sector.

This scenario depends on the key uncertainties of society accepting the shift to self-driving cars and the German Government passing regulations to encourage the adoption of self-driving cars domestically. If the German consumer opposes self-driving cars, the lack of a home market would hinder the ability for German car manufacturers to retool factories to produce cars for the larger export market. This scenario therefore assumes that the

German car industry supports the move toward self-driving cars and that Germany is one of the leading countries in its adoption. Nonetheless, employment will fall sharply in the German automotive manufacturing industry. While many jobs will be created in new sectors related to self-driving cars, or with resources that would have been spent on transportation, the need for fewer cars almost inevitably leads to a reduction in their manufacture.

German car manufacturers could lead the self-driving revolution, but Germany may lose out if the valuable components are mostly designed in California and China.

In scenario 3 the decline in the automotive sector has slightly reduced the volume of world trade and German self-driving cars and transportation-as-a-service. While the demand for automobiles may not drop as fast growth rates have faltered, from an expected average 2.4% annual growth rate to 2.3%. It is important to note that this is not certain if self-driving cars become ubiquitous - Germany could very well become a global leader in the area and find an even larger source of economic value.

However, it is a plausible outcome and highlights two dilemmas for Germany. First, self-driving cars will be wholly reliant on technological inputs, monitoring systems and data analysis. This means that Germany's automotive manufacturing clusters may be less important for the geography of the car's value than the technology companies working in the field that are currently clustered in the San Francisco Bay Area. Second, much of the merit in self-driving cars is that they are less expensive to operate and will free up resources for other consumer spending, reducing a self-driving country's spending on automobile transportation by as much as a quarter. It is implausible that there could be that much less money flowing into a sector without some shrinkage.

In addition to self-driving cars, productivity has increased for most sectors (in part due to the increased time available to workers in all sectors thanks to self-driving cars), though not as much as in the first two scenarios.

Figure 11. Automatic autobahn:
Selected sectors' share of German economy

Sector	2015	2030	Annual growth rate
Real estate activities	10.9%	13.3%	1.3%
Accommodation and food service	1.6%	1.9%	1.2%
Automotive manufacturing	4.7%	1.8%	-6.3%
Other manufacturing	1.5%	1.2%	-1.5%
IT	2.7%	3.9%	2.5%

Figure 12. Automatic autobahn:
Employees (thousands) in selected sectors

Sector	2015	2030	Annual growth rate	Net job gain/loss
Real estate activities	467	632	2.0%	+165
Accommodation and food service	1,837	2,612	2.4%	+775
Automotive manufacturing	983	295	-7.7%	-688
Other manufacturing	654	425	-2.8%	-229
IT	730	956	1.8%	+226

In this scenario, the automotive sector shrinks the most rapidly of all scenarios. However, it is important to note that the change is not as remarkable as might be expected. While automotive manufacturing employment drops by 70% (688,000 jobs) in a self-driving scenario from 2015 levels to 2030, it drops by 63% in Scenario 1, in which large firms see high productivity gains. This underscores how significant automation is to the car manufacturing sector under any plausible scenario.

Key takeaways

Decline of the auto sector

Across all scenarios, the automotive manufacturing sector sees dramatic declines, with employment falling by at least 50%. This is due to the tremendous productivity gains this sector has seen in the past two decades; even without a boost from machine learning in the baseline scenario, the sector employs less than half as many employees in 2030 as 2015. With the possible rise of self-driving cars cutting overall automobile manufacturing, Germany should be urgently looking for how to ensure that the employment car factories have traditionally provided is replaced.

Where are the workers?

The German labor force is expected to decline by approximately 3.5 million workers between 2015 and 2030. Yet in all scenarios, these key sectors will collectively add employment, ranging from 1.1 to 3.8 million new jobs. For the health, the accommodations and food services, and finance (the largest sectors by employee total), the question is by which pace will each grow. As the German population ages, questions around automation and employment may cease to be worries about unemployment, but about how to fill the many empty jobs that new industries are looking to create.

Support for SMEs

The differences between Scenario 1 and 2 are stark for many sectors. The real estate sector, with 74% of firms being SMEs, will require about 21% more workers if productivity gains are only captured by the largest firms. In a country with an expected tight labor market, this means that SMEs that do not enlist new technologies will find themselves severely constrained. Ensuring that smaller firms have access to the capital and training to embrace Industry 4.0 will be crucial to encouraging productivity growth and associated wage growth in the sectors that are most likely to add jobs underscores how significant automation is to the car manufacturing sector under any plausible scenario.

The automotive manufacturing sector sees less than half as many employees in 2030 under any scenario.



Digital transformation: threat or opportunity

What are the greatest challenges for firms to adopt new technologies?

“For established firms, probably the biggest inhibitor of digital transformation is their legacy. A lot of our customers are looking at a fragmented landscape of technology architectures and IT systems, that make it very difficult to adapt and transform in an agile way. And that sometimes lends itself toward short-term optimization rather than to more fundamental transformation. That has allowed digital native disruptors to come in and gain market share because incumbents were not able to adapt readily.”

Is there a geography or in an industry base where this transformation is happening more readily than in others?

“In terms of industries, digital transformation is hitting everyone across all the sectors. But it has started earlier in some industries, certainly earlier in B2C

than in B2B industries. Retail, utilities, financial services, and health care are the ones where digital transformation is most pronounced.

In terms of geography, a lot of trends in digitalization were born in the United States. That also has to do with the fact that the US is at the forefront of customer-facing process innovation. If you look at B2B scenarios, for example in digital manufacturing, the battle has not yet been won by any particular geography. Here, clearly Germany is trying to take a lead and there are many industrial players in Germany like Siemens and Bosch - also in partnership with SAP - who are among the leaders in this emerging space.

But when you look at the fundamental landscape, I think the German-speaking countries definitely have the scope and need to catch up, especially because the US and China are investing a lot of energy and funds into the next wave of digital disruptive capabilities.”

How do you look at this from the view of SMEs?

“For them, the opportunities and the challenges are maybe the biggest. From the opportunity perspective, SMEs lack two critical items with which digitalization can help them a great deal. They typically lack reach to new customers and they lack scale. If they can efficiently automate their processes based on digital capabilities, and find new ways to connect with more customers without stretching a limited sales capacity, they can unlock more market opportunities.

The second opportunity is that SMEs typically have fewer silos than you see in a large and complex organization. I am convinced that a lot of the build-up of their digital capabilities depends on a very close collaboration across different functions to create end-to-end transformations.

But there is a flipside to this as well, and one of the biggest challenges that I see German SMEs facing at the moment is that they are victims of their own current short-term successes. The German economy is booming and many SMEs have very full order books. For them to focus on the need to transform for the long-term while maintaining their very successful businesses running today is a real challenge.

Also, you have to be willing to take a bet and invest without being sure of a return. SMEs typically have tighter budgets to follow. I am a bit concerned that, especially in the German-speaking countries, where the Mittelstand has always been a key backbone of our prosperity and growth, we might be curtailed in our transformation to a digital economy by exactly those challenges, which are driven by the success of today.”

In order for these technologies to be successful, we need to have access to the right kinds of skill sets and talent. What are the skills that have to be prioritized?

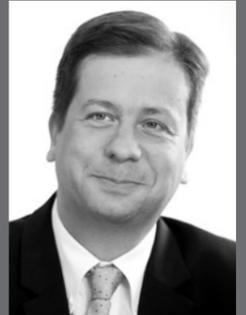
“Digital transformation will fundamentally reshape the landscape of skills and capabilities that we will need inside companies. To give you an idea of scale here, at SAP we have more than doubled our budgets for training and enablement in the last three years because we recognize that our employees need to refresh their knowledge in shorter time cycles, even though they are typically very IT- and technology-savvy people. There is clearly a need to adapt curricula as well. We are still living in a time when digital and IT-related skills are not a compulsory element of high school education in Germany. And it is not only about purely technical skills, it's also about the accompanying skills which need to be thought of differently. Social skills are all critical and they are not really part of the formal education system, which is still very much subject-matter-oriented today.”

What is or could the public sector role be in facilitating that transition?

“There are countries in which the public sector has been taking a very proactive and leading role in defining the parameters for digital transformation; unfortunately, they are mostly smaller countries like Estonia and Singapore. None of the three German-speaking areas - except for Austria a little - can be cited as best practice examples. It would not be helpful to take on digital transformation primarily from a reactive regulatory perspective. I would rather look at areas where this movement can be fostered and supported in terms of agility, for example, incentives to foster our R&D activities and innovation.”

What are the risks if we do not keep up with the digital transformation?

“Other states are taking digital transformation as a proactive opportunity. I have just come back from a business trip to Dubai, where His Highness Sheikh Mohammed bin Rashid Al Maktoum is following a new vision. That he calls “Area 2071” for the 100th anniversary of the UAE. He has emptied the huge luxury mall at the ground floor of The Emirates Towers, so that incubation space for start-ups can be created. He has mandated all of his public authorities to build a department there to work with the start-ups on new digital scenarios. He is personally inspecting their progress every 90 days. He has created the world's first Minister of AI position. We all need to realize that now is the moment to make sure that in Germany, Switzerland and Austria we can continue to enjoy the strong position we have built in the coming decades.”



Luka Mucic
CFO, SAP SE



In terms of industries, digital transformation is hitting everyone across all the sectors.

Switzerland

Scenarios on the Future of Work

Switzerland



Switzerland will have a growing working age population to 2030, unlike many of its peer countries.

As a knowledge-based economy, Switzerland is heavily dependent on industries such as finance, insurance and pharmaceuticals for economic growth. While it will undoubtedly see further automation in production and manufacturing, particularly within the food processing industry, the largest impact Industry 4.0 technologies might have on Switzerland is if they are used in areas where they have not been previously, such as financial services. This has the potential to disrupt the Swiss labor market, particularly if higher-wage professions see significant reduction in labor demand.

Foundations of the Future of Work

Switzerland maintains a positive business environment, with innovative firms and high levels of technology use. The country was ranked 7th by the World Economic Forum's Network Readiness Index, indicating that it has strong business foundations for the development and implementation of new technologies. Employment in knowledge-intensive activities is also quite high, with more than 52% of the workforce engaged in those roles. This positions Switzerland well in terms of digital human capital, as the workforce has already proven itself capable of meeting the knowledge and skill demands of new technologies.

Currently, 52% of the Swiss labor force is employed in knowledge-intensive roles.

The supply of talent with digital skills is also set to continue, as Switzerland has long been an attractive destination for high-skilled workers, providing the country with easy access to the global talent pool.³⁸ Labor-related immigration in Switzerland is four times higher than in Germany and Austria. Every fourth person living in Switzerland is an immigrant, with the majority coming from other countries within the EU.³⁹ These immigrants tend to be highly skilled, with their presence allowing firms the ability to fill the positions needed to maximize productivity growth from new technologies.⁴⁰

While Switzerland does not have a formal platform from which to discuss Industry 4.0 like Germany and Austria, it has established strong public funding tracks for new technologies. In 2017, Switzerland's Commission for Technology and Innovation (CTI) promised to promote research and development within the information and communication technology sector with investment of at least 30 million Swiss francs. The Commission has set up an Industry 4.0 network, to fund smaller companies engaging with these new technologies.⁴¹ The Swiss Government is also paying close attention to regulatory issues that might arise from new technologies, and is considering creating a test for evaluating the suitability of current regulations for Industry 4.0. These measures help to form the basis of a positive business environment for innovation and product implementation that can be built on as Industry 4.0 and digital technologies expand.

Current expectations of the Future of Work

With 61% of current jobs at a low risk of automation, Switzerland appears at first glance to be less at risk of suffering negative impacts from digitalization than both Germany and Austria.⁴² One report has estimated that 270,000 new jobs will be created in Switzerland by 2025 as a result of digitalization and automation.⁴³ The European Centre for the Development of Vocational Training in its 2016 Skills Forecast also predicts strong employment growth within Switzerland between now and 2025, with jobs for machine operators and assemblers, tasks normally associated with automation in Industry 4.0, estimated to grow by 14.8%. But these positive estimates do not tell the full story.

Switzerland is expected to see erosion of middle-skilled jobs as a result of technological progress. As in Germany and Austria, middle-skilled professions have been a significant part of the Swiss economic structure. But the share of middle-skilled jobs is decreasing in Switzerland while the demand for highly-skilled workers, particularly in technical industries, has continued to rise. This has seen growth in highly skilled industries, and a gradual reduction in the economic value add of middle-skilled jobs.⁴⁴

The current labor market for part-time work is expected to shrink as well. Part-time work is especially common in Switzerland, accounting for 36% of all jobs in 2015. Around 90% of these part-time roles are located within the service industry, with a high likelihood of automation, given the manual and routine nature of the work.

Similar to Germany and Austria, the advance of Industry 4.0 is expected to have varying regional impacts. The Swiss economy is highly differentiated by region, with different cantons often specializing in different industries. Some cantons, such as Bern, Basel and Zürich, have dominant tertiary sectors that are less likely to see widespread digitalization due to a lower potential for the automation of knowledge intensive tasks. Other cantons, particularly those that are relatively small, are more reliant on the secondary and primary economic sectors, and are thus more likely to see stronger impacts within the labor market.

Several smaller cantons such as Jura, Glarus and Neuenburg, have the highest percentage of jobs within the manufacturing sector, accounting for more than 30% of work in each region, which is more than 10% above the national average.⁴⁵ While normally a cause for concern, as traditional manufacturing roles are considered to be under threat from automation, Neuenburg and Jura also possess the highest percentage of high-tech jobs in Switzerland as a percentage of total cantonal employment, potentially alleviating any negative labor market effects of automation; while one sector might decline in employment, another is likely to grow.⁴⁶

The varying prevalence of SMEs within the Swiss economy is also likely to create another regional divide as Industry 4.0 takes hold. In northern Switzerland and the Lake Geneva region, a greater share of employment is with large businesses, while cantons in the south have 90% or more of employment provided by SMEs. As SMEs tend to have more limited access to capital and are less likely to automate early, it is possible that southern Swiss cantons, particularly Wallis, Tessin and Graubünden, will feel the impact of digitalization more slowly than those that have a higher concentration of capital and large enterprises.⁴⁷

Key macro drivers

As an advanced economy with a highly skilled workforce, the greatest trends and uncertainties for Switzerland are the potential of automation to replace, instead of augment, high-skilled jobs, and the level of government support necessary for Swiss firms to stay competitive. We have built our scenarios around those two key trends.

Potentially, 1.35 million Swiss jobs are at high risk of automation.

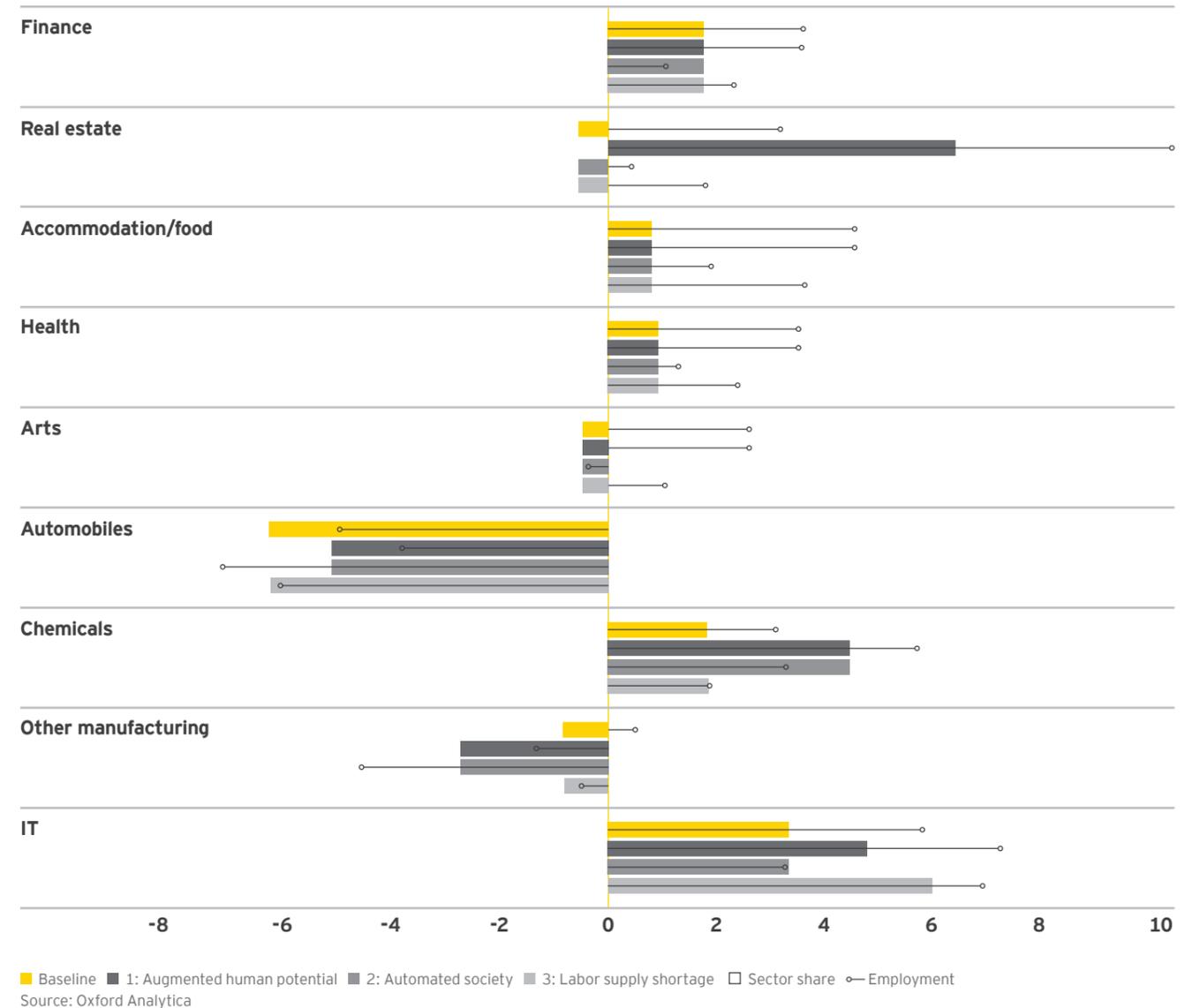
Automation vs. augmentation: where does the future lie?

Fears around job loss as a result of Industry 4.0 are widespread, but there are competing views of how technology could impact workers. According to a study that combined the Frey and Osborne methodology with Swiss labor statistics, some 1.35 million Swiss jobs are at a high risk of automation.⁴⁸ But this methodology equates tasks to jobs, leaving no room for augmentation of work. Augmentation allows for some tasks to be automated, while workers use their additional time to accomplish more complex and productive work. This would reduce the negative employment effects of technology-driven productivity gains.

Government support: engaged or distant?

The creation and adoption of new technologies is not purely a free-market activity, with government funding for research, education and infrastructure an important aspect of creating a favorable business environment for new technologies. While the presence of strong government support can reduce barriers to technological adoption, the absence of government support, where businesses are left to fund their own improvements in human capital or infrastructure, reduces firm investment in other activities and dampens the pace at which new technologies can be adopted.

Figure 13. Switzerland scenario comparisons for selected sector share of GDP and employment
Switzerland: Sector share annual change and employment annual change from 2015 to 2030 (%)



Baseline scenario

The baseline for the Future of Work in Switzerland sees the continuation of technological adaptation at the same pace as the previous 20 years, matched with predictions about the long-term overall economic growth. In this model, we assume that Switzerland will have an average annual growth rate of 3.1% in 2030, and will see an annual average growth rate of 1.7% in government expenditure. The economic growth rate is modeled from a pooled cross-sectional regression on 133 countries in the years 2007 and 2017. The virtue of this approach is the reduction of estimation bias due to, for example, variable mismeasurement. It also helps to balance one of the dilemmas of long-term economic forecasting: placing too much emphasis on recent performance.

Switzerland's work force is expected to grow by 3.31% by 2030. With much of this growth coming from skilled immigration.

For Switzerland, this is particularly relevant given the general European slow growth since the 2008 financial crisis and the 2015 unpegging of the franc from the euro. While a 3.1% GDP growth rate might seem optimistic, it reflects in part that Switzerland will have a growing working age population to 2030, unlike many of its peer countries.

Figure 14. Baseline: Selected sectors' share of Swiss economy

Sector	2015	2030	Annual growth rate
Automotive manufacturing	0.6%	0.2%	-5.9%
Chemicals	7.0%	9.1%	1.8%
Finance	12.1%	15.6%	1.7%
IT	2.9%	4.7%	3.2%
Other manufacturing	1.2%	1.1%	-0.8%
Real estate	1.3%	1.2%	-0.5%

Figure 15. Baseline: Employment (thousands) in selected sectors of Swiss economy

Sector	2015	2030	Annual growth rate	Net job gain/loss
Automotive manufacturing	15	7	-4.8%	-8
Chemicals	71	111	3.0%	+40
Finance	221	370	3.5%	+149
IT	84	190	5.6%	+106
Other manufacturing	47	52	0.6%	+5
Real estate	45	70	3.1%	+25

In the baseline scenario, we see strong growth in industries that require a high level of digital skills or education, such as IT, finance and chemicals, including the life sciences. This fits in line with the overall paradigm of Industry 4.0. These industries are also highly clustered within Switzerland, creating strong regional effects for Basel, Zürich and Geneva. As Switzerland's labor force is expected to expand by 3.31% by 2030, making it the only country within the study with a growing supply of labor, the majority of these new workers are likely to congregate in these regions, given the strong job growth they will produce.

On first glance, it seems Swiss manufacturing sectors fare less well, with the automotive industry shrinking by almost two-thirds in terms of its overall sector size. This would also be in line with the traditional narrative. When viewed in detail, however, while the automotive sector does struggle, other manufacturing sectors increase their levels of employment, and only see a relatively small decrease in their share of GDP. The loss in share of GDP is less a sign of a struggling sector, and more an indication that other sectors are merely growing at stronger rates. Total manufacturing in fact increases, displaying an annual growth rate of 1.63% over the model period, and its productivity almost doubles in terms of output per worker during the same period.

Scenario 1: Augmented human potential

For this scenario, we envision increased levels of government support for education, research and development (R&D), and advanced infrastructure, creating a favorable business environment for Industry 4.0 to take hold. We also assume that digitalization leads to augmentation instead of automation, creating industries that see high productivity gains and strong job growth.

Empirically, there are two industries within already developed economies that have previously shown the ability to become significantly more productive while increasing employment: the IT and real estate sectors.

To model these effects, we increased the efficiency gains within the IT and real estate sectors to mimic the need for expansion and productivity growth. We then put these in line with past industry performance for productivity and employment growth. We also held the development of the other industries to the linear progression seen in the baseline model. To account for high R&D spending, we increased the amount of investment in the economy.

The major uncertainty for this scenario is the ability of the Swiss Government to create a regulatory system whereby rules are put in place early that harmonize with the standards set by the EU and the United States, so that a favorable business environment for Industry 4.0 can be established.

Figure 16. Augmented human potential: Selected sectors' share of Swiss economy

Sector	2015	2030	Annual growth rate
Automotive manufacturing	0.6%	0.3%	-4.7%
Chemicals	7.0%	13.1%	4.3%
Finance	12.1%	15.6%	1.7%
IT	2.9%	5.7%	4.6%
Other manufacturing	1.2%	0.8%	-2.6%
Real estate	1.3%	3.1%	6.1%

Figure 17. Augmented human potential: Employment in selected sectors of Swiss economy

Sector	2015	2030	Annual growth rate	Net job gain/loss
Automotive manufacturing	15	9	-3.7%	-6
Chemicals	71	159	5.5%	+88
Finance	221	370	3.5%	+149
IT	84	231	7.0%	+147
Other manufacturing	47	39	-1.3%	-8
Real estate	45	186	9.9%	+141

This scenario shows strong growth in sector size for the IT and real estate industries. The IT industry remains the largest beneficiary, as its services are applied throughout the economy. With jobs augmented instead of automated, the industry transfers its productivity gains into new workers, which is why its employment grows so strongly. The real estate industry, which measures the economic output of buying and selling of commercial and residential properties, also sees strong growth. It must be noted, however, that the effect seen in the real estate sector is most likely overstated, as such strong employment growth in the industry in such a short period of time seems unlikely.

Through augmentation, the IT industry transfers its productivity gains into new workers, creating strong employment growth.

Growth of this size is, however, not unprecedented within the EU-KLEMS database, meaning that growth of this scale is indeed possible. Nevertheless, as productivity for the real estate sector grows relatively modestly within the model, it is conceivable that this substantial increase in employment is represented more in part-time, rather than full-time work.

The increased R&D spend in addition to high investment in education also produces add-on effects for the chemicals industry, which relies on a highly skilled workforce and significant investment in new products in order to grow. The favorable business environment created from government support gives the industry the right conditions to become an even larger sector. Regionally, this situation would have strong implications for Basel, which houses Switzerland's largest life science companies.

The rate of job loss in manufacturing industries is also slowed as a result of augmentation. While the automotive sector sees a sharp decline in employment, other manufacturing is able to protect more jobs as a result of the increased R&D spending, as well as improved infrastructure.

Scenario 2: Automated society

In Scenario 2, we continued to assume that there is increased government support for education, R&D and advanced infrastructure, which forms the basis for a favorable business environment for Industry 4.0. However, we switched our paradigm to allow for the automation of automation of jobs instead of augmentation, which equates to falling levels of employment across many sectors due to rapidly increased productivity.

To effectively show this scenario, we equated the productivity growth for the sector by its probability for automation. Sectors with less than a 30% chance of probability for automation received a 0.5 standard deviation in productivity growth. Sectors with between a 30% and 60% probability of automation received 1 full standard deviation increase in productivity growth, and sectors with a greater than 60% chance of automation received a 1.5 standard increase in productivity. This means that finance, real estate, health and social work, arts and entertainment, chemicals, and IT all experienced single standard deviations of productivity growth, while accommodation and food service, automotive, and other manufacturing saw a 1.5 standard deviation increase.⁴⁹ We also continued to factor in higher levels of investment in order to simulate the better business environment.

Societal acceptance and cybersecurity are the largest uncertainties impacting this scenario. For automation to fully take root, particularly in industries such as real estate and

health, individuals have to become comfortable replacing human interaction with robotics and digital processes. An economy that becomes heavily automated is also further exposed in terms of cybersecurity. If information cannot be secured on digital platforms, industries such as health and life sciences are less likely to automate.

Figure 18. Automated society: Selected sectors' share of Swiss economy

Sector	2015	2030	Annual growth rate
Automotive manufacturing	0.6%	0.3%	-4.7%
Chemicals	7.0%	13.1%	4.7%
Finance	12.1%	15.6%	1.7%
IT	2.9%	4.7%	3.2%
Other manufacturing	1.2%	0.8%	-2.6%
Real estate	1.3%	1.2%	-0.5%

Figure 19. Automated society: Employment (thousands) in selected sectors of Swiss economy

Sector	2015	2030	Annual growth rate	Net job gain/loss
Automotive manufacturing	15	5	-6.8%	-10
Chemicals	71	114	3.2%	+43
Finance	221	260	1.1%	+39
IT	84	126	2.8%	+42
Other manufacturing	47	24	-4.4%	-23
Real estate	45	48	0.5%	+3

As expected, this model led to far more muted employment growth than either the previous scenario or the baseline, which accounted for more modest increases in productivity. Manufacturing industries saw strong drops in employment and in their share of GDP, while high-skill industries saw job growth despite the strong increase in productivity. Areas outside manufacturing where manual and routine work is common, and should be easily automated, saw somewhat different results. The accommodation and food service industry recorded a growth in employment by more than 30%, despite automation.

In a scenario with high levels of automation, high-skill industries such as chemicals, continue to thrive.

Even in a scenario that accounts for automation, there are sectors that illustrate strong growth in employment. Chemicals, and the life sciences in particular, are the greatest demonstrators of this effect. The industry's share of GDP almost doubles, in this scenario it would employ 60% more people in 2030 than in 2015, and its real value-add would increase by almost 200% over the same period. While this particular example would imply strong economic growth for the Basel region, it is also relevant within the IT sector, which is geographically diverse within Switzerland.

Scenario 3: Labor supply shortage

In this scenario, we assumed that government support for education, investment and research remains the same as in 2015. We also estimated that digitalization led to augmentation in some industries, creating a demand for skilled labor to further increase productivity growth.

To model this, as a proxy for holding R&D as well as infrastructure spending as a constant, we cap inward Foreign Direct Investment (FDI) at its current level. We also see increased productivity growth across the board as a result of augmentation, which we modeled by increasing each industry's productivity by 0.5 standard deviation above the baseline model. This allowed us to simulate the employment demand for industries that are becoming more productive, but still require human labor to grow. We also included an expansion of IT services, as they are necessary in order to allow augmentation to function correctly.

The key uncertainties within this scenario are artificial intelligence and access to capital. As the scenario relies on augmentation the availability of AI, which would produce pressure to automate, could dampen the impacts from human productivity growth. Without an increased investment environment, particularly in the form of government support, the cost to firms for implementing Industry 4.0 technologies increases, potentially delaying their adoption.

Figure 20. Labor supply shortage: Selected sectors' share of Swiss economy

Sector	2015	2030	Annual growth rate
Automotive manufacturing	0.6%	0.2%	-5.9%
Chemicals	7.0%	9.1%	1.8%
Finance	12.1%	15.6%	1.7%
IT	2.9%	6.7%	5.7%
Other manufacturing	1.2%	1.1%	-0.8%
Real estate	1.3%	1.2%	-0.5%

Figure 21. Labor supply shortage: Employment (thousands) in selected sectors of Swiss economy

Sector	2015	2030	Annual growth rate	Net job gain/loss
Automotive manufacturing	15	6	-5.8%	-9
Chemicals	71	94	1.9%	+23
Finance	221	310	2.3%	+89
IT	84	221	6.7%	+137
Other manufacturing	47	44	-0.5%	-4
Real estate	45	58	1.8%	+13

While the expansion of IT services in order to enable augmentation led to strong growth within that sector, both in terms of its share of GDP and overall employment, other sectors showed much more restrained growth in comparison to other scenarios, including the baseline. Industries such as chemicals saw the same growth in GDP share as in the baseline scenario, but only added slightly more than 50% of the workers. While this outcome for chemicals would lead to a strong regional impact for Basel, the overall decrease in the level of employment growth would have national implications.

Total job growth in Switzerland in a scenario with a restricted labor supply will be 554,000.

As in Scenario 1, augmentation appears to also have different impacts across the manufacturing sector. Once again, the model illustrated strong job losses within the automotive sector, yet relatively minor ones in other manufacturing. This would result in other manufacturing undergoing a slow decline in its economic share, while the automotive industry would revert back close to the minor economic share it held in 2000.

Overall, this scenario demonstrates the importance of a favorable business environment for employment growth in the face of technological change. Even though employment growth is relatively limited, more than 250,000 jobs are still added in the sectors shown, and 554,000 jobs added in total.

Key takeaways

Bright future for Swiss chemicals

The chemicals industry, which includes the Swiss life science and pharmaceutical sectors, demonstrated consistently strong growth throughout every scenario. Even within the most conservative estimates, the industry experienced 30% growth in its share of GDP between now and 2030. Growth estimates for employment were equally strong. These findings highlight the changing nature of the Swiss economy and the growing importance of high-skilled professions that are non-automatable. The Swiss chemicals industry looks poised to be a key driver of economic growth throughout Industry 4.0.

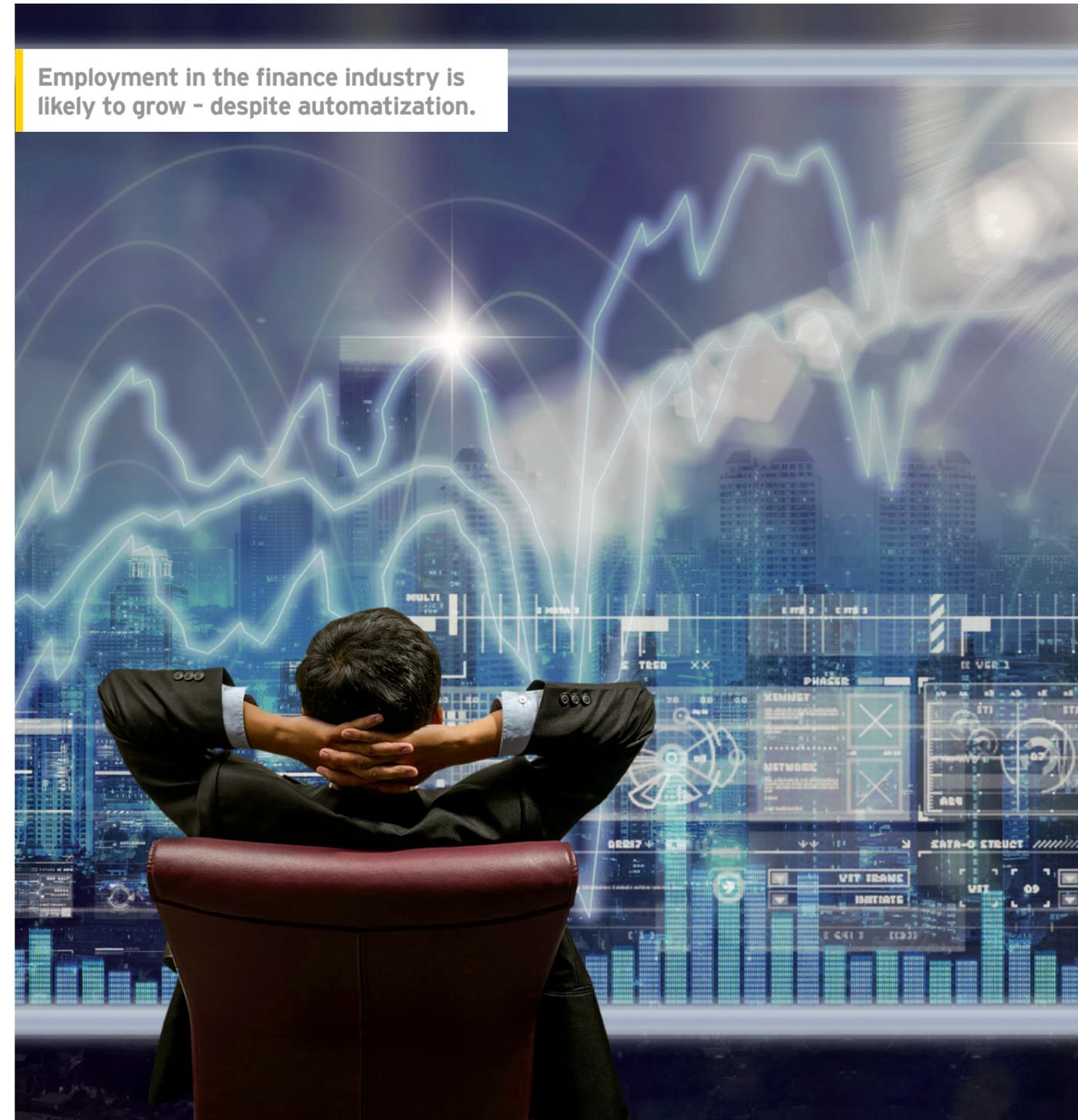
Banks continue to grow

Much has been written about the finance industry within Switzerland and if it is susceptible to significant automation. While there are concerns that some jobs will leave or be replaced by machine learning, the econometric scenarios we have designed show that the industry is set to grow despite the process of digitalization. In every scenario we outlined, financial services saw its share of GDP increase, to levels closer to what was seen in 2000. Employment is also set to grow, with some scenarios showing greater than 2% yearly job growth. In short, the demise of the Swiss finance industry has been prematurely reported.

Governments cannot remain idle

One of the macro drivers for Switzerland was strong government support, which includes investment in infrastructure, education and R&D. The outcomes of the scenarios reflect the importance of this variable and the currently favorable position of the Swiss economy given its high degree of network readiness and the influx of skilled immigrants. This position is not guaranteed to continue, however. Currently, the Swiss Government has provided funding streams for Industry 4.0 technologies, but has not yet brought together public and private sector players to discuss appropriate policy responses. More should be done to form a constant dialogue around these issues to help maintain the country's comparable advantage.

Employment in the finance industry is likely to grow - despite automatization.



Digitalization: an institutional perspective

The coming wave of digitalization, commonly called Industry 4.0, is poised to radically alter the mechanics of work. How has society reacted to similar significant technological advances in the past?

“We have already had several waves of profound technological change, the most fundamental being the initial period of industrialization. One reaction has been to move workers to expanding sectors and oftentimes, sectors that are expanding are not necessarily modern ones.”

For example, when trains were first introduced the number of horse carts exploded. While trains increased wholesale distribution, there was still a need to deliver goods more locally. This led to growth in what was already an old industry. A similar reaction occurred with the invention of cotton spinning, when a bottleneck existed in cotton weaving.

These transitions allow people to be sheltered in neighboring industries.

A modern example of this effect is in the logistics industry. The rise of e-commerce has led to substantial growth in the number of warehouse employees and truck drivers. When digitalization started everyone thought that these posts would evaporate, but the parcel business has exploded, increasing demand for people to deliver these goods.”

How can workers best prepare themselves for this workplace transition?

“Workers need to accept that education no longer ends when you leave school, and that you must educate yourself permanently. German speaking countries have a tradition of vocational training as well as university pursuits, creating multiple paths for getting a degree. This makes the workforce more flexible.

Early in their career, people should change jobs as often as possible, so that they can experience many different kinds of work. Once a person reaches a certain age, it becomes more difficult to change your job. If you change often, you learn new skills more easily as you learn to adjust to new working environments. This is a positive trend and it will help individuals react to structural change.

For older individuals it is very difficult, as a future employer has no idea what you are capable of doing besides the one skill you have previously demonstrated. Even if you are well educated and successful, changing your field is still very hard. Employers are not satisfied with a diploma, they want proof of skills.”

What can government and businesses do to prepare the next generation for a future that is changing evermore rapidly?

“I don’t believe that we will see a new form of institutional change. Education and social security are both still entirely relevant; we can adapt them to fit within the modern context, but structurally they will be the same. By having employment insurance, you also have means to encourage people to take courses and relocate to areas where there are jobs.

Those three programs - education, social security and employment insurance - are the three options that we have. Employment insurance itself acts as a means of a universal income as it ensures everyone receives some form of income. While I applaud Finland and Canada for trialing universal insurance, even if we adopt it, it is not a paradigm shift.

There is a tendency to look for new solutions, but a much more impactful strategy would be to work on existing institutions and adjust them to the current

environment. Things such as digital schooling, even for just an hour or two a week in a primary school environment, which combines theory and practice, would do a lot to advance these skills at an early age.”

There exists a strong gender imbalance in high-tech industries. As digitalization continues and these sectors become even more structurally important, what can be done to correct this imbalance within the workforce?

“Society is currently navigating through a double gender divide. The workplace remains male dominated, yet in education female students now make up the clear majority in universities and are the majority of higher performing students. There are clearly fundamental flaws with a system that still shows the some students, mostly female students, are less successful professionally, while the male students who don’t perform as well in school then succeed in the workplace.

In Switzerland, it is clear that schools are too tilted towards languages. Digital skills generally are not taught and male students who are interested in these fields are eliminated by the Gymnasium system, which leads to a shortage of male workers with those qualifications as they didn’t perform well in that school system. Meanwhile, there is also a shortage of female workers as they aren’t as interested in these subject areas at present. Sooner or later this will change, but we need to do more to realize the potential in both sexes.”

How do you think politics might change in response to workplace changes?

“For labor parties and social democrats, Industry 4.0 and the diversification of the workplace will make it much more difficult to organize workers. We have seen this shift ever since economies transitioned into the tertiary sector.

In my opinion, an unholy alliance has developed between governments and digitalization; the control systems in place now are counterproductive, but serve as a temptation for every government. Each government agency now uses a new software system, but the results in terms of productivity are discouraging. This will impact politics because it gives the bureaucracy opportunities to interfere with public or private life.

There also exists another wave of regulation that is also counterproductive. Globalization today isn’t so much about tariffs or transport costs, it is about standardization. The issue is that the global agreements on standards are not really democratically controlled, but are instead agents of bureaucracy, making it hard for individual governments and parliaments to say no to these international compromises.”



Tobias Straumann
Senior Lecturer, University of Zurich



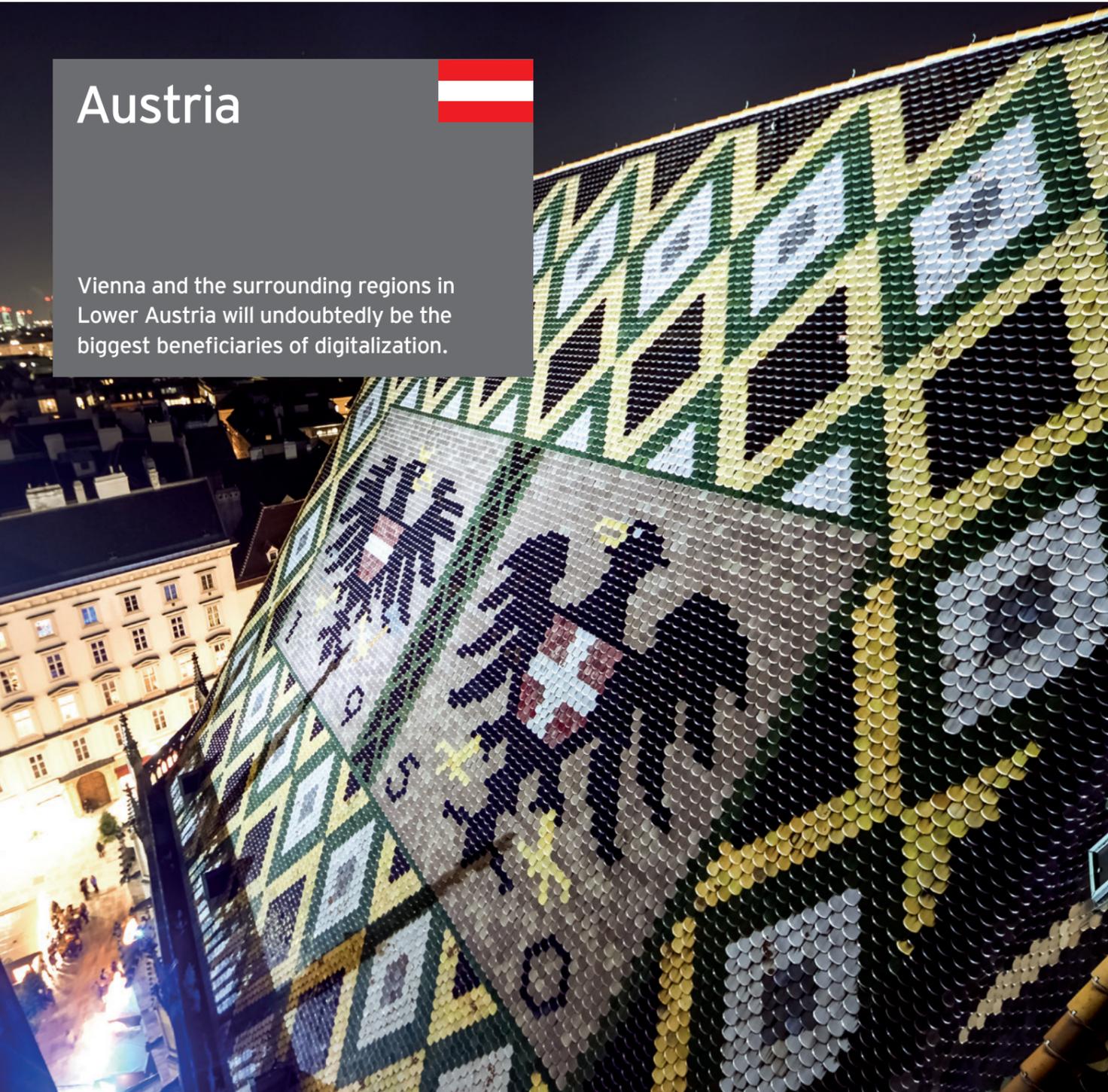
Austria

Scenarios on the Future of Work

Austria



Vienna and the surrounding regions in Lower Austria will undoubtedly be the biggest beneficiaries of digitalization.



Austria's economy is structurally similar to that of Germany, with strong unions, a high proportion of SMEs and important 'hidden champions' within the heavy industry and manufacturing sectors. Unlike Germany, which is not reliant on any single trading partner, Austria's economic wellbeing is heavily tied to that of its northern neighbor. Germany consumes 30% of Austrian exports and provides more than 35% of imports.⁵⁰ This uneven trading relationship is likely to create subsidiary effects on the Austrian economy, as German economic performance will influence demand within Austria.

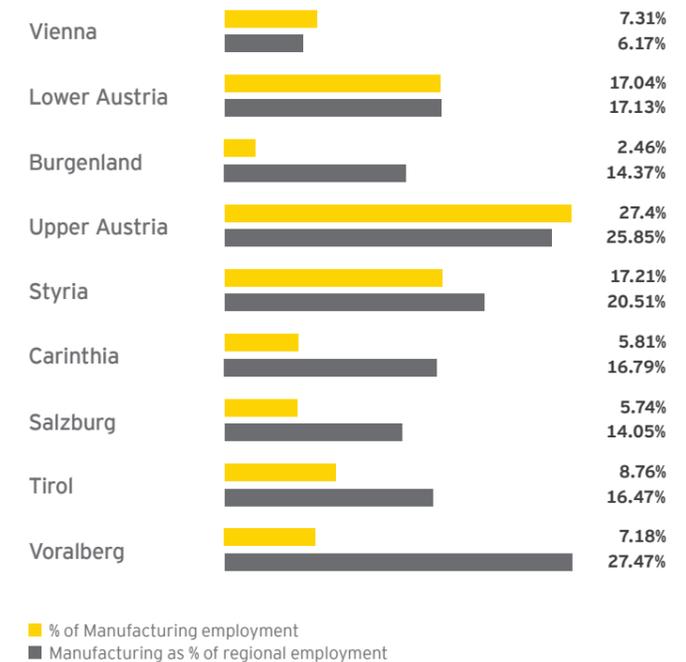
Austria is ranked as one of the top five countries globally for manufacturing production and efficiency, giving it a strong base from which to implement Industry 4.0.

Foundations of the Future of Work

Austria is well positioned to adopt new technologies, and is considered to be a global leader in the integration of new production methods, particularly in industry. The Bloomberg Innovation Index rated Austria as one of the five top countries in the world for efficiency in manufacturing production and overall capacity in 2017. The Roland Berger Industry 4.0 Readiness Index also found Austria to be one of the countries best able to implement production changes brought about by new technologies.⁵¹ This means that Austrian manufacturing, which accounts for almost 17% of national employment, 19% of value add and roughly two-thirds of exports, is well positioned to maximize productivity gains from Industry 4.0.⁵²

Austria also possesses well-developed regions and a strong correlation exists between regions that have high levels of productivity and those that already have high levels of digitalization.⁵³ Salzburg, Vienna and Vorarlberg already have comprehensive digital infrastructure. Vienna in particular is well positioned for the growth of digital technologies, as it houses the country's telecommunications industry, generating over €20b in value annually. The wider Vienna region includes more than 8,000 domestic and international IT firms, which represent 75%

Figure 22. Location of manufacturing in Austria
Distribution of Manufacturing in Austria



of the total industry in Austria.⁵⁴ Conversely, Upper Austria and Styria are the most industrialized regions of the country, with the highest percentage of businesses in the mining and machinery industries. As a result they are the most exposed to automation programs.⁵⁵

An educated workforce is necessary for a country to be able to embrace digitalization and implement Industry 4.0 effectively and this is an area where Austria is improving. A study conducted by the OECD showed that Austrian adults scored the highest in problem-solving in technology-rich environments. The survey also indicates that Austria's digital human capital is likely to steadily improve as more young people enter the workforce.⁵⁶ Austria is also producing the fourth largest number of STEM graduates in the EU per capita - another positive trend in the supply of human capital.⁵⁷

Current expectations of the Future of Work

Most existing studies conclude that considerable numbers of jobs will be lost within Austria, particularly those that have tasks that are easily standardized. There is also widespread agreement that the task-based composition of work in Austria will change as digital technologies reduce the need for workers to spend time on manual tasks. The mining, construction and service sectors are most at risk of automation, with heavy industry also likely to be negatively impacted.

Somewhat unique to Austria is that the country is expected to maintain a key component of its current economic structure: the presence of middle-skilled workers including skilled craftsman, clerks and trained service workers. While the use of digital technologies and machine intelligence has been interpreted as bringing about a three-speed economic structure of the better employed, underemployed and the unemployed, Austria is unlikely to see such a polarized economic system between high- and low-skilled workers. A strong supply of middle-skilled workers will keep the current skills structure roughly intact, with unique education programs such as short-cycle degrees in STEM subjects, helping to keep the Austrian workforce educated and not bifurcated (though OECD data found that Austria lost the highest percentage of middle-skilled jobs from 1995 to 2015, at 16.8%).⁵⁸

Slow transition
Austrian business leaders believe that a slow adoption of digitalization and Industry 4.0 technologies is the most likely path of development for the country.

There is not yet consensus on how extensive the potential job losses could be. A study which applied the Osborne and Frey methodology to Austria suggests that up to 54% of tasks within Austria are at a high risk of becoming automated, while the OECD estimates that only 12% to 13% of jobs (a key distinction from tasks) are at a high risk of being lost to Industry 4.0 technologies, the same rate as in Germany. The lowest predicted job automation rate for Austria is 8.5%, equivalent to some 319,000 jobs.⁵⁹

In a study by the Federal Ministry of Innovation, four possible scenarios for digitalization in Austria were discussed: being an Industry 4.0 front-runner; undergoing a slow transformation; a model focused on efficiency gains; and a digital collapse. While most business leaders want to achieve the front-runner scenario, the slow transformation was deemed the most likely outcome for Austria, based upon its economic history. According to a study cited below from the Austrian Institute of Economic Research, a slow transition within the country is already taking place.

The Austrian Government, like Germany, has adopted an Industry 4.0 initiative that pairs business interests with government support and funding. The country is investing heavily in an attempt to better equip the economy to handle the effects of digitalization, with €1b in subsidies for new broadband infrastructure already set aside, which is likely to help create 14,700 jobs within the telecommunications industry. The long-term structural effect will be even greater, as every 1% increase in ICT employment is estimated to correspond to a 0.3% to 0.4% employment increase in total employment.⁶⁰ The Government also hopes to increase its own R&D spending to 3.76% of GDP by 2020, as a means of prioritizing innovation.

Austrian firms are also aggressively pursuing investment in new technologies, currently investing in digital technologies at a rate of 4.1%, higher than the GSA regional average of 2.7%.⁶¹ Austria still lags behind, however, in terms of infrastructural investment, with investment in ICT at around €100 per person, significantly behind investment seen in neighboring countries such as Switzerland, which invests €500 per person.⁶²

Key macro drivers

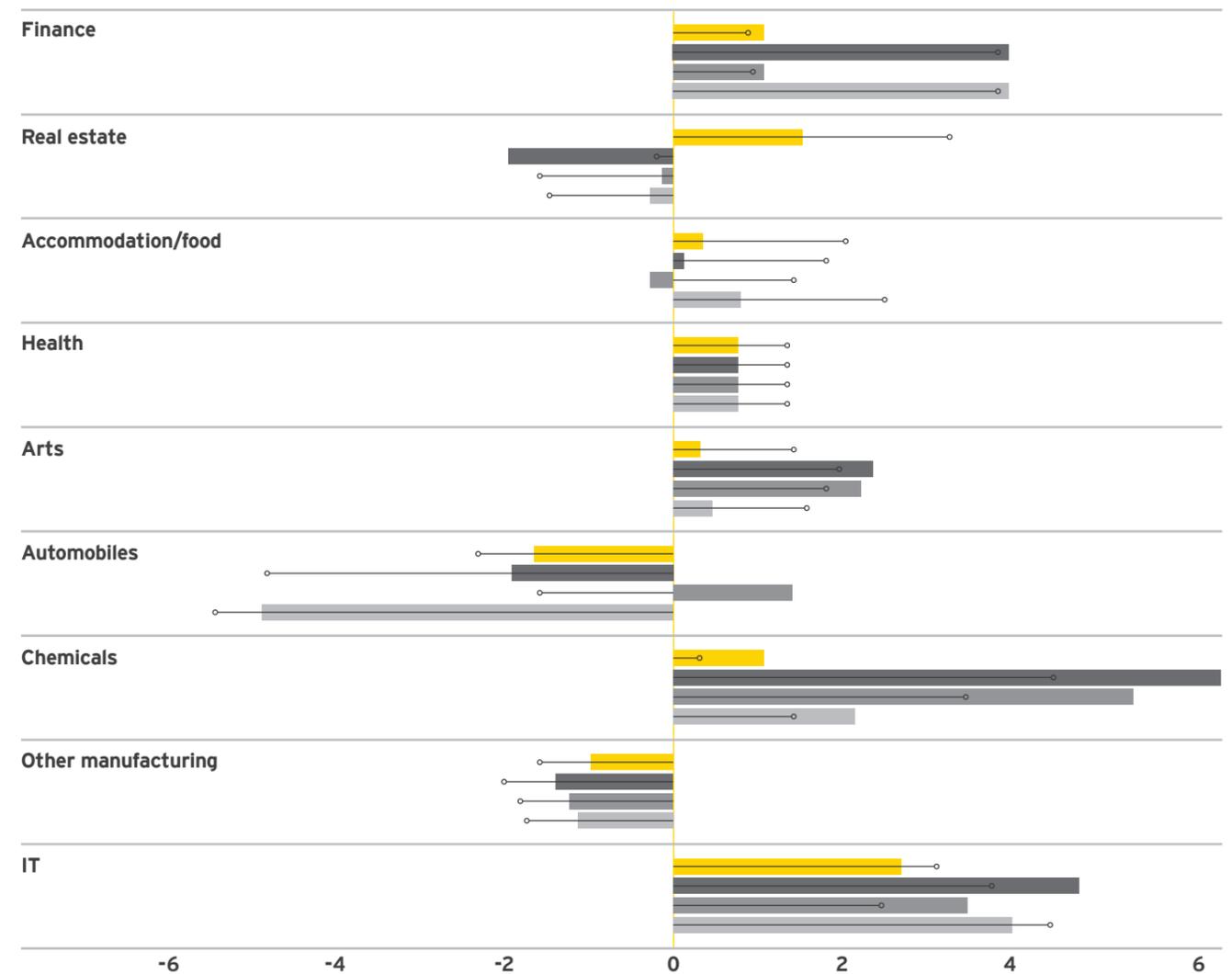
With a government keenly invested in educating a skilled workforce and an economy that shows strong regional diversification, the most important and uncertain trends for Austria are in the availability of talent for Industry 4.0 jobs, and the location of those jobs within the country. We have modeled our scenarios around two key trends that will shape Austria until 2030.

Clustering: urban/rural divide or national growth?

Clustering, the economic effect that describes the tendency of similar firms and industries to group together to access shared resources and improve efficiencies, has the potential to significantly alter national economic structures. Current clusters within Austria, such as heavy industry in Upper Austria, are

vulnerable to automation programs and this creates the potential for an imbalance between regional job losses.⁶³ Clustering in large urban areas, most notably Vienna, which houses Austria's IT industry, might increase technological adoption while simultaneously creating an urban/rural divide.

Figure 23. Austria scenario comparisons for selected sector share of GDP and employment
Austria: Sector share annual change and employment annual change from 2015 to 2030 (%)



■ Baseline ■ 1: Regional technology hubs ■ 2: Hyper productivity ■ 3: Dispersed talent □ Sector share ○ Employment
Source: Oxford Analytica

Digital skills: can supply meet demand?

In an Industry 4.0 and digitalized environment, the presence of digital skills will be the critical factor in determining the usability of labor. A highly skilled domestic workforce with few regional imbalances will allow firms greater choice when choosing where to locate and reduce barriers to growth. These factors will enable Austrian businesses to adopt new technologies early and maximize efficiencies. Conversely, the lack of native digital skills will require firms to attract talent from abroad, or will keep firms from being able to fill positions necessary for technological adoption and growth, limiting the potential productivity gains brought on by Industry 4.0 and digitalization.

Baseline scenario

The baseline for the Future of Work in Austria projects the linear progression of technological adoption as seen from 1997 to 2015, matched with predictions about the long-term overall economic growth. In this model, we assume that between now and 2030, the Austrian economy will have an average annual growth rate of 2.0%.

Figure 24. Baseline: Selected sectors' share of Austrian economy

Sector	2015	2030	Annual growth rate
Chemicals	1.6%	1.8%	1.0%
Automotive manufacturing	1.6%	1.2%	-1.6%
Art and entertainment	1.3%	1.3%	0.3%
IT	1.9%	2.8%	2.6%
Finance	4.2%	4.9%	1.0%

Figure 25. Baseline: Employment (thousands) in selected sectors of Austrian economy

Sector	2015	2030	Annual growth rate	Net job gain/loss
Chemicals	33	34	0.3%	+1
Automotive manufacturing	39	27	-2.2%	-12
Art and entertainment	64	78	1.4%	+14
IT	68	106	3.0%	+38
Finance	130	148	0.9%	+18

In this scenario, we recorded relatively modest shifts in employment and sector size for most industries. The model demonstrates a continuation of automation in traditional manufacturing sectors while strongest growth was reserved for industries that have a high percentage of jobs (155,000). Uneven growth within these industries would spark a greater urban/rural divide in Austria, as jobs leave traditional manufacturing areas and congregate in major cities such as Vienna, Salzburg and Graz.

Total manufacturing employment is predicted to fall by 25% if technological adoption proceeds at current pace.

While not represented in the table above, industries such as health and social work and accommodation and food services also experienced relatively modest growth as a percentage of GDP in this baseline scenario. Tourism, which makes up a substantial proportion of the Austrian economy, could help to explain the increase in the accommodation and food services industry. However, both industries also see significant increases in employment, based around automation and technological adoption, which would replace manual and routine work. This growth in employment is likely to put a strain on the Austrian labor market however, which is expected to contract by 2.81% by 2030.

Scenario 1: Regional technology hubs

For Scenario 1, we envisioned Austrian firms clustering at an elevated rate to maximize productivity gains of new technologies and access a shared knowledge and talent pool. Digital skills and digital human capital also increased, providing an educated workforce for high-skill jobs.

To model these effects, research was conducted on how clustering impacts employment growth, and the importance of digital skills. From this, we found that clustering mostly leads to greater efficiency, while also in many instances creating employment growth in many cases. The presence of digital skills, meanwhile, creates further demand and growth for jobs in industries that are digital-skill intensive. These assumptions were then fed into the baseline scenario to produce tailored results.

Clustering and the presence of digital skills will impact industries differently. For Austria, given its current economic clusters and industry compositions, we expect clustering to mainly manifest itself in the chemicals (including life sciences), automotive, arts and entertainment and IT industries.⁶⁵ With an increase in the supply of digital skills, we also expect there to be an expansion in the sectors that most require those skills. Namely IT, finance (including insurance) and arts and entertainment.⁶⁶

The key uncertainties impacting this scenario are digital education, i.e., the ability of the government to educate and equip an adequate workforce, and the cost of labor. As productivity increases so too do wages.⁶⁷ For industries experiencing strong productivity growth, the ability to translate that into salary increases in order to meet the demands of the workforce will impact the ability to bring in sufficient talent.⁶⁸ Conversely, for firms experiencing less productivity growth, the ability to hire becomes more difficult, which creates a reliance on automation. When accounting for these changes, including a 1 standard deviation improvement in productivity growth for the automotive industry, a half-step improvement in the other clustered industries and an increase in the current account balance brought about by an enlarged finance industry, we saw the following results.

Figure 26. Regional technology hubs: Employment (thousands) in selected sectors of Austrian economy

Sector	2015	2030	Annual growth rate	Net job gain/loss
Chemicals	33	62	4.4%	+29
Automotive manufacturing	39	19	-4.6%	-20
Art and entertainment	64	84	1.9%	+20
IT	68	116	3.6%	+48
Finance	130	224	3.7%	+94

Figure 27. Regional technology hubs: Selected sectors' share of Austrian economy

Sector	2015	2030	Annual growth rate
Chemicals	1.6%	3.9%	6.3%
Automotive manufacturing	1.6%	1.2%	-1.8%
Art and entertainment	1.3%	1.8%	2.3%
IT	1.9%	3.8%	4.6%
Finance	4.2%	7.5%	3.9%

For automotive manufacturing, we saw that despite clustering being a driver for general employment growth, not all industries will experience this, while further clustering of the Austrian automotive industry increased its productivity and output and, its employment fell by 50%.⁶⁹ While not pictured above, the same trend is true for other manufacturing within Austria. This signifies that the greatest impact from clustering is the efficiency gains, but that greater clustering will not fully negate the impacts of automation in certain industries.

There will be a 50% decline in employment in automotive manufacturing.

This occurs because as the supply of highly skilled talent increases in concert with industries such as IT and finance that demand those skills, talent is more likely to follow those industries. This is a result of employees hoping to avoid underemployment and because those digital-skill-intensive sectors are experiencing strong productivity growth, improving their ability to attract talent.⁷⁰

This scenario carried with it different regional effects for Austria. The greater Vienna region, which houses the country's IT and art and entertainment sectors, is likely to take the majority of the employment gains for those industries as they cluster, and digital skills become more prevalent. For chemicals, while Vienna does have a large portion of pharmaceutical jobs Tyrol, Upper Austria and Lower Austria have existing clusters within the chemical sector as well, meaning that those regions are likely also to add jobs if additional clustering takes place.⁷¹ Similarly for finance, while Vienna is the largest single region for the industry, Upper Austria and Styria also contain localized clusters representing 15% and 12.5% of the industry, respectively. These regions would also benefit from an increase in the rate of clustering.

For automotive, the industry cluster that saw the greatest decrease in employment, the job losses were most likely to be felt in Upper Austria and Styria, which houses 65% of jobs within the industry.⁷²

Scenario 2: Hyper productivity

For Scenario 2, we assume that Austrian firms cluster at an elevated rate, as seen in the prior scenario. However, we do not see the same increase in the supply of digital skills, meaning that demand for labor within industries that have jobs that demand a high level of digital skills reverts to the level of the baseline scenario. There is therefore less demand for workers within the IT, finance, and arts and entertainment industries.

To achieve this, we implement clustering effects similar to the previous scenario, again focusing on chemicals, automotive, arts and entertainment, and IT.

The presence of clustering without an increase in digital skills means that high-clustering industries will have to further increase productivity to cope with sluggish increase in the skilled labor force. The one exception to this is the IT industry, which, given its ability to offer a premium for the available talent, is unlikely to force through the same type of productivity gains as other industries.

The key uncertainties impacting this scenario are the cost of labor and access to capital. Similar to the previous scenario, industries experiencing extreme productivity growth are forced to turn that growth into wage increases. This increase affects salary levels across industries, due to internal competition for talent, making it exceedingly difficult for firms experiencing slower growth to hire.⁷³ Firms unable to attract talent are forced to automate, which is capital intensive. For Austrian SMEs, the inability to source capital could slow down the adoption of Industry 4.0 technologies.

To run the model, we apply a 0.5 standard deviation increase in productivity to the high-clustering industries and a 1 standard deviation to the automotive industry, as in the previous scenario. We also continue to apply the elevated current account balance, as it reflects the presence of clustering. This scenario produced significantly less employment growth across the board, highlighting the importance of digital skills and the add-on benefits of a robust financial sector.

The largest change in sectoral share of GDP was seen in the chemicals industry, which produced less employment growth than in the prior scenario, yet still saw a substantial increase in its share of GDP, more than doubling its effective economic size to 3.3% of GDP.

Figure 28. Hyper productivity: Selected sectors' share of Austrian economy

Sector	2015	2030	Annual growth rate
Chemicals	1.6%	3.3%	5.3%
Automotive manufacturing	1.6%	1.9%	1.4%
Art and entertainment	1.3%	1.7%	2.2%
IT	1.9%	3.2%	3.4%
Finance	4.2%	4.9%	1.0%

Figure 29. Hyper productivity: Employment (thousands) in selected sectors of Austrian economy

Sector	2015	2030	Annual growth rate	Net job gain/loss
Chemicals	33	54	3.4%	+21
Automotive manufacturing	39	31	-1.5%	-8
Art and entertainment	64	83	1.8%	+19
IT	68	97	2.4%	+29
Finance	130	148	0.9%	+18

Somewhat counterintuitively, the model records an increase in the GDP share of the automotive industry and a relatively small decrease in its employment figures. The relative increase in sectoral importance can be explained by the decrease in the availability of digital talent. As the supply of digital skills is decreased, labor looks to other sectors that have a lower skill threshold because Industry 4.0 technologies do not take hold to the same degree. This allows the automotive industry to protect its employment figures to some extent, despite the increase in productivity.

This scenario also described different regional impacts. Vienna was less likely to gain as much in relation to other regions, as the industries where it derived significant growth from in Scenario 1: IT, arts and entertainment and finance saw less growth. Conversely, job loss within the automotive sector is minimized, protecting jobs in Upper Austria and Styria and allowing those regions to potentially produce a greater share of GDP.⁷⁴ There is also relatively positive job growth within chemicals, meaning that clusters within Tyrol, Upper Austria and Lower Austria will also add jobs and increase the regions' economic value add, thanks to the strong sectoral performance. Vienna, which houses Austria's pharmaceutical and life sciences sectors, which have been modeled under chemicals, was also likely to see a proportion of these gains.

The chemicals industry represents 3.3% of Austrian economy in 2030 - a greater than 50% increase in relative economic size.

Overall, this scenario illustrates that if Austrian firms cluster and are forced to increase productivity due to an undersupply of high-skilled talent, regional economic clusters will continue to see some growth.

Scenario 3: Dispersed talent

For Scenario 3, we considered a future where Austrian firms did not cluster at an elevated rate, meaning that the geographic diversity of the Austrian economy remained the same. Meanwhile, digital skills and digital human capital increased, providing an educated workforce capable of meeting demand for high-skill jobs.

The supply of highly skilled talents allows firms to recruit easily, meaning that there is no need to focus entirely on achieving extreme productivity growth. Conversely, the positive employment and efficiency effects of clustering are removed, denying firms those benefits.

The key uncertainties impacting this scenario are digital education and societal acceptance of new technologies. For a scenario defined by the prevalence of digital skills, there must be a system in place in order to educate young and old for a digital workplace.

There must also be demand for those skills and that is driven by acceptance of new technologies. If society were to push back against automation in particular industries, then there would be less need for of digitally enabled human capital.

Figure 30. Hyper productivity: Selected sectors' share of Austrian economy

Sector	2015	2030	Annual growth rate
Chemicals	1.6%	2.1%	2.1%
Automotive manufacturing	1.6%	0.8%	-4.7%
Art and entertainment	1.3%	1.3%	0.5%
IT	1.9%	3.4%	3.8%
Finance	4.2%	7.5%	3.9%

Figure 31. Hyper productivity: Employment (thousands) in selected sectors of Austrian economy

Sector	2015	2030	Annual growth rate	Net job gain/loss
Chemicals	33	40	1.4%	+7
Automotive manufacturing	39	17	-5.3%	-22
Art and entertainment	64	80	1.5%	+16
IT	68	128	4.3%	+60
Finance	130	224	3.7%	+94

To model this scenario, we revert back to the baseline scenario for the chemicals, automotive, arts and entertainment, and IT industries, removing the employment and efficiency effects of clustering. We then add in the digital skills impacts seen in the first scenario, which equates to an expansion of the finance, IT and arts and entertainment sectors due to an increased supply in the critical skills needed for employment growth in those sectors. We also remove any increased productivity assumptions, as the supply of labor will keep firms from having to produce extra productivity gains.

This model produces the second largest total employment gain of any of the three scenarios for Austria, with total employment in these five sectors increasing by 155,578 jobs - a 47% increase in employment within these sectors by 2030. The automotive industry saw the largest drop in its share of GDP and its rate of employment. This indicates that without the efficiency gains from clustering, the sector experienced more employment losses than in the baseline scenario. These results demonstrate a reliance by the automotive sector on significant productivity increases in order to protect employment and attract talent.

For sectors reliant on digital skills, substantial employment growth is better achieved through a strongly educated workforce than the presence of hyperactive clusters.

The IT sector experienced growth close to the figures seen in Scenario 1 and far above those of Scenario 2, indicating that the supply of sufficient talent for the industry was a greater economic boost alone than any positive effects from clustering or forced efficiency gains. These results have far-reaching policy implications, as they indicate that substantial employment growth is better achieved through a strongly educated workforce than the presence of hyperactive clusters, particularly when labor supply is not available for industries that require workers with digital skills. For governments such as Austria's, this illustrates the continued need to focus on teaching digital skills and lowering barriers for firms to find and hire highly skilled talent.

The chemicals industry, which includes the life sciences, resulted in a different effect. Chemicals saw significantly lower growth than in Scenario 1, which combined clustering with the abundance of digital skills, as well as lower employment growth than Scenario 2 and a far lower annual growth rate in its share of GDP. Scenario 3 therefore demonstrates that within highly technical and non-digital sectors, such as the life sciences, the employment effect of clustering and aggressive increase in productivity are more important for economic performance and growth than the supply of talent with a high level of digital skills. This too has policy implications, as it illustrates the need for certain sectors to exist within a favorable environment that supports clustering.

Key takeaways

Clustering outweighs access to talent

Clustering is a stronger driver of growth than talent for non-digital industries. Scenarios 2 and 3 compared sector and job growth in environments that lack talent and that had no additional clustering of industries.

Scenario 2, which shows the growth of Austrian sectors where clustering exists and talent is scarce, showed strong growth in a highly technical sector: chemicals, including life sciences. Scenario 3 saw much more muted growth. This demonstrates the different importance of various drivers within industries and the value of industry ecosystems in respect of economic performance.

To Vienna go the spoils

While the scenarios representing more balanced growth and clustering both show that other highly developed regions in Austria, such as Salzburg and Vorarlberg, will benefit from the advance of Industry 4.0, Vienna and its environs in Lower Austria will undoubtedly be the biggest beneficiaries of digitalization. As the region that houses the largest share of the IT, finance, arts and life sciences industries, the city will be the largest recipient of growth within those fields, and is poised to become an even larger economic region within the country. Heavily industrialized regions are likely to suffer, as employment in manufacturing is set to decrease no matter which path Industry 4.0 takes in Austria.

The Germany effect

Although not discussed directly within the scenarios (they represent an economic picture of Austria alone), the external environment is a critical component of how Austria will ultimately adapt to the presence of new technologies. Germany is the country's largest trading partner, representing more than 35% of imports and less than 30% of exports. This type of oversized economic presence will tie Austria to the results of Industry 4.0 in Germany to some extent, creating a situation whereby the two countries could both succeed or struggle with the coming wave of digitalization.

Digitalization and our relationship to work

In your research about the long-term labor market consequences of the Fourth Industrial Revolution, what are the common limitations you have witnessed?

“The capacity to imagine both new types of work and our relationship with work. For most people, it’s hard to imagine that maybe 10 of the 20 most popular jobs of 2030 do not exist today. Jobs such as drones or self-driving car sensor repair workers; psychologists specialized in artificial emotional intelligence software; artificial-skin dermatologists who create and maintain facially expressive and hyper-dexterous robot; and hyper-spectral

space-data storage technicians, are all potential future avenues of work. These jobs will be based on technologies and work processes that have yet to be developed or are just emerging. We may also have new forms of human activity that are not productivity-driven. Automates may just free up time for us to be more available to our children, ageing parents or to our neighborhood. Alternatively, we may use our time to perform more creative or social tasks that are oriented toward achieving something different than a paycheck. In future politicians may not be elected for job creation but ‘time creation’. For having allowed socioeconomic performance that gives citizens an extra

four or six days off per year because of increased automation and productivity, for example.”

Is there a chance that today’s emerging anti-automation movement may steer us away from this this “prosingularity,” pro-technology future?

“Indeed. Not all revolutions that start with asymmetry end without it. In the case of a smart tech-driven workplace where technological asymmetry affects employability, the debate will move from ‘the haves vs. the have nots’ to ‘the can vs. cannot work’. It is already affecting the

competitive landscape - with disruptors, early adopters and established firms feeling power pricing, distribution or market regulation asymmetries. Geopolitics may be affected by geo-technologies as the asymmetries between countries will grow. At a country-level, think about tech ownership or leadership, tech divergence, tech-generated wealth, well-being and soft power. When it comes to non-replicable life-saving or defense technologies, some high-tech nations may not want affordability and accessibility for all. This could influence labor mobility and immigration as well.”

Given that jobs themselves are changing, is a university degree still the best protection for workers against technological unemployment, in your opinion?

“After the agricultural, industrial and computerization revolutions, the Fourth Industrial Revolution - the digitalization revolution - will be seen as the first one that displaced very well-educated people. You can switch from carriages to cars in one big transportation revolution and only witness minor turmoil because the millions of horses we did not need anymore ‘retired’ silently. Radiologists, pharmacists, physiotherapists, notaries, journalists, engineers, assets managers and other professionals with advanced degrees may be replaced by automated systems and smart apps. This won’t just be about truck drivers, cashiers or travel agents’ job loss complaints, but sophisticated workers with university degrees as well. Some German, Swiss or Austrian universities may even start capping program enrolments due to ‘future technological unemployment risks’.”

If education alone is no longer enough, what else is required for individuals to succeed in a digitalized workplace?

“The best defense against the machines is a two-pronged approach. First, an education and skillset that are aligned with the non-routine cognitive tasks that the Industry 4.0 economy requires. Second, the willingness and courage to learn and perform something completely new. It won’t be so much about the ‘where’ do I get that, a vocational or a PhD degree, in a university or online, but ‘when’. Besides our own desire to be life-long learners and having a willing employer and enough money to re-enter education, we also need time. People say they are too busy to focus on training. Similar to labor laws or working agreements that define your number of annual holidays, a mandatory time bank in which you cumulate a number of training days, let’s say 3% of your annual worked time, could give workers the free time to schedule up-skilling or career recycling when necessary. Reassured that they can use some of their holidays and their time-bank to invest in their career development, workers will take on new programs or qualifications. Europeans could have an edge here as they already have more time off than Americans or Asians. In parallel, it will be important that organizations recognize non-traditional education and diplomas, that academic institutions offer shorter diplomas and that governments facilitate the registration and lifelong accumulation of such trainings within individual know-how accounts, like we do for health records or driving license files for example.”



Eric Noël
Senior Vice President,
Oxford Analytica

We may also have new forms of human activity that are not productivity-driven.



Finding

... our way to the Future of Work



Risk

Regulatory uncertainty will delay the adoption of new digital tools and potentially increase costs of adoption.

Opportunities

Employees need to be aware of emerging jobs in growing sectors and continuously acquire new skills throughout their working careers.

Action

Society as a whole needs to support current workforce transition to new professions.

As our models show, there is not one Future of Work, but many different paths that Industry 4.0 and digitalization could carve out toward 2030. What is clear is that for Germany, Switzerland and Austria, no matter how these processes unfold, there will be sectoral shifts within these respective national economies. While some industries will almost inevitably decline in employment, others are likely to flourish, creating their own opportunities for growth and expansion.

For Germany, the automobile industry - long a symbol of the country's manufacturing prowess - looks likely to decrease in economic importance as a result of new methods of production and the introduction of electronic and self-driving vehicles. With every scenario showing a minimum of a 50% decrease in economic share and a similar loss in total employment, the automotive sector and the manufacturing industry as a whole will undergo a dramatic shift in a short period of time. Germany's labor market is also likely to be strained by shortages in the health and social work sectors, as the industry must cope with greater demand due to an aging population, relatively limited automation potential and a shrinking work-force.

Switzerland seems best positioned among the three countries, thanks to its growing workforce and the relative importance of high-skilled industries. Fears over the future of the finance industry in Switzerland appear overstated. Even within the scenario demonstrating the effects of automation, where productivity per worker more than doubles, the industry still manages to add jobs. In Switzerland it is the chemicals industry, including the life sciences and pharmaceuticals, which will be the largest driver of growth during this coming wave of technological change. As a high-skilled industry relatively protected from automation, this sector looks best positioned to add high-value jobs to the economy.

Much like Germany, Austria is set to see a decline in the importance of manufacturing in favor of roles in the tertiary sector. Even within the baseline scenario, Austria is expected to lose 25% of its manufacturing jobs by 2030. High-skilled industries such as IT, finance and chemicals, including life sciences, are poised to grow. As these changes occur Austria will see a small contraction in its labor market and increasing competition for talent, potentially serving as a driver for immigration.

The IT sector will be a driver of future growth in all three countries.

As our models show, there is not one Future of Work, but many different paths that Industry 4.0 and digitalization could carve out toward 2030.

Despite their differences in size and structure, some trends and themes are common to all three economies.

In all three countries the IT industry is set to become an important economic sector and a driver for future growth. While the industry today is relatively unimportant in this region (failing to account for even 3% of GDP), even the most conservative scenarios have shown that by 2030 the industry will have increased its economic share by almost 50% in all three nations, possibly even more. This new economic driver brings with it new demands, particularly in terms of infrastructure and skills. Countries able to meet those demands most quickly and efficiently will be able to leverage the industry for greater growth in other sectors.

Within each country, the process of digitalization is likely to spur on regional divides. In Germany, the East-West division is set to expand as the already declining labor force in the east of the country will continue to migrate internally in search of jobs. Those with high levels of education or skills are particularly likely to move in search of work, further increasing the economic divide.



In Switzerland, the Basel region and its life sciences industry looks the most likely to benefit from both automation and augmentation, due to its concentration of high-skilled labor.⁷⁵ Cantons such as Zürich, Geneva and Vaud will also thrive, but regions with smaller tertiary sectors will struggle to compete in the knowledge economy.

Within Austria, as Industry 4.0 takes hold and the finance and IT industries grow, Vienna is likely to grow disproportionately to other regions, particularly in relation to those tied to the secondary economic sector, such as Upper Austria and Styria.

While focused on a specific region within a group of developed countries it is also necessary to remember that the Future of Work is global and that these new technologies will be impacting economies outside of Germany, Switzerland and Austria. Those economic and political forces, whether brought on by EU

regulations, Chinese competition in the high-tech sphere or Brexit, will also play a role in the environment in which these countries adapt. Even for the countries within this study, the reactions of one can impact heavily on the outcomes of another. For example, Germany's economic and regulatory path will undoubtedly have a large effect on how Austria embraces Industry 4.0 and digitalization.

The global nature of this coming revolution also brings with it broad international challenges that all nations will face. Industry 4.0 and its productivity gains are challenging governments to ensure that GDP growth outpaces job losses. Industry 4.0 also raises additional economic questions to which the answers are not yet clear. As economies automate and become more efficient, will workers find themselves with more disposable income? What will that money be spent on? Answers on topics such as these will also define how technological adoption progresses.



Risk and opportunities

Industry 4.0 and digitalization



The research conducted for this report, together with the econometric scenarios and the interviews, highlight many of the potential pitfalls and positive prospects that come with the advancement of Industry 4.0 and digitalization.

Risks

- ▶ **Regulatory uncertainty**
The technologies that will be implemented as part of this transition require an advanced regulatory regime, which not only promotes innovation but also creates clear direction for businesses on the potential uses and boundaries of new technologies. Without regulatory certainty, there will be a delayed adoption of new digital tools and the potential for increased costs of adoption.
- ▶ **Institutional obstruction to change**
Industry 4.0 represents a structural shift. Workers, political parties and governments have previously opposed similar changes because of understandable concerns about their impact on workers' salaries and job security. In countries such as Germany and Austria, where labor unions and social democratic parties are strongly entrenched, this creates the risk of a political backlash against technological progress, limiting the potential economic gains of Industry 4.0 unless solutions to the social and political implications of new technologies are found.
- ▶ **Outdated infrastructure**
Digital platforms and machines are only as good as the systems they run on. If infrastructure like broadband internet access is not kept up to date in parallel with advances in technology, then businesses will be unable to adopt new tools and services however willing they may be to do so.

Opportunities

- ▶ **New industries**
Machine learning is best suited to pattern recognition, for perceptual data or any other big data set. These techniques will lead to new types of robotics and uses for robotics. This could create new fields that currently do not exist, in the same way that advanced robotics did not exist before computerization.
- ▶ **Formulating standards**
Standards are the economic equivalent of tariffs in the digital economy. As this new wave of technological change takes shape, firms and governments that are able to set industry- or technology-wide standards will be able to maximize the economic benefits of those new technologies.
- ▶ **Lateral job movement**
While digitalization will ultimately create a paradigm shift in work, during the interim there will be opportunities for workers from declining industries to make lateral moves to areas that have not adapted to new technologies. Opportunities exist to look for the 21st century 'horse cart', which can serve as a bridge for workers.

Action items

Society as a whole needs to act



Individuals

- ▶ **Enter the workforce with an open mindset**
The Future of Work is more flexible and less permanent. Employees must be willing to ask questions about how each job might contribute to their work journeys. The key for employers is to understand that they will need to appreciate the employee experience and what individuals can gain from having a relationship with the firm.
- ▶ **Think beyond current business competencies**
It is important for business leaders to be able to think about big questions that may intersect with mobile workplaces, and explore how new technologies may lead to negative consequences. Philosophy, history and psychology should be considered essential in completing a business education.
- ▶ **Think about portfolio careers**
Obtaining skills during the first 10 years in the workforce is a critical component of job flexibility. Switching jobs and careers frequently and adapting to changing work environments allows an individual to become more agile.



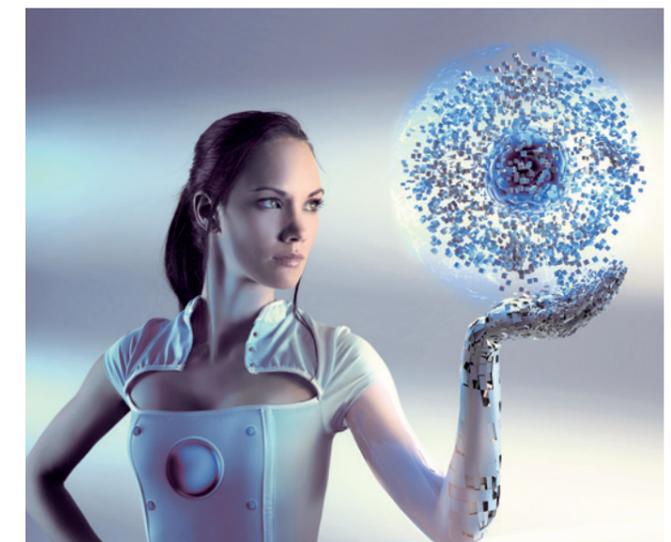
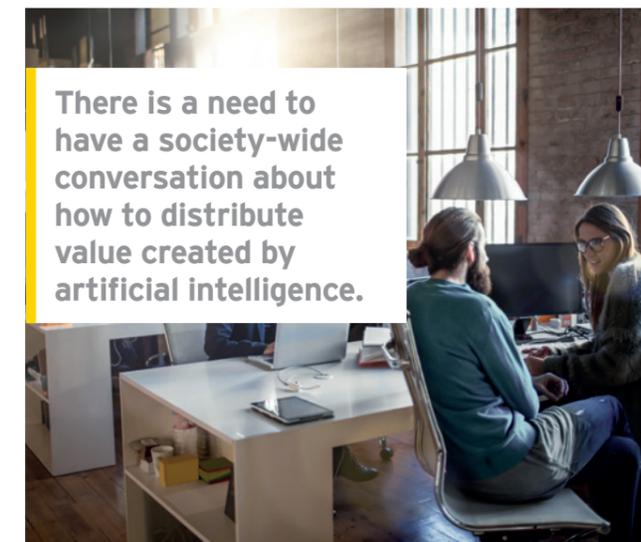
Companies

- ▶ **Focus on mindset and purpose**
Research by the EY Beacon Institute indicates that a well-articulated and integrated organizational purpose drives innovation and helps individuals and teams work across silos in order to pursue a single compelling aim.
- ▶ **Shift to permanent learning**
As technology develops at an increasing rate, employee knowledge becomes outdated at a corresponding pace. Firms must shorten the time between the intervals when employees receive training on the latest technology to ensure that their employees - their human capital - is collectively taking full advantage of the possibilities of physical capital.
- ▶ **Create a process for scaling technology**
Industry 4.0 will arrive in phases, in 'real-time', as technology is invented and brought to market. Properly testing that technology and formulating a process for wider implementation will help firms maximize the value from their investment and help protect productivity gains.



Organizations and governments

- ▶ **Regulatory frameworks**
In the short term, firms and governments should focus on creating formal processes by which new automation technologies can be tested and brought to market. It is important to have a regulatory process for this and not have it done in a vacuum.
- ▶ **Foster a society-wide conversation**
There needs to be a conversation throughout society about how to distribute value created by artificial means. Should this be seen as a resource for the country (as we treat mineral deposits) or as the profits of private owners (as we generally treat factory equipment)? This will be especially important as value creation shifts from individuals to technology.
- ▶ **Update unemployment insurance and social security**
While Finland and Canada are currently testing forms of universal income, they are not likely to be widely adopted in the near future. Instead, existing social programs such as unemployment insurance, should be updated to focus on retooling professionals with additional skills and directing them into areas where the jobs are located.



Appendix 1

Scenario methodology

We assess labor demand and sectoral size in several key areas of the economy. This assessment takes into account different scenarios for technology, automation and work-enhancing technologies.

Labor demand

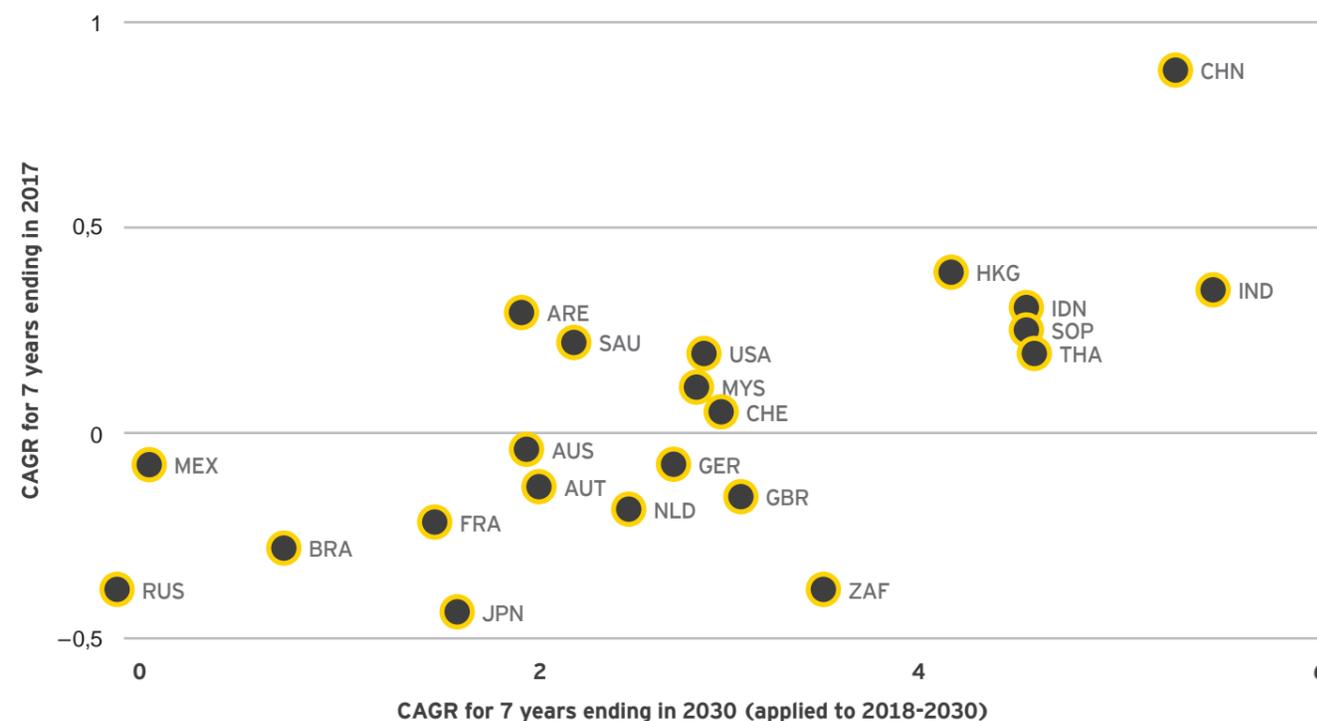
We forecast the talent needs of several skill intensive sectors: finance, real estate, accommodation and food, health care, arts, automotive, chemicals, other manufacturing and IT. Information for total manufacturing was also collated.

Our forecast is based on modeling each of these industries' share of the economy, given a host of other factors such as per-capita income, export position, natural resource endowments and several other variables. To establish the size of the economy itself, we forecast the compound annual growth rate (CAGR) for the 2018-2030 period based on the 2000-2007 and 2007-2014 7-year CAGR relationships with real government expenditure, world trade growth, 7-year lagged CAGR of GDP and 7-year

CAGR in the real oil price, processed with an indicator variable for oil rents in excess of 15% of GDP (see GDP in 2030 section below for more details). The forecast of sector share of economy, combined with size of economy, gives us a forecast of sector value-added in 2030.

We derived the number of required workers in 2030 by dividing the sector's value-added by the productivity rate (the value-added per worker). To establish the productivity rate, we allowed four scenarios: average productivity in the sector since 2000 (across all advanced economies) and the average plus 0.5, 1 and 1.5 standard deviations in this cross-country productivity rate data.

Figure 32: Average growth rate over two 7-year periods (actual and forecast)
CAGR for 7 years ending 2030 (applied to 2018-2030)



Source: Oxford Analytica
Note: in constant US dollar terms (%)
Note: ARE is UAE

Sector data

The data came from the EU-KLEMS database, available for 30 countries covering 1970-2015 or recent sections thereof. As Switzerland is not included, we used Swiss National Statistics' estimates of value-added and employment per sector.

Regression modeling

The first talent-demand component we modeled was sector share-of-economy. We did this first for the financial services sector, given its unique status vis-à-vis all other sectors.⁷⁶ Modeling of subsequent sectors takes into account the size of the financial services sector, as this is a 'known' correlate (having already been forecast in the financial services model).

Most of the models estimated for this project are for proportional variables: e.g., the proportion of the economy that is attributed to the IT Services sector. We used an appropriate estimation approach to help ensure that the predicted outcomes are proportions.

Regression results

The estimation sample is generally 1995-2015 and covers 26 countries (the EU-KLEMS universe, of which our KLEMS countries are a subset, plus Switzerland). There is a reasonable range of per-capita income represented by these countries, from Bulgaria (about half the EU-27 average income level) to Switzerland (top of the world).

Model assumptions (forecasts of correlates)

Macroeconomic models report the historical relationship between the variable of main interest (the 'dependent variable'; e.g., in our case 'proportion of the economy taken by financial services') and a host of correlates (things that are related to the dependent variable; in our case per-capita income, population, trade position and other key variables). To project future values of the dependent variable, we need future values of the correlates. This is where model assumptions come in.

We forecast the future size of the economy as already noted. We used the OECD's projections for the current account position (a reflection of the trade balance). For countries not covered by the OECD forecast, we used the 2015-2022 trend in the current account to project forward the current account to 2030. We projected the last known value (2016) of oil rent per GDP to 2030.

Other assumptions are stated in the different working electronic files that were applied to the overall model.

GDP in 2030

We modeled the 7-year CAGR in real local currency GDP in a pooled cross-sectional regression on 133 countries in the years 2007 and 2017. The virtue of this approach is the reduction of estimation bias due to, for example, variable mismeasurement. In Monte Carlo estimations of a variety of estimators on growth data, Hauk and Wacziarg (2012) report least bias from their cross-sectional model (known as a 'between' estimator).

The correlates in our model are 7-year average annual growth in real government expenditure, 7-year annual average volume growth in world exports of goods and services ('world-xmean'), 7-year lag of the dependent variable, 7-year growth in the oil price and oil rents per GDP 'orent15_', an indicator variable taking the value of 1 if exceeding 15%, else 0. We interact these with indicators for region of the world or advanced/non-advanced status.

Table 33: Dependent variable is 7-year CAGR in real, US dollar GDP

Linear regression

Number of obs	195	R-squared	0,6955
F(18, 177)	40,2	Root MSE	0,02909
Prob > F	0		

gdprealusbcagr7	Coef.	Robust std. err.	t	P>t	[95% conf. interval]
Advanced	0,7083912	0,3764774	1,88	0,062	-0,0345708 1,451353
East Asia & Pacific	0,5519848	0,1526294	3,62	0	0,2507772 0,8531923
Europe & Central Asia	0,7441844	0,1932518	3,85	0	0,3628103 1,125558
Latin America & Caribbean	0,7970869	0,1305272	6,11	0	0,539497 1,054677
Middle East & North Africa	0,1519117	0,1196296	1,27	0,206	-0,0841722 0,3879957
South Asia	0,7590223	0,2641284	2,87	0,005	0,2377762 1,280268
Sub-Saharan Africa	0,0358393	0,1997758	0,18	0,858	-0,3584096 0,4300882
iregion#c.worldxmean_					
Advanced	0,0048525	0,0015413	3,15	0,002	0,0018109 0,0078942
East Asia & Pacific	0,0059748	0,0013471	4,44	0	0,0033164 0,0086332
Europe & Central Asia	-0,0000203	0,0020492	-0,01	0,992	-0,0040643 0,0040236
Latin America & Caribbean	0,0012429	0,0014527	0,86	0,393	-0,0016239 0,0041097
Middle East & North Africa	0,0060409	0,0014217	4,25	0	0,0032352 0,0088466
South Asia	0,0015714	0,0037114	0,42	0,673	-0,0057529 0,0088958
Sub-Saharan Africa	0,0092142	0,0020615	4,47	0	0,0051459 0,0132825
iregion1#cL7.gdprealusbcagr7					
0	-0,0863908	0,074166	-1,16	0,246	-0,2327542 0,0599727
1	-0,3586106	0,1137514	-3,15	0,002	-0,5830942 -0,134127
orent15_#c.oilrcagr7					
0	0,1068583	0,0429317	2,49	0,014	0,0221345 0,1915821
1	0,2539321	0,1134374	2,24	0,026	0,0300683 0,477796

Source: Oxford Analytica

Notes: "govexprncbcagr7_" is 7-year average annual growth in real government expenditure, "worldxmean_" is the 7-year average in annual growth in volume of world exports of goods and services. "iregion#cL7.gdprrpcridln" is the 7-year lag in log of per-capita GDP in constant PPP international dollars, interacted with regional indicators. "orent15_" is an indicator variable taking the value of 1 if oil rents exceeded 15% of GDP in the past seven years.

Appendix 2

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Appendix 3

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