

Automation, digitalisation and employment

Report of the Conseil d'orientation pour l'emploi (Employment Advisory Council)

Volume 1: impacts on job numbers, structure and location

Summary

January 2017



Introduction

The progress achieved in the field of robotics and artificial intelligence, the expansion of the Internet of Things, big data and the advent of 3D printing are currently contributing to **fears of a possible “jobless future.”**

Several studies published in international economic literature since 2013 have attempted to estimate the percentage of today's jobs potentially at risk as new automation capabilities arise. These studies, most of which are based on foreign data and focus exclusively on job cuts, consider **the potential effects on job numbers could be significant if not massive, but fail to come to any sort of agreement on the magnitude of this risk.**

A conclusion on this matter is of crucial importance, however, because this is the foundation on which changes in public policy must be built. Such changes differ in magnitude and nature depending on how fast or sudden the transformations are, whether they are minor or massive, and focused or not on specific areas of expertise, geographic areas or job categories.

This is why the Conseil d'orientation pour l'emploi wished to expand and refine the analysis by fully examining the foreseeable impacts of the new wave of technological innovations on work and employment.

In this first Volume, it sought to assess **the observed and foreseeable impacts:**

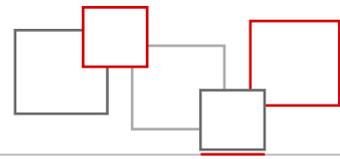
- on **the number of jobs** (in terms of jobs cut and created);
- on **job structure** (What businesses and sectors are the most affected? How are professions liable to change? What types of skill sets will be given priority in the future?);
- on **job locations**, both nationwide (What local labour markets could be the most affected) and internationally (Could technologies trigger the reshoring of jobs in France?).

To this end, it asked the General Secretary of the Council to **conduct a statistical study, using French individual data** from the *Working Conditions* survey, with the following objectives:

- **quantifying the percentage of jobs potentially affected by automation**, whether they might be at **risk of being cut or transformed;**
- **determining the overall results by profession**, again in terms of the risk of being eliminated or transformed.

This study showed that:

- **less than 10% of existing jobs are subject to cumulative vulnerabilities liable to threaten their existence due to automation and digitalisation;**
- but **half of existing jobs are liable to change in terms of content, from significantly to very significantly;**
- **technological advances should continue to promote qualified and highly qualified jobs:** of those that may be vulnerable, over-represented professions with respect to volume or their percentage of total jobs, are often relatively unqualified or less qualified jobs.



For the second volume of this report, which will be published in the Spring, the Council plans to review exactly what is at stake in terms of skill sets, professional mobility, organisation of working hours and management methods, working conditions and support for innovation, taking into account the uncertainties associated with the phenomenon based on different scenarios. It will also formulate public policy recommendations covering all fields of work and employment.



What are automation and digitalisation?

Until the 1970s, the term automation referred to machine technologies used to perform certain tasks, primarily for the manufacture of industrial products. The advent of computers broadly expanded the range of business tasks and functions that could be automated, a range that now includes services.

When the Internet was rolled out in the 1990s, a new wave of innovations launched what is currently referred to as the digitalisation of the economy. This is the phenomenon whereby digital technologies have spread to the entire productive system, not only making it possible to go even further in terms of automation, but also radically challenging the operation and organisation of certain sectors and business models.

Even greater technical possibilities are shaping up on the horizon for automation and digitalisation. Several technologies – many of which belong to the digital field and tend to be **highly interdependent** – hold **considerable potential for transforming the productive system and our economies.** This is the case of **artificial intelligence and robotics.** Through the development of computer programs and robots able to perform increasingly complex activities and increasingly capable of learning, current and future advances in these fields will expand the scope of automation:

- to new activities within sectors that have been using automation technologies for several years now, such as the manufacturing industry and agriculture;
- to sectors which, until recently, had been on the sidelines of the automation trend, such as healthcare and services.

Two other good examples are 3D printing and the Internet of Things. Although a certain number of technical obstacles must still be overcome before 3D printing can become more widespread, the Internet of Things should dramatically alter the organisation of the productive system within the next few years. This technology lies at the heart of the “Factory of the Future”, a new manufacturing model based on the largest integration of new technologies in manufacturing processes and considered to be a springboard for maintaining or rejuvenating competitiveness in the manufacturing industry.

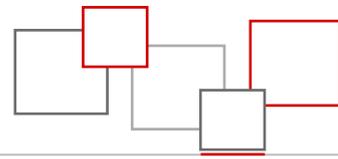
What economic analysis and history have taught us

Technological unemployment: an old fear, constantly debated over the past two centuries, but not rooted in facts

The link between technology and employment has long been the subject of heated debate. And yet, the technical innovations of the past two centuries have not reduced, much less eliminated, employment. **While it is true that employment has changed in the wake of previous technological revolutions, it has also increased.**

The report shows that, while economic literature has not drawn any clear, definitive conclusions on the impact of technologies on employment, it does provide a useful description for analysis purposes of several types of innovations liable to have differentiated effects on employment. It describes possibly differentiated effects according to the level of analysis (microeconomic at the corporate level, sector-oriented or macroeconomic) and timescale. It also presents the mechanisms likely to promote job cuts or job creations.

The introduction of more efficient production methods or tools is not limited to replacing workers with machines. The projected impacts on employment vary depending on the type of technological innovation.



Innovations consisting of new production techniques or methods may well increase productivity, thus making it possible, if production does not increase, to **manufacture more with fewer workers**.

However, there are offsetting mechanisms that can reduce, if not fully offset or exceed, the initial job losses. This is possible through the construction of new machines, lower production costs, increased demand, new investments, and greater demand for labour stemming from wage cuts.

Their magnitude depends on several different factors such as the institutional environment (social, legal or technical standards), the operation of the markets (nature and intensity of competition, price elasticity), the respective costs of capital and labour and the substitution potential between these two production factors, and the development of anticipations by economic agents (businesses and consumers). Consequently, the ultimate impact on employment is hard to predict.

Furthermore, the innovations behind new products or services may spontaneously create jobs by paving the way for new activities, provided that these activities do not cannibalise existing ones.

Technical progress affects job numbers as well as structure depending on the types of jobs it promotes or replaces.

In addition, by reducing coordination costs in particular, technologies can also alter the distribution of jobs between countries or within a given country.

Questions on the evolution of productivity and the path to long-term economic growth

The risk of technological unemployment, invalidated by two centuries of robust job growth, once again became an issue starting in the 1990s as growth of labour productivity began slowing in most developed countries. Yet labour productivity growth can be considered as a driver of economic and job growth. No consensus has arisen to explain this slowdown. The fact remains that current and future transformations brought on by digital innovation could be a contributing factor.

For “techno-optimists”, this slowdown in productivity cannot be attributed to the nature of recent technologies, which boast real stimulation potential, but rather to how **quickly** they are appearing compared to how fast companies and institutions are able to adapt, making it more a **question of the rate of dissemination of these technologies**.

For “techno-pessimists”, on the other hand, digital innovations are not as powerful, in terms of their impact on the economy, as the innovations ushered in by the two previous industrial revolutions. This does not mean there will be no more innovations. It only means they will not drive productivity and the creation of wealth on a par with the innovations of past centuries.



Impacts of automation and digitalisation on job numbers, structure and location

How can these impacts be assessed? A few key questions

The impacts of the spread of the most recent technologies on employment can be assessed from a retrospective standpoint (the report predominantly examines the effects of technologies from the last 30 years) or a prospective standpoint. Taking the forward-looking approach is especially challenging in that it is rooted in the **major uncertainty surrounding the displacement of the technological frontier**. The aim is to assess the future impacts of current and future technological advances on employment, meaning we cannot know with any certainty when these technologies will be fully developed, or how they will be disseminated and combined tomorrow to impact employment.

Whether we take the retrospective or prospective view, however, analysing the impacts of the deployment of technologies on job numbers, structure or location requires answering a set of key questions:

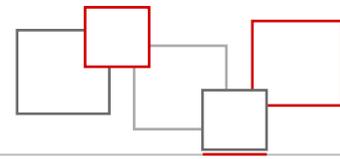
- How can technological progress and its impact on employment be measured?
- How can the risk of job automation linked to technological progress be assessed and how can the jobs most likely to be affected be identified?
- Which level of analysis should be used (macroeconomic, sector-oriented, microeconomic)?
- How should the timescale question be addressed?
- How can the potential estimation biases of prospective analyses be resolved?

The report documents the following key points:

Isolating the impact of technical progress alone on changes in job numbers and structure is a tricky endeavour: other related factors come into play through neighbouring channels. This is particularly true for globalisation (which, by the way, is also largely associated with the dissemination of technical progress), socio-demographic changes (ageing of the population, more women in the workplace, higher education levels, etc.), job market regulations and institutions, and organisational changes in the operation and strategy of corporations (some of which may be directly linked to technical progress, while others can be traced to changes in management methods).

The impact of new technologies on employment also takes many forms (differentiated sector effects, cumulative job-destruction and job-creation effects that differ by company, etc.). Results may vary depending on the level of analysis as well (national, sector or corporate).

Nor do analyses converge as to the timescale of technological impacts on employment. This issue is addressed in two ways. First, the magnitude and interaction of the various offsetting mechanisms liable to reduce or even offset the job losses initially arising from the introduction of a new technology are still a source of uncertainty. Next, it turns out the duration of this transitional period for technological changes in progress is very difficult to pin down: largely associated as it is with the very nature of the technologies in question and their rate of dissemination, the timescale of the impacts on employment of the last wave of technological innovations is potentially different from the duration of the transitional periods of past technological revolutions, with there being no way to confirm whether this duration is likely to be shorter or longer.



In the case of prospective analyses, there are several biases liable to cause the number of jobs at risk due to automation to be overestimated:

- it is not because a given technology can replace a worker that it will be directly and massively used by companies. Matters of social acceptance, the institutional and regulatory environment, and economic profitability conditions are all factors that can limit or slow the pace of automation;
- existing prospective studies aim to measure *gross* job cuts. They do not factor in job creations (direct or indirect) linked to digital innovation, and as a result they cannot estimate the overall *net* effect on the level of employment.

Conversely, there may also be a bias causing the number of jobs at risk due to automation to be underestimated: current studies assess the risk of automation through an ex-ante analysis of the current state of technologies and their automation potential. There is no guarantee that the evolution of technologies will not be faster than expected or that the technological frontier will not shift faster than the automation threshold.

Impacts on job numbers

The debate on the impact of automation on employment has recently focused – particularly since the Frey and Osborne study was published in 2013 – on the question of the volume of the jobs in question and the professions most exposed to automation risk. More specifically, the debate is leaning towards an exclusively prospective approach aimed at estimating the percentage of jobs potentially facing extinction due to advances in automation. However, this approach has not even come close to exhausting the debate on job number impacts.

Retrospective studies have globally converged to show that the technological advances of the last 30 years have had a positive impact on employment

Several empirical studies¹ have attempted to assess the impacts of technological innovation waves on job numbers in France and abroad: despite the differences in approaches and methods, they tend to converge towards the conclusion that the **introduction of innovations has had a positive overall impact. These impacts vary, however**, according to the type of technological innovation and level of analysis used, as shown in the table below. **Studies examining the impact of digital and robotic technologies alone on job numbers are still few and far between.**

¹ The COE report recaps the principal retrospective studies evaluating the impact of technological progress on employment conducted since 2000.



Table 1: Impacts of product and process innovation by level of analysis

	<i>Product innovation</i>	<i>Process innovation</i>
Microeconomic level	<p>Positive impact on employment</p> <p><i>Even factoring in the replacement of old products with new products</i></p>	<p>(Direct) negative impact on employment</p> <p><i>When production is constant</i></p> <p>(Indirect) positive impact on employment</p> <p><i>When production increases</i></p>
Sector level	<p>No impact on employment</p> <p><i>When innovation helps a company take market share from another company in the same sector (the job created offsets the job destroyed)</i></p> <p>Positive impact on employment</p> <p><i>When innovation helps create a new market</i></p>	<p>(Direct) negative impact on employment</p> <p><i>When innovation only allows companies to gain market share within a given sector or results in the reallocation of jobs to other sectors</i></p> <p>(Indirect) positive impact on employment</p> <p><i>Depends on the sector</i></p>
Macroeconomic level	<p>Positive impact on employment</p> <p><i>When the new product does not replace the old product</i></p> <p><i>Depends on the economy's capacity for radical innovation (proximity to technological frontier)</i></p>	<p>(Direct) short-term negative impact on employment</p> <p><i>When capital allows the workforce to be replaced at a lower cost</i></p> <p>(Indirect) short-term positive impact on employment</p> <p><i>Offset by the increase in demand (lower prices, higher income)</i></p> <p>Nil or positive total long-term impact</p> <p><i>Depends on the balance of effects and necessary adjustment time</i></p>

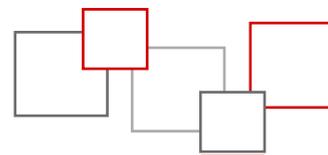
Source: Calvino F. and Virgillito M.-E. (2016), COE.

Without reaching any consensus whatsoever on data, prospective studies have observed a potential significant if not massive risk for employment

Even if they only seek to determine the potential for job cuts, without considering job creations, **prospective studies aimed at assessing the magnitude of the impact on employment of new changes stemming from automation – and more recently from digitalisation and advances in big data – have drawn much less positive conclusions.**

It should be noted, however, that the results of these studies vary widely. Depending on the methodology adopted, for example, existing prospective studies (e.g. Frey and Osborne, 2013; Arntz, Gregory and Zierahn, 2016; Le Ru, 2016; McKinsey, 2016) have drawn wildly different conclusions as to the number of jobs endangered by automation.

The risk may be significant, if not massive, however.

**Table 2: Recap of conclusions drawn by the principal prospective studies on France**

Study	Analysis level	Data	Timescale	Percentage of jobs at high risk
Roland Berger (2014)	Professions	French job structure (INSEE)	Medium/long-term (10-15 years)	42%
Arntz, Gregory, Zierahn (2016)	Individual (tasks)	PIAAC	Medium/long-term (10-15 years)	9%
Le Ru (2016)	Individual (working conditions)	Working Conditions survey (DARES)	Near future	15%

Source: COE.

These studies are subject to a certain number of serious limits, however, as pointed out by the authors themselves.

First of all, such limits are inherent to the prospective quantification of automation risk: it is not possible to scientifically establish a threshold past which a given job would be automatically automated.

They also result from methodology choices and constraints. The studies presented above address the potential risk of jobs being replaced by machines as estimated at a point in time “t”: they **rely on estimates based on the current technological frontier**, which by definition may evolve at a faster or slower pace.

They also focus on the risk of man being replaced by machine from a technical standpoint only and **factor in neither the possible transformation of existing jobs, nor the direct or indirect job creation potential** of automation technologies.

Nor do they consider all the parameters involved in the decision to replace human workers with machines, such as the social, institutional and economic obstacles liable to impede the actual dissemination of automation technologies.

The study commissioned by the COE shows that less than 10% of jobs accumulate vulnerabilities liable to threaten their existence, and that approximately half of existing jobs may see an extensive change in content

The COE wished to obtain additional components of analysis **specific to France** which could be used not only to better assess the number of jobs liable to see a significant change in content due to automation (instead of focusing the analysis exclusively on job destruction risk) but also to identify jobs most likely to evolve due to some of their specific features. The General Secretary's Office performed such a study based on data drawn from the *Working Conditions* survey. These data helped zero in on the individual conditions in which jobs are actually performed by the employees holding them.

This study aimed to resolve a number of shortcomings identified in the methodology choices adopted by existing prospective studies. Instead of conducting a profession-by-profession analysis, it drew up an



inventory of actual working conditions, addressing not only jobs assumed to be “threatened” by extinction but also those liable to evolve, based on recent individual French data.

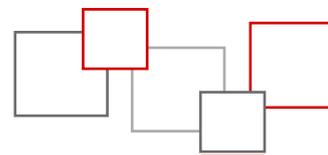
That said, the approach taken by this study was not intended to offer a final analysis of the actual replacement of workers by machines. It naturally presents its own general limits characteristic of any forward-looking study on this topic. Above all else, it should be seen as a way to shed light on workers' exposure to technologies in France.

Methodology

Based on the answers given by employees participating in the Working Conditions survey, the study put together a job automation index for each individual. This study aggregated the four factors identified by recent economic literature as determining a given job's vulnerability to automation under current technological conditions: flexibility, capacity to deal with unknown situations, capability of resolving problems, and social interactions. In addition to these factors, there is precision, identified as a major bottleneck for manual jobs.

Each factor is defined by a set of features characteristic of the job in question, which varies depending on whether the job is exercised in the manufacturing or services sector, and whether the job is manual or not. Each feature corresponds to a question raised in the Working Conditions survey. For example, in the case of a manual job in the manufacturing sector, a lack of adaptability is denoted by the fact that the worker would not have to stop performing a task in order to perform another unplanned task, or by the fact that the worker has to strictly follow a set of orders, guidelines or instructions to complete the task. Overall, 12-17 questions in the survey were mobilised (depending on whether non-manual services or manual manufacturing jobs are taken into account).

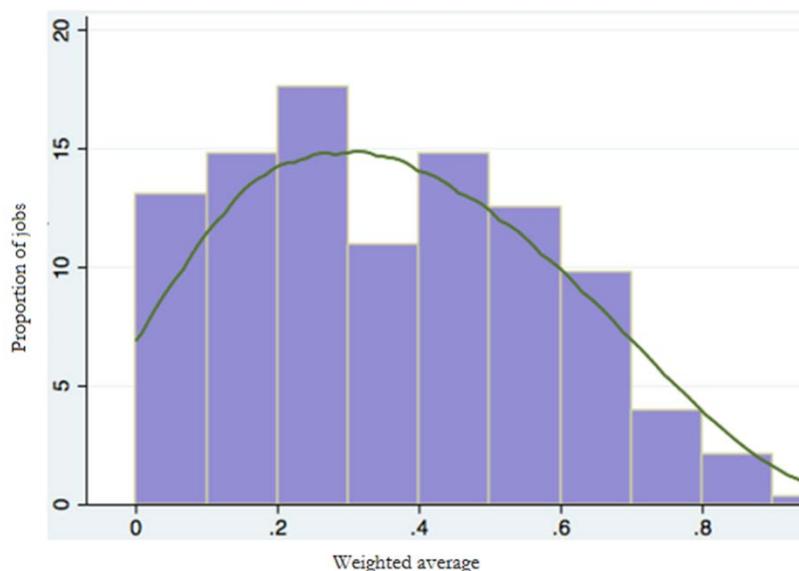
The automation index is standardised from 0 to 1. The more the job presents features, according to the person surveyed, corresponding to the four vulnerability factors, the higher the value of the index. As a result, the jobs most exposed to automation risk are those for which the automation index is close to 1.



Results: less than 10% of jobs are highly exposed to automation due to technological changes, while approximately half are liable to be extensively altered

The study assesses the working population's degree of exposure to automation, as shown in the chart below.

Chart 1: Distribution of the automation index in the working population



Note: The chart can be read as follows: approximately 13% of jobs in France have an automation index ranging from 0 to 0.1.

Source: General Secretary's Office of the COE

Three main conclusions can be drawn from this chart:

- **the distribution of the index shows no polarisation of the workforce.** This conclusion differs from that of the Frey and Osborne study, which indicated a higher proportion of the workforce at both ends of the scale;
- **only a small percentage of jobs has a high automation index:** less than 10% of jobs significantly total a large number of features making them vulnerable to current technological advances. This document will refer to these jobs as “exposed”;
- **a much higher percentage of jobs is nevertheless potentially affected by automation:** nearly 50% of jobs could see a change in content with the development of digitalisation and automation technologies. This document will refer to these as “jobs whose content is subject to change.”

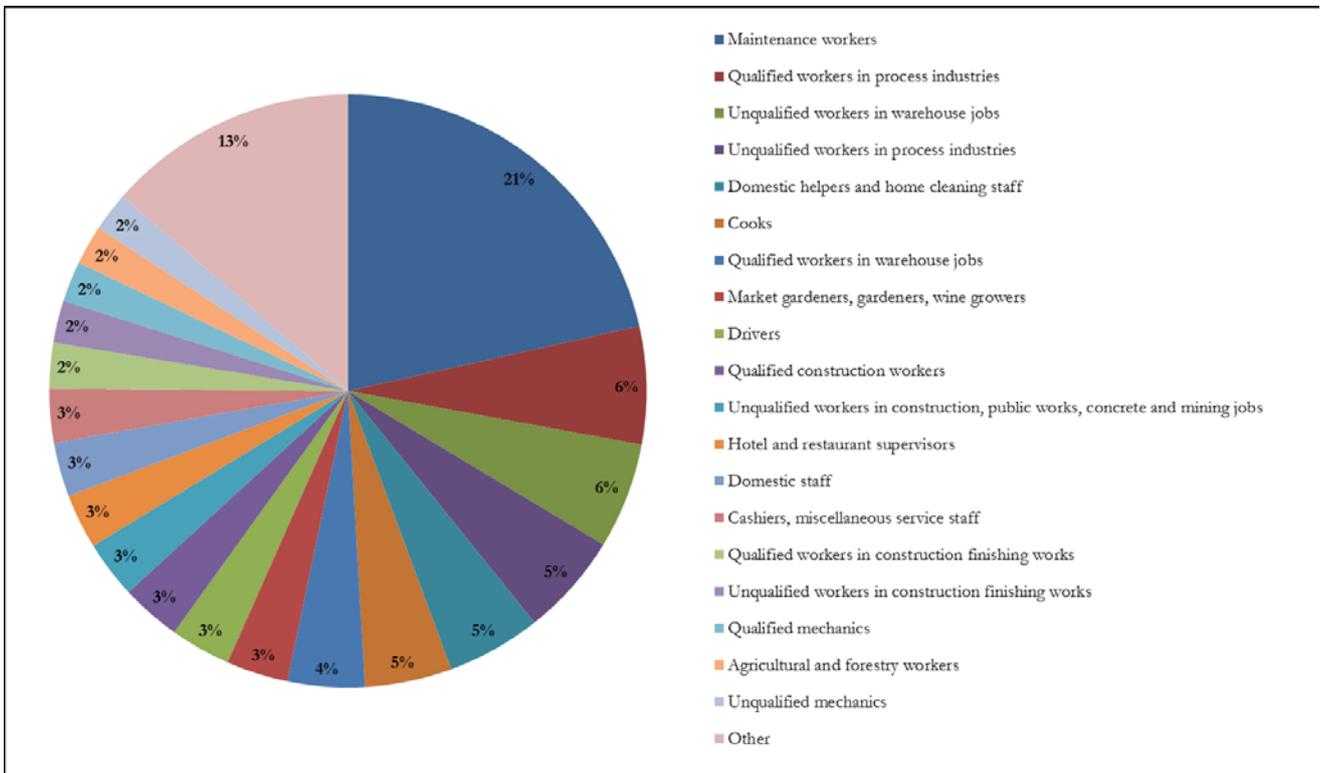


Breakdown of “exposed” jobs and jobs “whose content is subject to change”

Based on these data, it is possible to look at the degree of exposure of each job in the sample to determine which professions are the most exposed and most affected by automation. This complementary analysis can take two forms:

- first, examining which of the “exposed” and “subject to change” jobs are, in volume terms, the most represented, i.e. looking at which professions have the largest “exposed” and “subject to change” workforce;
- next, fleshing out this initial volume-based approach, we can try to identify the main professions which are over-represented among the most “exposed” jobs (or the most “subject to change” jobs), i.e. those for which the share of most “exposed” (or most “subject to change”) jobs due to automation technologies is higher than their share in total employment.

Chart 2: Breakdown of most “exposed” jobs by volume



How to read the chart: of the jobs totalling the highest number of features exposing them to automation and digitalisation risk (automation index of at least 0.7), maintenance workers account for 21% of all “exposed” jobs. This chart only includes professions representing more than 2% of exposed jobs.

Source: General Secretary's Office of the COE

Of the most “exposed” jobs, the most proportionately represented professions relative to their percentage of total wage-earning jobs are more often than not manual and relatively unqualified professions, particularly in the manufacturing sector: unqualified workers in process industries, unqualified workers in warehouse jobs, unqualified workers in finishing works jobs, maintenance personnel, unqualified mechanics, cashiers. This category also includes a few qualified professions, such as qualified mechanics and qualified workers in process industries.

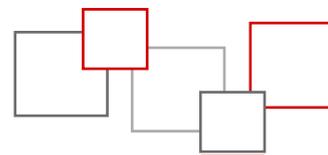
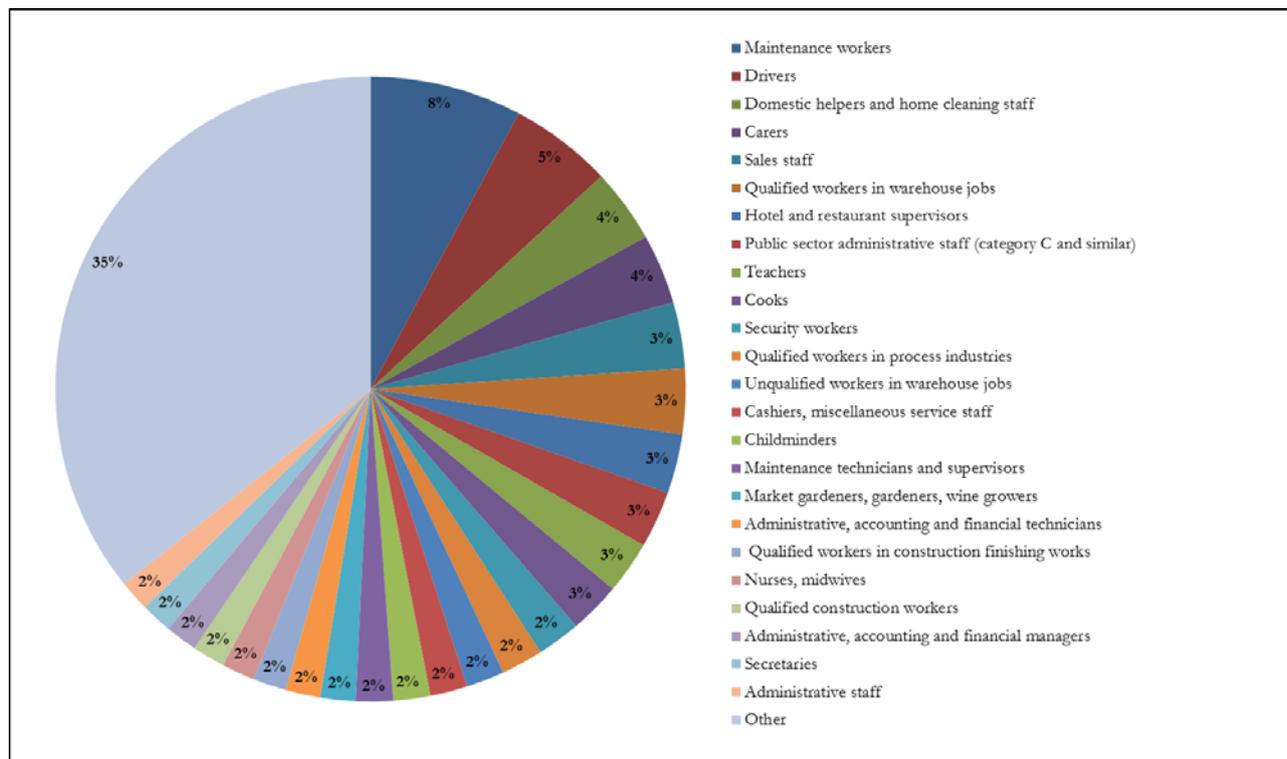


Chart 3: Breakdown of “subject to change” jobs by volume



How to read this chart: Of the jobs affected by the reconfiguration of content and working methods due to automation (automation index ranging from 0.3 to 0.7), maintenance workers (T4Z) account for 8% of all “subject to change” jobs. This chart only includes professions representing more than 1.5% of jobs subject to change.

Source: General Secretary's Office of the COE

Of the most “subject to change” jobs, the most proportionately represented professions relative to their percentage of total wage-earning jobs also often tend to be manual and relatively unqualified professions, but more are found in the services sector than among the most “exposed” jobs: drivers, cashiers, transport operators, hotel and restaurant supervisors, domestic helpers and home cleaning staff for example.

Real, but difficult to measure, job creation potential

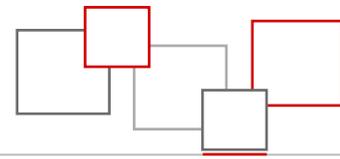
The job creation potential of new technologies is twofold. First, there is the potential to create direct jobs specific to the development of the technology in question (digital and robotics professions). More importantly, there is the potential to create indirect jobs across the entire economy, mainly through offsetting effects.

In this case, in terms of the current digitalisation and automation movement, the report details the reasons for which:

- **direct job creation potential is differentiated: job creation potential is significant in the digital field** (according to existing prospective studies, net job creation momentum should remain strong in the coming years) and **is more limited in robotics** (mainly because the sector is currently small in France);
- **indirect job creation potential, which is much harder to measure, is real, thanks in large part to three factors:** advances made in artificial intelligence and robotics are part of a broader movement of



technological advances capable of leading to the **emergence of product or service innovations** with a greater chance of having a positive impact on employment than process innovations. The dissemination of automation technologies could then **help exposed sectors (particularly in manufacturing) improve their cost and non-cost-based competitiveness alike**, with a positive impact on employment (French manufacturing companies, made more competitive, could gain market share outside France and thus increase their production with ultimately positive impacts on employment); finally, the improvement in productivity and competitiveness in exposed sectors linked to these new technologies could have **additional multiplier effects in sheltered sectors**.



Impacts on job structure and content

Job structure has been dramatically altered since the 1980s, due in part to the dissemination of digital technologies

France has seen a change in job structure since the 1980s which appears to have benefited the highest-qualified jobs the most. In other countries such as the United States, the increase in the highest-qualified jobs has come with an increase in relatively unqualified jobs, to the detriment of intermediate qualifications: this is known as job polarisation. This trend is less prevalent in France.

One of the main explanations given for this distortion of job structure is the dissemination of new technologies, and notably digital technologies. These technologies are thought to be more easily substitutable for the jobs associated with manual and “routine” cognitive tasks. This category tends to include intermediate qualifications. However, they are said to be complementary to jobs associated with “non-routine” tasks in which employees must solve problems or show creativity or leadership. This category tends to include highly qualified jobs.

Although the matter has been addressed predominantly in the US, several studies have validated that new technologies in France have a relatively negative impact on the employment of workers performing manual and “routine” cognitive tasks, versus a relatively positive impact on the employment of workers performing “non-routine” tasks. While the dissemination of technologies may have contributed to the distortion of job structure, skewing in favour of more qualified jobs, in particular, other contemporary factors such as globalisation, demographic changes and organisational changes have also played a role in this trend.

The dissemination of new technologies has also contributed to a major shift in professions, underscored by the widespread complexification and rapid development of analytical and interpersonal skill sets

In addition to job structure, digital technologies have also helped alter the content, in terms of tasks and skill sets, of professions in recent decades.

Several studies have observed the relative complexification of existing jobs in connection with the dissemination of new technologies, underscored by the rapid development of analytical and interpersonal skill sets. For example, there has been a widespread increase in cross-disciplinary skills sets (particularly for executives): project management, ability to work on a multi-disciplinary team, ability to develop a network or communicate (with colleagues or customers), strong grasp of business strategy, incorporation of commercial objectives.

The change in skills in demand on the job market has also been driven by the advent of new professions in the digital field, which are associated with new and more complex tasks. Of the 149 new jobs that have appeared since 2010², 105 belong to the digital field. These new jobs are representative of new business requirements, involving new and specialised skill sets.

In addition to the dissemination of technologies, other factors such as the growing number of regulations and increasing implementation of standards, changes in consumer practices and behaviours, and the energy transition, can also help explain the changes observed since the 1980s.

Prospective factors: job structure and content (in terms of tasks and skill sets) has changed in line with the spread of new technologies, which should continue benefiting the highest-qualified positions first and foremost

² According to ROME nomenclature (French Directory of Jobs and Professions).



Several prospective studies have examined the impacts of current and future technological advances on job structure in France. **Although expected advances in the fields of artificial intelligence and robotics are likely to extend automation possibilities to increasingly qualified jobs, the least-qualified jobs are subject to the highest risk in volume terms.**

While it is important not to confuse automation risk with actual automation, the replacement of at least some of the least-qualified jobs identified as being threatened by machines should contribute to the continued modification of job structure in favour of higher-qualified jobs. **Consequently, fewer jobs would be available to less qualified applicants, thus raising a number of challenges. The study performed by the General Secretary's Office of the COE found that relatively unqualified or unqualified jobs in the manufacturing sector had the highest exposure to automation risk.**

Irrespective of sector or profession, existing prospective studies have pointed to the increasing complexification of professions, with the rapid development of cross-disciplinary cognitive skills (ability to work in project mode, interactive analytical skills) and new technical skills.

This shift in job content – which applies to all sectors and professions – is another sizeable consideration that may help increase the status of certain professions, but which also calls for special consideration for less qualified workers.

Impacts on job location

On the international front: technological advances, job offshoring and reshoring

Current and future technological advances are liable to influence the international distribution of new and existing jobs by weighing on key business location factors.

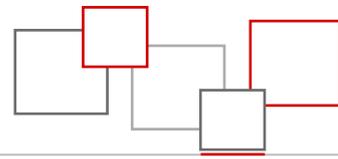
The choice of where to set up a business depends in particular on the size and growth of the local market, production costs (including wages and transport), availability of natural resources, suppliers and adequately skilled workers, the institutional environment (taxes, contract and intellectual property protection) and the competitive environment.

The relative significance of each of these key factors varies by type of activity: for sectors with low barriers to entry, companies may tend to favour countries offering cheap labour and efficient transport infrastructures; for sectors producing and distributing hard-to-transport products, companies will tend to set up operations as close as possible to their end market; finally, for sectors in the knowledge-based economy, companies will lean towards ecosystems offering plenty of partners and qualified workers.

By transforming production methods or cutting down on the cost of coordinating with geographically distant players, technological innovations can alter the relative significance of each key business location factor.

By reducing “distance costs”, information and communication technologies have encouraged the offshoring of certain “routine” manufacturing and services operations to countries with lower labour costs. **This trend has been in place since the 1980s, but may slow down or even reverse in some cases (reshoring), thanks in large part to growing automation possibilities.**

The dissemination of new digital and robotic technologies, coupled with shifts in demand, higher production costs in emerging countries and increased transport costs, **may encourage companies to repatriate activities previously relocated to emerging countries.** Today's consumers expect an increasing level of personalised goods and services, backed by product quality guarantees. As a result, companies now prefer to be closer to their end users, allowing them to quickly adapt their production as needed. In terms of transport, higher commodity prices, environmental regulations and the complexity of managing global



value chains are additional incentives for firms to set up operations close to their end market. Wage rises in emerging countries have also lessened their comparative advantage over developed countries. **Finally, the expansion of automation possibilities in manufacturing as well as services may drive companies to reassess the distribution between capital and labour, and thus the relative significance of their cost.**

Consequently, the combination of new digital technologies and other trends may alter the geographic distribution of activities, they do not at this point appear to be driving a large-scale job repatriation movement. This trend, which is difficult to define and measure, and varies by country, is thought to have affected, in recent years, less than 10% of European companies having previously relocated their activities. Though automation is only rarely pinpointed as the key deciding factor in relocations, the fact remains that technology-intensive companies tend to repatriate their activities the most.

Finally, it is still hard to determine the impacts of business location choices (either relocation or repatriation) on domestic employment. The quantification of the magnitude of job cuts (identified and projected) due to relocations is a source of divergence. Each year in France, an estimated 2% of non-financial retail companies with 50 or more employees relocate their activities, resulting in some 10,000 job cuts (estimates over the 2009-2011 period). The problem with such estimates, however, is that it is impossible to measure the impacts on employment had these companies decided not to relocate.

For now, job repatriation is thought to have a limited impact on domestic employment. According to some studies on the United States and the United Kingdom, future job repatriations will go hand-in-hand with significant net job creations. In France, it is important not to underestimate the significance of the potential for job creations linked to repatriation largely made possible by technological advances, simply because of the shortcomings in available studies on the matter.

On the national front: new technologies should help further the agglomeration of activities, particularly in large cities

The current and future dissemination of digital technologies has different impacts on employment depending on sector composition and the type of workers in the local labour market considered.

On the one hand, the regions most likely to see jobs destroyed by increasing automation possibilities should be those in which manufacturing sectors traditionally considered to be relatively non-technology-intensive account for a high percentage of jobs (especially if these regions specialise in these sectors), **but also if they tend to have a high density of relatively unqualified workers and where jobs involving predominantly “routine” tasks make up a large percentage of local jobs.**

On the other, regions that can be expected to benefit from the dissemination of technologies include:

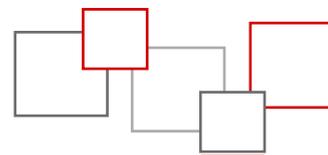
- first, regions capable of **attracting job repatriations** particularly in manufacturing;
- next, urban areas where companies can benefit from **agglomeration economies** and draw from a **talent pool** whose skill sets are compatible with new technologies.

Finally, the development of sectors driven by such technological advances may have more indirect effects on local employment by promoting the development of spinoff jobs. Jobs in technology-intensive industries, or more generally in the trade sector, can also lead to job creations in qualified and relatively unqualified service positions within the same local economy. And while this trend has clearly been observed in France, the value of this multiplier effect is still subject to debate.



Conclusions

- 1. Economic history has taught us that, while employment has changed dramatically in the past two centuries, it has also continued to increase with each technological revolution.** The fairly positive link between employment and new technologies has also been confirmed in the last three decades.
- 2. The nature and unprecedented scale of progress associated with digital and automation technologies, coupled with the recent slowdown in productivity, have called into question the evolution of employment at the heart of public debate. Amid growing uncertainties surrounding future technological advances and their rate of dissemination in the economy, the COE wanted to address the issue in its entirety in order to shed light on this debate and the development of public policies. All too often, the issue is only partially analysed, potentially leading to distorted conclusions.** Either the studies focus on job destruction alone, when they should also consider job creations, albeit harder to conceive and quantify. Or they look at the issue from a purely quantitative standpoint while completely overlooking the qualitative aspects, i.e. the transformation observed in the content of jobs and labour.
- 3. The lessons learned from recent economic analysis invite us to consider timescale aspects, and not just how fast the technological frontier is shifting.** After all, the introduction of new technologies is not simply a matter of machine replacing man, or making more with less, with merely job destruction at stake. The productivity gains associated with process innovations, allowing companies to operate with fewer employees, are also liable to promote market share gains, especially on the export side of the equation. Alongside or in the wake of such process innovations, product innovations may appear, with positive impacts on employment – provided of course that the new products do not replace the old ones. Furthermore, more or less quickly, offsetting mechanisms or macroeconomic knock-on effects end up increasing employment, either directly through jobs needed to implement new technologies, or indirectly through increased demand. **Two critical issues need to be considered: it is important to ensure that these offsetting mechanisms can operate in the best possible conditions and in the shortest possible timeframes, and the transition period has to be well managed.**
- 4. An economy cannot avoid or even temporarily steer clear of technological advances, lest it run the risk of falling behind:** technological progress is not an option and speed of adaptation is also criterion for success in an increasingly globalised world.
- 5. The dissemination of new technologies, and consequently their impact on employment (and particularly national employment), is by no means set in stone:** at any given technological frontier, scenarios may vary widely depending on the choices made by economic operators – entrepreneurs and investors alike – and the conditions resulting from their environment. Additional decisive factors include **ethical and social standards** as well as **public policy choices**. This category includes public and private sector innovation and R&D support, the establishment of technical standards, the application of anti-trust law (oligopolies), education, training and employment. All of which affects the social compact and support for global supply and demand. The magnitude and critical nature of choices to be made call for the most extensive possible assessment taking all eventualities into careful consideration, which is the only way to make the right decisions in an uncertain environment.
- 6. Of course, the right framework of analysis must be used in order to establish this forward-looking assessment. The empirical studies analysed by the COE clearly show that, when a machine takes over a man's job, it replaces one or more “tasks”, i.e. it changes the way a job is done by mobilising certain**



skill sets – it does not replace entire jobs. First of all, all the individuals that perform the same “job” do not necessarily perform the same tasks; second, the content of the tasks within a given job may evolve with technological advances in particular.

7. Accordingly, it is better to use individual data that describe the reality of jobs in France and take the complexity of their content into consideration. **The study performed by the General Secretary's Office of the COE** on wage-earning jobs in France, based on data taken from the *Working Conditions* survey, showed that:
 - ✓ **less than 10% of existing jobs are subject to cumulative vulnerabilities liable to threaten their existence due to automation and digitalisation;**
 - ✓ **but half of existing jobs are liable to change in terms of content, from significantly to very significantly;**
 - ✓ **technological advances should continue to promote qualified and highly qualified jobs:** of those that may be vulnerable, over-represented professions with respect to volume or their percentage of total jobs, are often unqualified or relatively unqualified jobs.
8. **The prospect of the massive destruction of existing jobs, hinted at by certain studies stating that nearly 50% of jobs may be exposed to high automation risk, is therefore not the most likely. That said, the changes in progress are sure to trigger big changes in existing jobs,** including in sectors and professions which up to now had not appeared to be the most directly affected.
9. New digital technologies have tended to initially encourage the out-of-country relocation of certain activities, and thus some or all of the corresponding jobs. **The automation and digitalisation movement may ultimately encourage companies to repatriate activities, with potential positive impacts on employment, even though only a few examples have been observed at this point.**
10. **The importance of an assessment that factors in the uncertainty surrounding the impacts of new digitalisation and automation technologies cannot be underestimated** because this is the foundation on which changes in public policy and regulations must be built. Such changes differ in magnitude and nature depending on how fast or sudden the transformations are, whether they are minor or massive, and focused or not on specific areas of expertise, geographic areas or job categories. In Volume 2 of this report, the COE plans to review exactly what is at stake in terms of skill sets, professional mobility, organisation of working hours and management methods, working conditions and support for innovation, taking into account the uncertainties associated with the phenomenon **based on different scenarios**. It will also formulate public policy recommendations covering all fields of work and employment.