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RAPPORT

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Artificial Intelligence and Work

Report to the Minister of Labour and the Minister of State for the Digital Sector

ARTIFICIAL INTELLIGENCE AND WORK

Rapporteurs
Salima Benhamou and Lionel Janin

With contributions by
Agnès Bocognano, Julia Charrié and Guillaume Thibault

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FOREWORD

Following on from work carried out in spring 2017 in the context of the #FranceIA initiative, to which France Stratégie contributed, Member of Parliament Cédric Villani was assigned the task of analysing the economic, social, environmental and ethical issues involved in artificial intelligence. Muriel Pénicaud, Minister of Labour, and Mounir Mahjoubi, Minister of State for the Digital Sector, commissioned France Stratégie to make a special study of the impacts of artificial intelligence on the world of work, which is the subject of this Report.

The key question is whether artificial intelligence represents a technological disruption that will transform the world of work abruptly and without warning, with major repercussions on employment, or whether it is simply another step in the digital transformations that have been at work for several decades. In order to try and answer this question and provide concrete examples of the issues involved in upcoming changes, our report focuses on three sectors, transport, banking and health, outlining scenarios for ways in which the world of work may be transformed.

This investigation sheds light on sectoral specificities and sometimes unexpected and counter-intuitive phenomena. A chatbot that responds automatically at midnight may nonetheless require a human being able to take over from it in case of need. And if machines come to relieve humans of the most routine activities, the latter run the risk of only being assigned the most complex tasks, leading to work intensification and risks of cognitive overload.

The many factors that lead an organisation of whatever kind to decide whether or not to use systems based on artificial intelligence – including cost, profitability, impacts on employees and consequences for customers – and the role played by the demographic, regulatory and social context explain why attempts to forecast impacts on professions and jobs will continue to lack certainty.

As regards transport, the impact that autonomous vehicles may have on employment is especially hard to anticipate: the technology involved is yet to achieve a safety level that would make it possible to make any accurate predictions on a timeline for their

universalisation, which would require new regulations and adaptation of insurance. The consequences that their adoption might have on employment in such specific sectors as long-distance road transport might nonetheless be significant when the time comes.

As regards banking, excluding any scenarios envisaging rapid development of new, highly innovative actors (which is yet to come to pass), integration of artificial intelligence should have a significant impact on financial advisors' professional practices and reinforce the trend of reducing their numbers in branches, but without any major disruption.

As regards health, the most spectacular applications – surgical robots and interpretation of x-rays and electrocardiograms – are not the only ones that will impact definition of professions and employment. Computer-assisted diagnosis and prescription and remote monitoring of patients may also make far-reaching changes in the current order, in particular with regard to distribution of tasks between health professions (physicians, and advanced practice nurses (APNs)).

This Report proposes avenues for action that mobilise means of anticipating impacts, training and safeguarding career paths. Adopting them should make it more likely that work transformations connected with use of artificial intelligence will take place in a controlled fashion.

Gilles de Margerie
Commissioner General, France Stratégie

CONTENTS

OVERVIEW

Artificial intelligence – meaning the group of technologies that aim to carry out tasks traditionally assigned to human beings computationally – is central to current debate on social transformations. First and foremost, expected changes in the world of work give rise to two contrasting attitudes. Some people proclaim their optimism in the face of a technology that ensures productivity gains and is therefore a source of wealth, and which promises to do away with the most tedious tasks. Others make pessimistic prophecies on the inevitable disappearance of whole realms of activity and corresponding jobs. This being so, public debate is polarised in unproductive opposition as it fails to highlight factors of transformation or levers for action.

In order to help clarify such debate, Muriel Pénicaud, Minister of Labour, and Mounir Mahjoubi, Minister of State for the Digital Sector, entrusted France Stratégie with the mission of analysing the impacts of artificial intelligence (AI) on the world of work[1]. This mission is complementary to the one that the Prime Minister entrusted to Member of Parliament Cédric Villani, which, given its wider scope, tackles questions of research, industrial policies and ethics. The goal is the same: educate to eradicate fantasy, but take stock of expected transformations while identifying appropriate public policies[2].

AI has been making spectacular progress over the last few years. Technologies resulting from recent research, such as machine learning and deep learning, have arrived from laboratories to carry out tasks that previously seemed impossible for machines to perform, such as image recognition, providing a satisfactory translation of a simple text, or winning a game of Go. Such technologies are already at work in our smartphones and constitute the framework of much of the pairing software already deployed in such areas as online advertising and profiling.

[1] See the Mission Letter in the Appendices.

[2] The rapporteurs would like to thank all those heard in the context of this mission (see the list in the Appendices), especially Pierre Blanc, Manuel Gea, David Giblas, David Gruson, Enguerrand Habran, Claude Leicher, Antoine Malone, Alain Sauvant and the Villani mission.

With the exception of a few specialised fields, AI is not yet much in evidence in most professions. This does not make its possibilities any the less significant, in particular for retail banking, transport and health – three sectors which are examined here in depth.

Artificial intelligence will undoubtedly be called upon to carry out complicated but repetitive or regularly performed tasks, which will obviously affect professions that include such tasks. But this transformation is not radically different from digitisation of the economy, which has been with us for some time and to which the banking, transport and health sectors have adapted more or less happily by modifying job content, training workers and developing new activities. Employees have also been adding to their skills for some time now in response to robotisation, in particular in industrial sectors, a fact that may guarantee their continued employment if it ensures growth of a company's or sector's activity. This is evidenced by the advanced robotisation of Germany's automotive industry: in 2016, although it is one of the most robotised industries anywhere in the world, it had over 800,000 employees, 100,000 more than twenty years ago, as against 440,000 in France[1].

There can be no doubt that employees risk losing their autonomy by being subjected to increasingly insidious automated monitoring, with all the psychosocial risks involved. We are well aware of the controversy over working conditions in a number of warehousing facilities, where automated monitoring of employees is carried out by a system incorporating voice synthesis. Such systems may lead to greater fragmentation of tasks, performed with support from software tools.

None of these challenges is completely new, and improvement of working conditions is just as likely a hypothesis as alienation and work intensification. Everything depends on the way in which productivity gains enabled by artificial intelligence are shared and the choices made in task and team organisation.

Of course, factors other than technology have an impact on work. The behaviour of workers, customers and suppliers, qualification levels of a sector's workers and possible tensions connected with lack of manpower, along with regulatory obligations, often play a determining role in the evolution of work.

What makes the present context different is that artificial intelligence is often based on a learning mechanism, with ongoing accumulation of data enabling continuous

[1] Le Ru N. (2016), "L'effet de l'automatisation sur l'emploi : ce qu'on sait et ce qu'on ignore" (The effect of automation on employment: what we know and what we don't), *La Note d'Analyse*, no.49, France Stratégie, July; see also key figures for the automotive sector.

improvement of systems – to the point of creating, one day in five or ten years' time or more, a real breakthrough in what it is technologically possible to do, depending on tasks concerned. Emblematic of such a future breakthrough is the promised advent of the autonomous vehicle. This revolution in mobility may eventually do away with the profession of driver, but at the same time it opens up a whole range of possible new professions in complementary activities. Construction, maintenance, fleet management and passenger assistance will remain, while recreational outings, logistics and straightforward professional travel will all benefit from lower costs and/or increased availability.

Spectacular progress is to be expected in all three fields examined in this Report: autonomous vehicles providing mobility, automated financial advisors in the form of chatbots, and medical assistants participating in monitoring health and wellbeing on a daily basis, as well as in prediagnosis and therapeutic proposals.

How many people are concerned in their everyday working lives? Potentially everybody, all the more so in that artificial intelligence tools are generic in nature, typically concerned with natural language processing and voice or image recognition. The 800,000 people in France who work as drivers are likely to see their work change radically as use of autonomous vehicles increases. The transformation will not necessarily be a sudden one, but will lead to orientation of work content to supervisory and reception tasks, or tasks that machines are unable to manage (such as finding the doorbell, for a delivery man).

All this may still seem a long way off, but it is already mobilising actors (innovators, longstanding professionals, customers and users alike), which also affects work transformation dynamics.

We must prepare ourselves for artificial intelligence, not because its advent is inevitable but because, in the society in which we live, technological possibilities open up new prospects for individuals, organisations and structures. There is nothing at all to be gained by lasting opposition to solutions that improve our fellow citizens' health, provide access to safer and less expensive mobility, and provide cheaper financial services better adapted to consumers' needs.

There is more than one way to go in such evolution, however, and this is where the public authorities must concentrate their efforts: setting a path that matches citizens' social expectations, by defining appropriate controls on critical subjects (responsibility, security, etc.), and by accompanying evolutions that occur too quickly, so that the social and economic fabric adjusts naturally.

On the basis of the analysis it presents, the Report identifies three focuses to respond to the issues involved in artificial intelligence as far as the world of work is concerned:

- carrying out forward-planning work at industry and sector level on the potential of artificial intelligence, in order to ensure that stakeholders are fully informed and able to anticipate changes to come;
- seeing that workers receive training on the issues of tomorrow's world: training highly qualified workers for production of AI, and workers who are fully aware of the technological, legal, economic and ethical issues involved in the use of tools based on artificial intelligence;
- improving schemes for safeguarding career paths in the sectors and subsectors that are set to be heavily impacted by the risk of automation.

Lastly, we should take care not to underestimate risks with regard to working conditions – loss of autonomy, work intensification, etc. – connected with the conditions in which AI tools are deployed in organisation of work.

DEFINITION
AND FIELD OF INVESTIGATION

1. Issues

Artificial intelligence has become a central topic in recent debate on social and technological changes in France itself and across the world. As a recent France Stratégie publication[1] emphasises, AI is a technological building block in the digital transformation. Even though its popularity only goes back a few years, it is heir to a long lineage – formal neural networks were first conceived in the 1940s and the term artificial intelligence was coined in 1956 – and is only one of many transformations brought about by digital technology, which include the advent of data platforms and exploitation. All such technological advances have a major influence on changes in the world of work: the subject of this Report.

Some observers see artificial intelligence as an economic opportunity due to the productivity gains it may generate (lower costs as a result of automation of operations, improvement of coordination processes, production flow optimisation, etc.) and the new markets it may create. AI is also perceived as a social opportunity, largely thanks to processing of big data generated by connected systems; which may well give rise to new professions (data scientists, AI programmers, etc.) and improve working conditions, in particular by taking over repetitive routine tasks. Others, however, see AI as a threat to employment and a vector for aggravation of inequalities and social polarisation, with almost certain disappearance of whole realms of activity in many sectors (industry, banking, finance, trade, etc.) and various

[1] France Stratégie (2017), *Mutations sociales, mutations technologiques* (Social Changes, Technological Changes), Seminar report, October 2015 – June 2017. This document provides an assessment of two years of seminars organised by France Stratégie in partnership with the *École des hautes études en sciences sociales* (EHESS – School for Advanced Studies in Social Sciences) and the *Institut national de recherche en informatique et en automatique* (INRIA – National Institute for Research in Computer Science and Automation).

professions, some requiring few qualifications but others that are highly skilled (lawyers, auditors, physicians, etc.).

At present, there is no general consensus between these two extreme scenarios. The situation leaves plenty of room for uncertainties, even fears, as to the ways employment will evolve in a context of slackening economic growth and continuing mass unemployment. Such worries are expressed in a recent survey[1], in which 49% of respondents thought there would be significantly fewer jobs available in the next ten years.

A number of researchers have put forward the hypothesis of massive automation of existing jobs – up to 47% of all jobs – by technologies including artificial intelligence[2]. However, this very high figure may be partly explained by the fact that the researchers concerned reasoned by profession rather than task. Analysis of the risk of a job becoming automated should take full account of all the tasks it is composed of, their nature and their integration into the way work is organised. Automation of some tasks is not enough to determine the risk of an entire profession becoming automated. Observing at task rather than profession level, other researchers have assessed the risk of automation as between 10% and 15%[3].

Furthermore, such studies only focus on the potential for job elimination, without taking account of the fact that technology is only one of the factors leading to transformation, and that new jobs will be created by it. It is therefore difficult to assert with any degree of certainty whether recent technological evolutions, including AI, are really a threat to or an opportunity for employment.

In the face of such uncertainty, we have turned to history in order to imagine what work will be like in tomorrow's world and the consequences that artificial intelligence will have on employment. History shows us that technological advances have never led to abrupt changes leading to massive destruction of jobs; on the contrary, they have always seen the advent of new forms of work. But are we not confronted with an

[1] Ipsos/Sopra Steria survey carried out for *Lire l'Economie* and *Le Monde*, published on 6 December 2017.

[2] Frey C.B. and Osborne M.A. (2017), "The future of employment: How susceptible are jobs to computerisation?", *Technological Forecasting and Social Change*, Vol. 114, pp.254-280.

[3] Nicolas Le Ru (2016), "L'effet de l'automatisation sur l'emploi : ce qu'on sait et ce qu'on ignore" (The effect of automation on employment: what we know and what we don't), *La Note d'Analyse*, no.49, France Stratégie, July; *Conseil d'orientation pour l'emploi* (COE – Employment Advisory Council, 2017), *Automatisation, numérisation et emploi, Tome 1 : Les impacts sur le volume, la structure et la localisation de l'emploi* (Automation, digitisation and employment, Volume 1: Impacts on volume, structure and location of employment), January.

altogether new phenomenon? Artificial intelligence may not only impact the volume of employment – as its dissemination is partly consequent to possibly very rapid dissemination of software – but also its content, as it is no longer a matter of increasing physical strength, agility and speed, as was the case in previous industrial revolutions, but rather of carrying out cognitive tasks.

AI has made very considerable progress over the last few years, due in particular to big data, an increase in computing capacities and advances in the field of algorithmics. It can now enable performance of complicated tasks as long as they are regular in nature or a large number of examples of them exist. In the near future, technological progress may well enable AI to carry out increasingly complex tasks, coming ever closer to rivalling human cognitive capacities. The machine's victory in a game of Go, the first autonomous vehicles, and performances by computer-aided medical diagnosis software are all emblematic of the advances made thus far.

It is difficult to know what will be happening in fifteen or twenty years from now, both as regards technological advances and their dissemination and appropriation, particularly in the world of work.

Technology and how much it is used are certainly factors of change, but are far from being the only determinants of transformations of work organisation and practices. Other factors also come into play, including legal environment, economic context (competition in particular) and social environment (whether as regards level of education, access to training, individual aspirations or demography), all of which also contribute to "shaping" work. If we want to project ourselves into the future in order to identify benefits and risks connected with AI, forward planning must also incorporate these contextual factors, which, combined with future advances in AI, may well transform work and employment.

With a view to shedding light on the debate underway, Muriel Pénicaud, Minister of Labour, and Mounir Mahjoubi, Minister of State for the Digital Sector, asked France Stratégie to come up with scenarios for transformation of work resulting from AI[1], a mission carried out in parallel with that entrusted to Member of Parliament Cédric Villani, which, given its wider scope, covers questions of research on AI, industrial development of AI and its applications in the public sphere, along with ethical issues and social acceptance. Both missions follow on from the Summary Report produced in spring 2017 under the #FranceIA label, to which France Stratégie contributed alongside the *Conseil national du numérique* (CNNum – National Digital Council) with

[1] See the Mission Letter in the Appendices.

their report on the economic and social impacts of AI[1]. This Report also continues on from work on transformation of work organisation and changes in the world of work by 2030[2].

Defining artificial intelligence is the first step in providing the keys to understanding future transformations. The uncertainties regarding its long-term potential help "inflame" ongoing debate, given the fact that AI raises questions that go far beyond the world of work – more fundamental questions connected, among other things, with ethics and social acceptability, from personal data protection, AI designers' and users' responsibility and transparency of human/machine interactions to monitoring of individuals… These aspects are analysed in detail in the context of the mission entrusted to Member of Parliament Cédric Villani.

This Report does not seek to supply exact answers on what work will be like in tomorrow's world. Its main goal is to provide a realistic picture of plausible possibilities in various fields of application and selected activity sectors. This sectoral approach aims to examine potential opportunities and risks in detail with focuses including task evolution, learning dynamics, increases in technical and social skills, changes in working conditions, managerial practices and gains in or loss of autonomy.

We have purposely chosen to concentrate on three sectors – health, retail banking and transport – that seem to us capable of providing an adequate picture of changes to come. AI has already started to spread in these sectors, if it is not already well and truly integrated. They are also regarded as sectors that create jobs and are therefore a major focus of public policies. Lastly, this Report identifies the main short- and medium-term challenges that the State, companies, social partners and civil society in its widest sense will have to face up to.

[1] France Stratégie and the *Conseil national du numérique* (CNNum – National Digital Council) (2017), Contribution to the national strategy on artificial intelligence: *Anticiper les impacts économiques et sociaux de l'IA* (Anticipating the economic and social impacts of AI), report by the workgroup co-chaired by Rand Hindi and Lionel Janin, March.

[2] Benhamou S. (2017), "*Imaginer l'avenir du travail - Quatre types d'organisations à l'horizon 2030*" (Imagining the future of work – Four types of organisation by 2030), *Document de travail*, no.2017-05, France Stratégie, April.

2. What definition?

Looking back at history

We do not claim to provide an exact technological definition of artificial intelligence in this Report. The subject has been tackled in a great many earlier reports, including those published by INRIA[1], FranceIA[2] and the Academy of Technologies[3]. Let us just say that artificial intelligence is a scientific discipline that is by no means new, with its foundations dating back to the beginnings of computer science in the 1940s and 1950s, with numerous different methods, whose purpose it is to reproduce cognitive functions by computer science. The term “artificial intelligence” itself was coined in 1956.

Highly efficient technologies...

One branch of AI, known as machine learning or statistical learning, has made spectacular progress over the past few years, due to the remarkable efficiency of multilayer deep neural networks in performing classification tasks, of images in particular, following a learning phase based on a large number of examples.

Without going into the details of these technologies, suffice it to say that they reproduce existing classifications or achieve well-defined objectives such as winning a game. Even though the exact mechanisms that result in such efficiency are not yet fully understood from a theoretical point of view, the technology is nonetheless determinist and controlled, insofar as the AI programmer chooses the software architecture he wishes to use (type of neural network, number of layers, etc.), the learning method (initialisation algorithm and updating of weights for each neuron) and the training data to be used. We are therefore a long way off from an autonomous system escaping from its designer in a re-enactment of Frankenstein and his Monster.

Such systems possess a real capacity for learning, in the sense of automatic exploration of a group of solutions a great deal larger than the algorithm’s designer would have been able to imagine. This is how AlphaGo software, which had been trained to play Go on the basis of millions of recorded matches, was able to evolve

[1] INRIA (2016), *Intelligence artificielle, les défis actuels et l’action d’Inria* (Artificial intelligence, current challenges and INRIA action), White Paper, no.01, September.

[2] France IA (2017), *Rapport de synthèse* (Summary Report), March.

[3] The Academy of Technologies’ ICT Commission (2018), *Renouveau de l’intelligence artificielle et de l’apprentissage* (Renewal of artificial intelligence and learning), upcoming publication.

into a new version – AlphaGo Zero – to play against itself and use a new simple objective function – win the match – to improve its strategies until it could win against a human being. This example does not serve to demonstrate any intelligence or consciousness on the machine's part, but rather an ability to solve complicated problems with high configuration space.

Form recognition seemed to require human intelligence, given the almost infinite dimension of the problem to be solved (the number of parameters characterising an image). Advances in neural network design show that this is not the case, however, and this is what sparked off the recent AI revolution that justifies work underway and questions concerning transformations in the world of work: a new category of tasks may now be carried out by machines. In days gone by, it was the same case with physically demanding work, carried out by steam engines, electric motors or combustion engines; it was the case only yesterday when computer science developed calculation and classification aptitudes based on programmable rules; and it is now the case with form-based classifications, whether of images, sound, video or texts. But not, however, of thought.

…but a long way from general intelligence or strong AI

The term "artificial intelligence", coined in 1956 to refer to a scientific discipline imagined as a meeting of computer science and the cognitive sciences, has led the general public to conjure up fantasies of machines that are intelligent in the human sense of the word, gifted with self-awareness, capable of making choices on their own, and – in science-fiction – all too likely to acquire autonomy harmful to humankind. Systems so far developed are a very long way from possessing consciousness. Even so, software malfunctions (bugs, cyberattacks, bad training data, etc.) can have serious, even fatal consequences, whether for automated vehicle steering systems or administration of a therapeutic treatment.

Nonetheless, such advances are still a long way from portending the advent of so-called "strong" AI, which would actually be comparable to human intelligence, in particular in its ability to understand context, make use of "common sense", with an ongoing capacity to learn. Such an achievement seems well out of reach at the present time, as the researcher Yann LeCun[1] has emphasised. However, the generic

[1] "As long as the problem of unsupervised learning has not been solved, we will not have a truly intelligent machine. This is a fundamental scientific and mathematical question, not a question of technology. Solving this problem may take many years, even several decades. Truth to tell, we know nothing about it", Yann LeCun, Computer Science and Digital Sciences Chair, 2016-2017, class at the Collège de France.

character of technologies developed so far is enough to give us a foretaste of future impacts on all sectors of the economy.

Fields of application

AI brings together a range of fields including logical reasoning, knowledge representation, and natural language perception and processing. Its main applications at present are connected with advances in machine-learning techniques, deep learning in particular, which usually requires availability of big data.

A first type of application consists of radically simplifying human/machine interaction. Voice recognition and synthesis and natural language processing (NLP), whether to engage in simple conversations between people and machines or for automatic translation, are just a few examples of this initial group of generic applications usable in a whole range of activity fields.

A second type of application is recognition of specific patterns in big data, resulting from multiplication of sensors or organised collection. Examples include image and video analysis, facial recognition and detection of breakdown precursor signals.

These two major use categories, both of which are closely connected with the degree to which the activities concerned are digitised, are already possible.

A generic technology?

Are we then talking about a "key generic technology"[1], as is the case with smartphones? The debate is ongoing, in particular because, in practice, artificial intelligence includes a whole range of overlapping technologies. Without settling the issue either way, we may nonetheless note that AI is based on software architectures that are widely disseminated in open source, enabling appropriation and reuse of tools developed in a particular sector. Furthermore, machine-learning methods developed in a given sector may often be adapted to other activity fields. For example, AlphaGo Zero software, which was developed to play the game of Go, was successfully adapted to playing chess[2].

[1] According to the European Commission, Key Enabling Technologies (KETs) rely on research and development, rapid innovation cycles, major investments and highly qualified jobs. They are multidisciplinary, often at the boundaries of several technological fields, with a tendency towards convergence and innovation, often resulting from the integration of several KETs.

[2] Silver D. *et al.* (2017), "Mastering chess and shōgi by self-play with a general reinforcement learning algorithm", December.

That said, the highly "artisanal" character of many current applications cannot be ignored. The remarkable efficiency with which AI performs certain classification tasks still has something "magical" about it: developers don't quite know how it all works[1], even though the software itself and the learning method employed are entirely determinist. Exactly how a matrix of several million coefficients manages to achieve the image recognition goals expected of it is still uncertain and is the subject of much current research work. This Report does not intend to explore the question of AI "explicability" further, although it continues to constitute an obstacle to various of its deployments in fields where understanding of results is essential – to determine responsibility in the event of error, for example.

AI and robotics

Another problem concerns definition of the borders between artificial intelligence and robotics. Deployment of robots, in particular in industry and above all in the automotive industry, did not wait for the recent advances in AI. This Report does not therefore focus on automation resulting from robotisation. Nonetheless, modern robotics often includes AI building blocks. Such is the case with robots capable of learning gestures from manoeuvres carried out by operators[2]. Robots increasingly incorporate sensors making use of AI, shape recognition for example, resulting in their developing increased capacities for "stepping out of their cages", as the *Institut national de recherche et de sécurité* (INRS – National Research and Safety Institute) pointed out during its hearing. Previously, robots were "caged"; in other words, they were enclosed in protected areas inaccessible to workers for safety reasons. AI increasingly enables implementation of "soft" human/robot interactions, through use of force sensors. This evolution, which is a priori a beneficial one for workers, who can now interact much more naturally with machines capable of assisting them in carrying out arduous tasks, still has its risks, however, as it gives rise to debate on acceptable force thresholds for unintentional contacts between humans and robots. One of two approaches may come to predominate here: either consider that all unintentional contact should be avoided, or define an acceptable force threshold via standardisation. Without going so far as to deliver an opinion on this particular point, we may nonetheless note that it is the operators themselves rather than technology who define interaction standards, which only raises further questions.

[1] The problem of deep learning's "black box" is the subject of in-depth studies: Castelvecchi D. (2016), "Can we open the black box of AI?", *Nature*, Vol. 538, October, pp.20-23.

[2] For example, the German manufacturer KUKA's IIWA mechanical arm.

Lastly, we should make it clear that this Report bears on existing AI technologies and those that will almost certainly be available in the near future. It looks ahead to evolutions likely to occur over the next five years, but does not take account of possible radical technological progress, in particular as regards the ability to achieve strong artificial intelligence.

3. Three activity sectors under scrutiny

In order to provide concrete examples of the possibilities opened up by artificial intelligence and its impacts on work, this Report draws on analysis of three activity sectors: transport, banking and health, all of which enable us to supply exact descriptions of trends underway and ensure that the issues involved are adequately explored, with possible extension of certain conclusions beyond their borders. Together, the three sectors cover a whole range of realities in terms of types of production, between industry and service, as well as between types of actors, coming from the private and public sectors alike. By focusing on them, we seek to understand the impacts AI is having and will have on various types of employment and in various institutional and regulatory contexts.

The earlier report produced by France Stratégie and the National Digital Council focused on the economic and social impacts of artificial intelligence and adopted a general approach[1]. It drew up a list of various potential effects that AI might have on the world of work and focused on the importance of analysis centred on tasks rather than jobs and identification of substitutable tasks based on current technological progress, as well as contextual factors, social acceptability, the importance of emotional intelligence, and recourse to complex manual operations. It presented concerns with regard to human/machine complementarity: well deployed, AI alleviates repetitive tasks and enriches work content; poorly deployed, it may lead to increased “proletarianisation” of workers, disempowerment and impoverishment of interpersonal relations, and even total disengagement in the workplace.

In order to provide greater depth to and examples of these generic reflections, we now propose to go on to more concrete examination of the impacts of artificial intelligence on three activity sectors generally regarded as being the most exposed:

[1] France Stratégie and the National Digital Council (2017), Contribution to the national strategy on artificial intelligence: *Anticiper les impacts économiques et sociaux de l’IA*, *op. cit.*

- transport, due to the possible rise of the autonomous vehicle, which has been much publicised since Google, followed by Waymo, Uber, Tesla, General Motors, Renault, Peugeot, Navya, Volvo and other corporations announced or started to try out test vehicles;
- retail banking, due to the sector's already advanced digitisation and the intangible nature of the "matter" it handles: exchange of information on transactions, which lends itself perfectly to exploitation by AI;
- health, due to the fact that everybody is concerned, the complexity of explanatory mechanisms developed by life sciences, and of processing corresponding data, taking the examples of genome data (some 3 billion pairs of bases, which we now know how to sequence at a cost of a few hundred euros)[1], and imaging system data, for analysis of which AI is particularly well adapted.

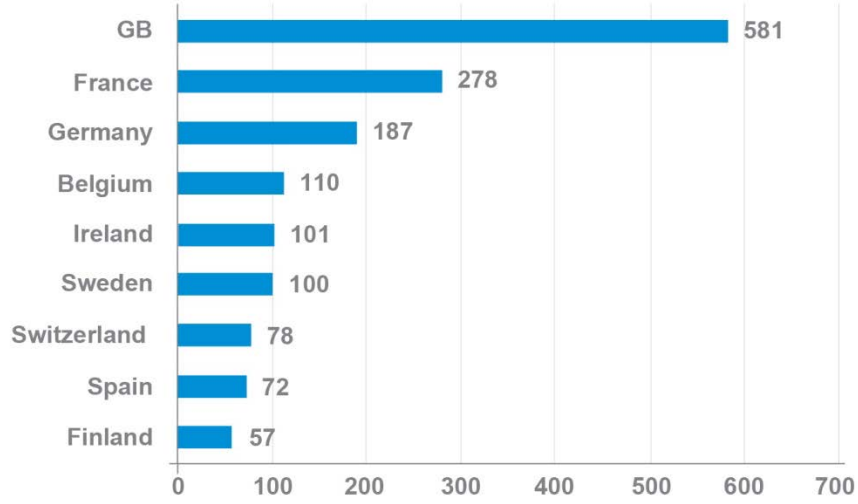
These three sectors are also regularly referred to in the report on UK's artificial intelligence strategy[2], which has similar focuses on applications in healthcare, the automotive industry and financial services. In addition, they are often well to the fore in mappings of innovative operators: coming in 2nd (HealthTech), 3rd (FinTech) and 6th (automotive), for example, in the ranking of sectors by numbers of investment transactions in startups in Europe in 2016 (see the graphs below).

[1] www.genome.gov/sequencingcostsdata/.

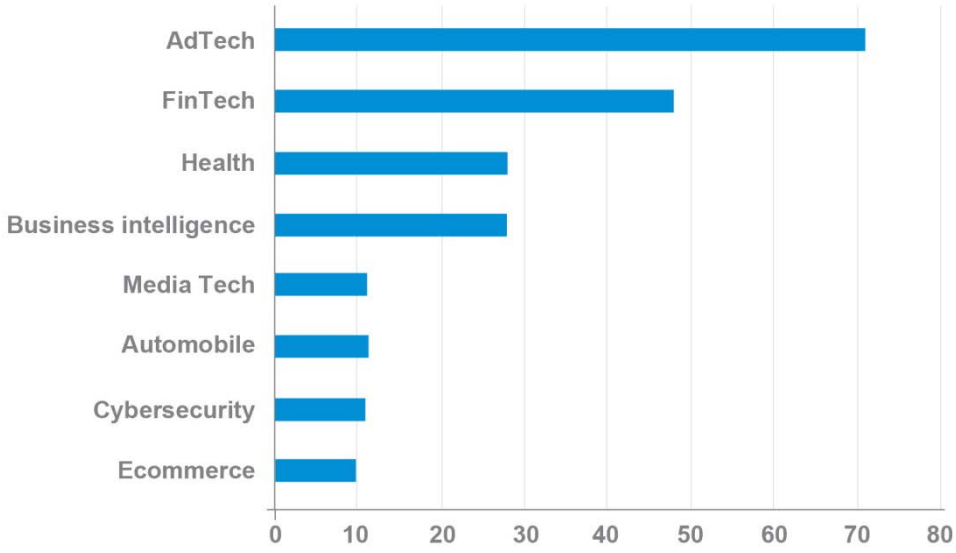
[2] Hall W. and Pesenti J. (2017), *Growing the artificial intelligence industry in the UK*, October.

Graph 1 – Investments in artificial intelligence made by startups in Europe in 2016

Fundraising by country in 2016 (in millions of euros)



Number of transactions by sector in Europe in 2016



Source: France IA (2017), Summary Report, workgroups, according to 2016 European AI Scale-Ups; Sirris, Omar Mohout

Finally, the health, banking and transport sectors have enough economic weight in the French economy for the impacts described to bring about real changes (see table below).

Table 1 – Weight of different economic sectors in France's GDP

Gross added value by sector at current prices, in billions of euros	2016	
Agriculture, sylviculture and fishing	1.6%	32.7
Manufacturing industry, extractive industries and others	14.1%	280.0
Construction	5.5%	109.6
Trade, automobile and motorbike repair	9.9%	196.6
Transport and warehousing	4.8%	96.1
Accommodation and catering	2.9%	57.8
Information and communication	5.2%	103.6
Financial and insurance activities	4.1%	82.1
Real-estate activities	13.0%	259.1
Scientific and technical activities, administrative and support services	13.2%	262.5
Other services	3.0%	60.0
Public administration and defence – compulsory social security	8.0%	158.5
Education	5.4%	106.7
Activities for human health	6.0%	119.9
Medicosocial and social accommodation and social action without accommodation	3.4%	67.0
Total for all sectors		1,992.3

Source: National Accounts - Base 2010, INSEE

Two possible scenarios

Technological advances will extend artificial intelligence's potential field of action quite rapidly. Such progress may be the result of improved processing capacities, optimised learning ability based on a more limited number of examples, or lower cost or consumption of microchips enabling deployment of AI-based systems. Research on these various fields is currently underway and the next few years may well see spectacular new advances being made. However, this is not the approach taken by this Report. It seems to us that the progress made in the early 2010s was no more or less than the technological breakthrough that extended AI's potential. Therefore, the evolution scenarios we have developed are not based on future technological advances in artificial intelligence that go beyond the trend rate of progress, but rather on its dissemination in France.

The progressive dissemination scenario

As a new digital technology, artificial intelligence may be integrated into the operation of companies and organisations in the context of the general dynamics of their digital transformation (computer equipment, website, data digitisation, exploitation of customer/user feedback, etc.). Such transformation is taking place at varying speeds depending on sector. Dissemination of AI may occur in the wake of companies' and organisation's digital transformation, which would lead to progressive transformations of tasks, jobs, skills and organisation, with the possibility of accompanying such evolutions for workers and users alike.

Examples of such progressive transformation, anticipated in the carrying out of technological and organisational change, may be found in the three sectors we have selected.

The disruption scenario

Sectors' digital transformation may also come about more abruptly, with the arrival of new French and foreign companies that beat the competition in identifying opportunities provided by these new tools and taking full advantage of them. AI technologies may be a vector for disruption in sectors or various realms of activity, which would lead to a major shakeup among established operators. In this scenario, existing companies may only have a very short time to adapt, leading to real problems, both as regards evolution of their internal organisation and support provided to users and customers. The revitalisation of AI is certainly too recent for us to provide any concrete examples of this scenario being played out, but an example drawn from previous technologies – the development of the smartphone and GPS – provides an illustration of the possibility.

How are scenarios to be interpreted?

Scenarios are described in very general terms, so as to be able to potentially apply them to all activity sectors.

They must then be adapted to each activity sector, but incorporating their specificities. We have outlined them for the three sectors we subjected to in-depth examination. It is altogether possible – even the most likely probability – that different scenarios will play out within each sector, or even depending on activities concerned.

Scenarios are not presented in terms of what should or should not be done: they aim to clarify two possible trajectories, on the basis of which public policies and stakeholders may seek to favour one scenario or another, or to mitigate negative effects and accentuate positive effects in the event of this or that scenario playing out. It is above all a matter of being prepared, whatever scenario plays out.

It is for the same reason that they are sharply contrasted even to the point of caricature: they constitute two possible extremes; it is quite possible that more moderate scenarios might play out in practice.

It is therefore possible to develop public policies that seek to avoid any occurrence of a scenario deemed to be negative, or, conversely, seek to foster a positive scenario.

Of course, different scenarios would seem more likely for each sector, depending on its characteristics. We have outlined them for the various sectors we have concentrated on.

Nonetheless, the general message is that we cannot know with any certainty which scenario will finally play out, and the examples studied in this Report show that any sector may find itself subjected to the disruption scenario. This being so, our main recommendation to stakeholders is “Be ready!”

IMPACTS IN THE TRANSPORT SECTOR

The transport sector includes road, rail, sea, river and air transport. This chapter only analyses the impacts that artificial intelligence may have on road and rail transport, which will be the segments most affected by development of autonomous vehicles, the main innovation connected with AI development in the sector.

1. Artificial intelligence applications in transport

Autonomous vehicles

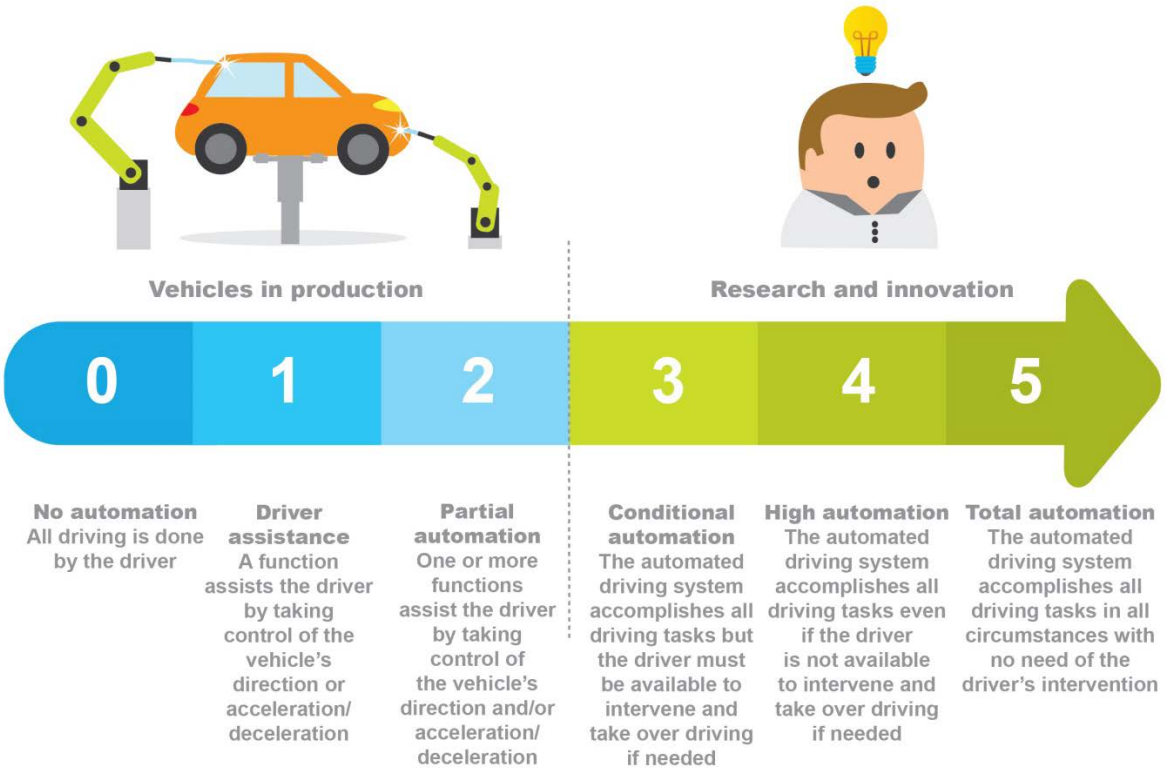
The major innovation brought about by development of AI in the field of transport will undoubtedly be the autonomous vehicle, even though the timeline for its deployment remains uncertain. Of course, it all depends on the degree of autonomy we are talking about, as automation of driving is divided up into six levels (see Figure 1): the technological maturity required for each level, followed by their dissemination will be determining factors in the transport sector's transformation.

At present, vehicles are equipped with Level-1 automation systems that simply provide assistance with driving. A few vehicles have been classified as Level 2, including those developed by Tesla[1] and the new DS models announced by PSA in 2018[2]: they integrate such functions as automatic line change on motorways and handling of parking manoeuvres.

[1] www.tesla.com/presskit#autopilot.

[2] www.groupe-psa.com/fr/story/en-route-vers-la-voiture-autonome/.

Figure 1 – The six vehicle automation levels



Source: BIPE according to SAE

Truly autonomous vehicles only really come about from level 3 onwards, when the machine takes over driving and supervision of the environment. Level 3, at which the driver must be able to take back control of the vehicle if needed, will certainly only be an intermediate phase before achievement of level 4. Experiments show that drivers/passengers may need a considerable time, up to 30 seconds, to react adequately in the event of a complicated situation in which the machine does not know how to react. At level 4, the vehicle is fully autonomous in specific contexts (such as movement and parking in a car park or driving on a motorway). Manufacturers and a number of studies see this as a possibility by 2025. The advent of Level 5, which corresponds to a totally autonomous vehicle whatever the situation (heavy urban traffic, country roads, etc.), is yet to be announced by any manufacturer. Nonetheless, experiments on driverless travel on the open road were announced in early November 2017 by two of the leading autonomous vehicle manufacturers, Waymo[1], the Google

[1] See the Waymo website and *Le Monde*, "*Google va réaliser des tests grandeur nature de ses voitures autonomes*" (Google is set to carry out full-scale testing of its autonomous cars), 8 November 2017.

subsidiary, and the French company Navya[1], while General Motors presented its totally autonomous Cruise model, which has no steering wheel or pedals, at the 2018 CES trade fair. The model has not yet received authorisation to run, but General Motors hopes to deploy its fleet as from 2019[2]. Such projects open the way to autonomous taxi-type services. Technological progress with regard to autonomous vehicles has sometimes come about more quickly than expected. The first cities and countries to test out their full-scale deployment will also be the de facto creators of a quasi-standard. In any event, this Report limits its analysis to the impacts of dissemination of level-4 autonomous vehicles within the next ten years.

As well as doing away with costs connected with the presence of a driver, autonomous vehicles enable better traffic management. Incorporated into the automatic steering system, artificial intelligence is capable of optimising a vehicle's speed, taking account of acceleration and braking times and road congestion. Such optimisation results in energy savings, and also enables higher speeds on railway lines, which is particularly helpful in mass transport of passengers.

Equipment and production chain maintenance

Use of industrial sensors is already widespread to measure machinery wear points and equip production-chain control points. Reduction in the cost of such sensors enables collection of big data. Artificial intelligence can process such data on a greater scale than human processing can manage, so enabling addition of more control points while refining diagnoses resulting from analysis of such data.

This being so, companies can have smart diagnostic tools available that facilitate maintenance operations and develop indicators prior to the appearance of anomalies, which opens the way to predictive rather than preventive maintenance. Maintenance and control operations are only carried out when required, before any anomaly occurs that might hold up a production chain, or before a piece of equipment wears out.

Predictive maintenance is of major interest to all (rail and road) network and vehicle (aircraft, trains, heavy goods vehicles, etc.) operators, as it optimises operation, limits immobilisations due to maintenance and reduces servicing costs. Maintenance services may also be able to anticipate and even avoid peaks of activity.

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[1] See the Navya website and *Le Monde*, "*Navya présente son taxi-robot électrique attendu dès 2018*" (Navya presents is electric robot-taxi, expected in 2018), 8 November 2017.

[2] https://techcrunch.com/2018/01/11/gm-and-cruise-reveal-their-fourth-generation-steering-wheel-free-cruise-av/.

Logistics and optimisation of flows

Artificial intelligence also enables optimisation of logistics in the event of crisis. This application, which was initially designed for railway traffic, may also be used on the road. When an incident occurs, mainline and metro train operations can be seriously disrupted, and return to normal running sometimes takes several hours, even several days as was the case at Montparnasse railway station in Paris in late July 2017[1].

When preventive maintenance has been unable to avoid a crisis, its resolution may still be speeded up by artificial intelligence. These days, crisis-scenario responses are standardised, with information processing and coordination of required action as the two main stumbling-blocks: two obstacles that AI can help remove. It may well be able to bring more specific responses to crises by taking more information into account – for example, in the event of a breakdown on a Paris metro line: numbers of passengers, which determine optimal speed for relieving congestion on the line, availability of replacement trains and the workforce required to put them into service, available alternative routes, etc.

Such optimisation of logistics and flows is only possible if AI is provided with real-time data on a wide range of parameters, with all the risks of blockage that the diversity of actors involved may generate.

2. A generally favourable context for dissemination

It would seem possible for the applications described above to reach a level of technological maturity enabling their deployment within the next five to ten years. However, such maturity must also be able to respond to various parameters affecting dissemination of artificial intelligence.

Data availability

At this stage, data sharing does not appear to be an obstacle to AI's technological development, but it may well become one in the near future, with large-scale deployment of autonomous vehicles.

[1] *France Info* (2017), "Gare Montparnasse : ce qu'il faut retenir du rapport de la SNCF sur la panne qui a provoqué une pagaille monstre" (Montparnasse Station: the key points in the SNCF's report on the breakdown that caused total chaos), 3 August.

Initial steps may draw on data collected by companies themselves: Google, for example, had its Google car travel some 5 million kilometres[1]. However, continuing on to industrialisation of production and marketing of vehicles raises the question of access to data they collect, which is no longer their manufacturers' property.

The question of respect for individual owners' privacy has already been raised with regard to development of connected vehicles. The *Commission nationale de l'informatique et des libertés* (CNIL – National Commission for Data Protection and Civil Liberties) published a sectoral reference framework enabling manufacturers to comply with European regulations on data protection[2]. Among other things, the framework foresees a scenario in which "data collected in the vehicle is transmitted to the exterior in order to trigger an automatic action in the vehicle".

However, in any future deployment of artificial intelligence in transport, issues of data collection and exploitation will essentially be raised between companies, and consequently will not concern the question of respect for privacy but rather that of sharing value. For optimal use of AI's possibilities, data on vehicle navigation and maintenance and on infrastructures will have to be shared between several types of actors, railway (SNCF network and RATP) and road (Vinci, Bouygues, etc.) infrastructure managers and vehicle operators (Ouigo, RATP, road hauliers, etc.) in particular. Economic and technical conditions – whether with regard to harmonisation, quality, interoperability, real time, etc. – will therefore have to be clearly defined.

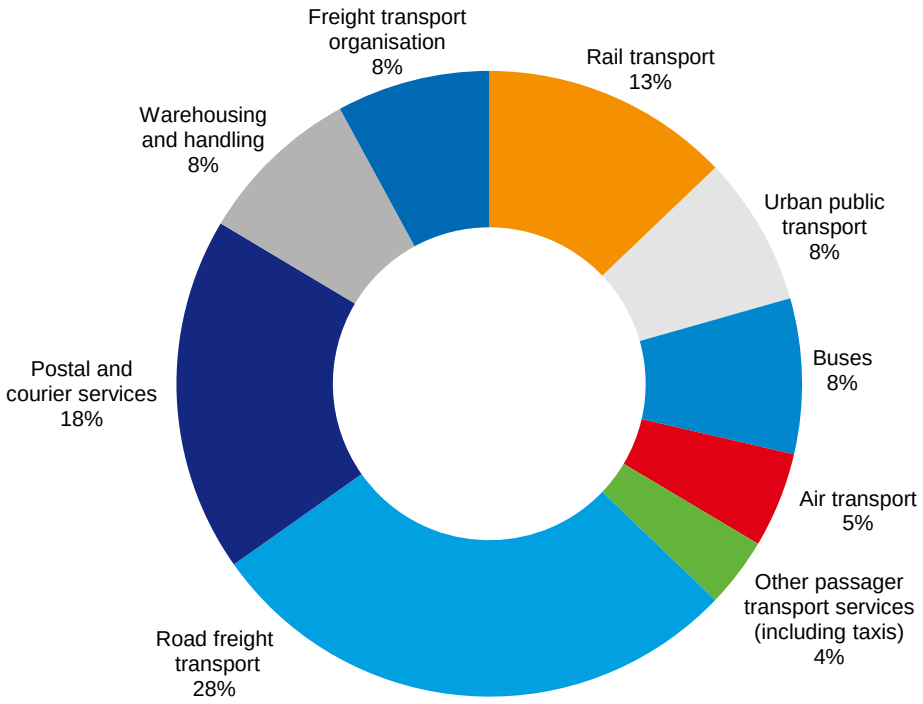
Employment: an ageing workforce

The transport sector is organised into four major focuses: freight transport (32.8% of sector production), warehousing and ancillary services (33.6%), passenger transport (27.1%) and mail services (6.5%).

[1] https://waymo.com/ontheroad/.

[2] CNIL (2017), "*Véhicules connectés : un pack de conformité pour une utilisation responsable des données*" (Connected vehicles: a compliance pack for responsible data use), 17 October.

Graph 2 – Job distribution in the transport sector



Source: Transport accounts for 2016, CGDD

This sector is still recovering from the economic crisis. Salaried employment increased by 0.8% in 2016, after 0.2% in 2015, mainly in freight transport (+2.9%), but is still below what it was in 2008. Road freight transport is undergoing tension in the long-distance sector, where numbers of job offers have risen significantly more (+25.6%) than new takers (+10.2%). The jobs concerned are mostly jobs as drivers or qualified workers (79.6%) and face increasing competition from other European countries. Such changes and tensions have been highlighted by debate on application of the European directive on posted workers. The shortage of drivers is likely to increase over the next few years due to the ageing population. As regards maintenance, there is a shortage of manpower – in particular of people in their early thirties with a little experience – due to a fall in recruitment at the time of the 2008 crisis.

Regulations

The various activities covered by the transport sector are subject to special regulations that shape more or less competitive markets. Road freight transport, for example, is open to international competition, while rail transport is still dominated by the SNCF: artificial intelligence is unlikely to be integrated at the same pace. The

authorisations required for putting autonomous vehicles on the road are on the way to being harmonised at European level[1]. An authorisation granted by a member State may therefore soon extend de facto to the entire European territory. And it is hard to imagine a member State's protective regulation delaying the arrival of autonomous vehicles on European markets once they have been perfected.

As regards public transport in urban areas, it currently depends on *Autorités organisatrices de la mobilité* (AOMs – Mobility Organising Authorities)[2], in particular via allocation of public funding. In this context, choice of transport services depends both on economic considerations, with major constraints closely connected with decreasing budget allocations, and social considerations, with account being taken, for example, of the impact that autonomous vehicles are likely to have on numbers of jobs. There is a risk that lower costs in transport services – due in particular to autonomous vehicles – will lead to development of economically sustainable private offers competing with subsidised services. As there is no guarantee that AOMs will be able to regulate competition or encourage modal complementarity, this could result in juxtaposition of offers and consequent economic inefficiency.

Social acceptability

Artificial intelligence also comes up against the constraints of social acceptability, both at individual and collective levels.

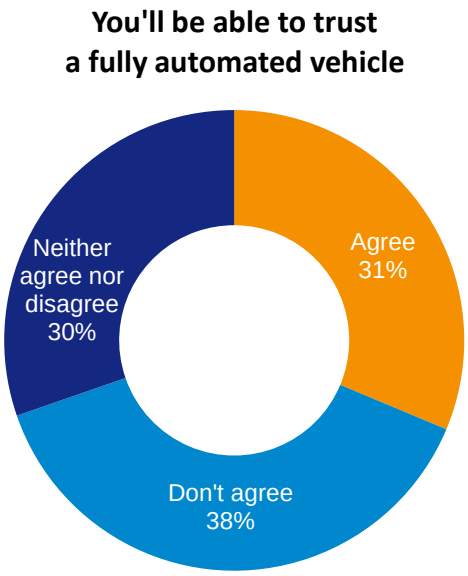
In the transport sector, will autonomous vehicle manage to overcome passengers' reluctance to board a driverless vehicle? A recent poll[3] shows that the French are divided on this question.

[1] "Declaration of Amsterdam: Cooperation in the Field of Connected and Automated Driving", 14-15 April 2016.

[2] www.gart.org/nos-adherents/autorites-organisatrices-de-mobilite/.

[3] OpinionWay (2017), "L'usage des innovations par les Français" (The use of innovations by the French), November.

Graph 3 – French citizens' confidence in autonomous vehicles



Source: OpinionWay, November 2017

French citizens' fears and expectations vis-à-vis autonomous vehicles seem to focus on safety aspects: 58% of them are expecting to see smart vehicles with improved safety functionalities. Their chief uncertainties centre on fears that the vehicle will not make the right decision, lack of control over the vehicle, fear of accidents, and risks of the vehicle being hacked. However, it may be assumed that once a certain level of safety is guaranteed, autonomous vehicles will enjoy a much greater level of acceptability.

As regards public transport, the fact that there are no professionals on board vehicles is sure to raise other questions on safety, of the kind that might be raised in any public place, especially at night and in places where few people are out and about. Even if a driver is no longer required, some form of human presence or communication tools, coupled with possibilities of rapid intervention, would appear necessary.

Autonomous vehicles will also have to be accepted by pedestrians. Experiments[1] have been carried out to test their reactions when they are about to cross the road and find themselves faced with a driverless vehicle. Absence of communication with a

[1] Experiments conducted by the Swedish company Semcon: https://semcon.com/smilingcar/, and the automobile manufacturer Ford: https://media.ford.com/content/fordmedia/fna/us/en/news/2017/09/13/ford-virginia-tech-autonomous-vehicle-human-testing.html.

driver – often via visual contact – is a source of uncertainty and therefore of worry. International standards will have to be developed in order to ensure such communication between vehicles and pedestrians, so as to guarantee overall confidence and safety. This will also provide an opportunity to improve sight-impaired pedestrians' safety, through incorporation of audio signals complementing visual signals.

As smart maintenance and logistics tools are not in direct contact with users, there should be no acceptability problems regarding their dissemination.

At collective level, the improvements provided by artificial intelligence applications will be weighed against their impacts, in particular on employment levels. But if existing major expectations with regard to safety are fully met, it is possible that they will take precedence over destruction of jobs.

Available workers' skills

Autonomous vehicles require a new form of handling on the part of anybody having to drive them in case of need, in particular outside specified traffic areas. These days, learning the ins-and-outs of a new car only requires an hour or so with the dealer, but it may well take a good half-day in the case of an autonomous vehicle. There should however be room for continuous learning as vehicles are equipped with driver-assistance tools. Training of professionals, lorry drivers in particular, can therefore be carried out progressively.

Deployment of smart maintenance tools should also follow the profession's natural course of evolution. A word of warning though: there is a risk of polarisation between experts able to make advanced diagnoses on a piece of equipment when smart tools have reached their limit, and "performers", who are confined to carrying out tasks indicated by such tools, with no overall vision of what they are doing and why. This risk would seem limited as far as maintenance of heavy goods vehicles is concerned, as there is a determination to improve levels of general qualification among sector employees so that they will each be able to work autonomously and carry out full diagnoses. This may not be the case, however, with services to individuals, in particular with regard to local garage-owners.

Logistics professions will also be able to integrate these new tools over the course of time, with continuing acquisition of the necessary skills.

In maintenance and logistics alike, then, lack of skills is not of crucial importance when it comes to using AI tools, but shortcomings make themselves felt when it comes to their dissemination and implementation, in particular with regard to data

processing. Commissioning and operating such tools require availability of historical and real-time data alike. Not all present-day databases are digitised or harmonised, *sine qua non* conditions of a switch to artificial intelligence. The question then arises on their interoperability for optimal AI functioning. All such processing requires skills that are few and far between, and which the competition is also looking for. It also requires detailed knowledge of whatever profession is concerned in order to ensure that data processing is in line with sectoral needs. Such dual skills are hard to find at present, as they require major effort in terms of initial and continuing training alike (see Recommendations).

3. Impacts on transport professions

Prospects for deployment of autonomous vehicles vary depending on the transport activity concerned.

Road freight transport: the lorry driver

In France, 90% of freight transport is by road, with the remaining 10% by goods train. Road freight transport (RFT) is therefore a major source of drivers' jobs. In Europe, the sector's workforce accounts for between 35% and 45% of total costs[1], constituting a major incentive for companies to invest in technologies likely to save them money. The sector is also pressured by strong international competition, a further factor encouraging integration of innovations.

The advent of level-4 autonomous vehicles opens up the prospect of automated RFT driving on motorways, which provide an environment particularly well suited to this type of vehicle. In addition, on major roads used by large numbers of lorries, driving in convoys enables reduction of fuel costs while increasing safety thanks to interconnection of vehicles[2].

Automated convoys would initially enable lorries to spend more time on the road, by modifying regulations on mandatory rest periods for drivers, who would no longer be required to drive the entire route (see Table 2). Eventually, a driver may only be needed at the head of a convoy. A human presence of some kind would be required in order to carry out tasks yet to be automated (such as refuelling).

[1] International Transport Forum (2017), *Managing the Transition to Driverless Road Freight Transport*, May.
[2] www.eutruckplatooning.com/About/default.aspx.

Table 2 – Provisions bearing on drivers' driving times and rest periods (European regulation no.561/2006)

Subjects	Provisions
Continuous driving	4½ hours
Interruptions	45 minutes or a 15-minute interruption followed by a 30-minute interruption
Daily driving	9 hours, increased to 10 hours twice a week
Weekly driving	56 hours
Weekly driving average over 2 weeks	90 hours
Daily rest period	11 consecutive hours out of 24 hours, or 3 hours and then 9 hours. May be reduced to 9 hours 3 times a week
Daily rest period (two-man crew)	9 consecutive hours out of 30 hours
Weekly rest period	45 consecutive hours, after a maximum of six 24-hour periods. May be reduced to 24 hours (alternating with normal rest periods and compensated before the end of the third following week)

Source: Ministry of Labour

Later on, new road freight logistics may be developed. As is already the case with rolling motorways, drivers would take lorries to interface areas at the entrance to motorways, where they would be attached to autonomous convoys, to be recovered at exit points for delivery to final destinations. In this scenario, the decrease in the need for long-distance drivers would be accompanied by an increase in demand for local drivers, who would enjoy better working conditions (shorter journeys in limited geographical areas).

New activities connected with remote supervision

Jobs as "controllers" may well come into being for remote supervision of fleet circulation. Owing to the diversity of RFT companies (over 80% of which are VSEs, as Table 3 shows), there may well be some reorganisation depending on their degree of maturity. Countries that pioneer convoys and other forms of automated driving in the RFT sector will in all likelihood see their market share increase.

Table 3 – Size of road freight transport companies

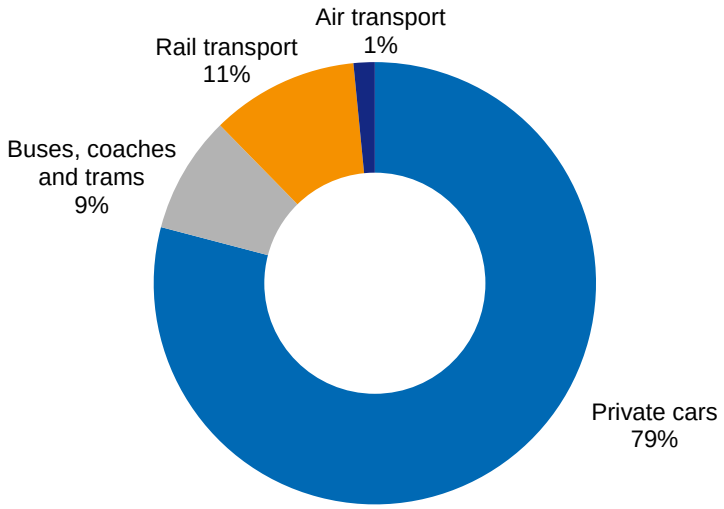
Size (in number of employees)	0 to 9 employees	10 to 19 employees	20 to 249 employees	250 or more employees	Total
Number of companies	29,147	2,695	2,855	77	**34,774**
Percentage of companies	83.8	7.8	8.2	0.2	**100**
Workforce at 31 December 2014	67,441	46,023	174,179	50,442	**338,085**
Percentage of workforce	19.9	13.6	51.5	14.9	**100**

Source: Ministry for the Ecological and Inclusive Transition

Impact on transport of private individuals

In France, transport of private individuals is mostly by personal vehicles (see Graph 4). Autonomous vehicles are unlikely to make any major impact on this segment as the advent of level-5 automatic driving is still difficult to predict. However, level 4 should already enable development of new public transport services that might replace a percentage of individual journeys.

Graph 4 – Domestic passenger transport in 2016
(in billions of passenger-kilometres)



Source: INSEE

Initial experiments underway focus on shuttle services travelling routes in delimited areas. Navya, a world leader in this area, has already deployed over 50 vehicles across the world on short-distance routes (up to two kilometres). We may therefore imagine that the coming years will see increasing numbers of autonomous shuttles providing new public transport services – on local routes with fewer potential passengers and not covered by present-day services, for example, or night services. The Rouen Normandy Autonomous Lab[1] experiment on mobility-on-demand services on the open road is very much in this direction. The Japanese authorities are hoping to develop a large-scale autonomous mobility service for the 2020 Olympic Games in Tokyo – an innovative experiment at global level that would open the way to autonomous taxis.

Such autonomous shared shuttles ensuring local services will complement the existing public transport offer, competing with mass public transport and transport of individuals by taxi or chauffeur-drive car, in which case there may well be an impact on drivers' jobs in these areas. However, as long as level-5 autonomous vehicles remain on the drawing-board, taxis and chauffeur-driven cars will remain the leading means of transport for door-to-door journeys. Moreover, circulation capacities of autonomous vehicles that take to the road will not be able to rival classical means of public transport on the most frequented routes: that would lead to unacceptable over-congestion of highways.

Development of this particular offer will also be accompanied by creation of jobs for supervision of fleets, as well as customer-relations positions responsible for passenger reception and safety.

Intercity public transport services along motorways may also see the light of day, competing with current offers with regard to (Blablacar-type) carpooling, so-called "Macron" buses and regional trains. Customer-switching phenomena, similar to those observed when carpooling services were first deployed and the above-mentioned buses introduced, are to be expected[2]. There should not be a great deal of competition where longer distances are concerned, due to the higher speed of rail and air travel.

[1] Transdev (2017), "Rouen Normandy Autonomous Lab", *press release*, 2 October.

[2] ARAFER (2016), "Les pratiques de mobilité de longue-distance des voyageurs sur les lignes régulières d'autocar librement organisées" (Long-distance mobility practices among passengers on freely organised regular coach services), field surveys, October-December 2016.

A risk of "tripolarisation" of public transport jobs

Deployment of autonomous vehicles in public transport, first of all to provide new services and then progressively on existing lines (buses, metros, tramways and trains), may well lead to "tripolarisation" of jobs, between those who obtain supervisory positions, those who are reorientated towards passenger reception, and those that disappear altogether.

New work organisation for maintenance staff

The smart maintenance tools that will form part of new vehicles' and infrastructures' standard equipment could also be installed on existing vehicles. People responsible for service and maintenance will consequently be faced with a new daily work framework, both as regards tasks to carry out and tools available to them.

More autonomous, connected and cleaner vehicles include new equipment, electronic devices in particular, that may well lead to new types of breakdowns. However, as autonomous vehicles are mainly electric, engine operation is greatly simplified and breakdowns are less frequent. Whatever the case, it will be essential to provide maintenance staff with appropriate training. Such technological evolutions may also modify distribution of the value chain on maintenance services. Manufacturers may not only seek to sell vehicles but also the maintenance services they require, by highlighting the level of expertise required. This would play in favour of the sector's vertical concentration and lead to a reduction in the economic weight of SMEs.

A necessary increase in skills and autonomy

Smart tools will provide help and even "instructions" in both diagnosis and performance of maintenance tasks. It is hard to contradict a machine on the origin of a breakdown, especially if it has not happened yet, as will be the case with predictive maintenance. Artificial intelligence will not just indicate the component that needs repairing, it will also indicate how the repair is to be carried out. To borrow an image from the medical sector, it will provide both diagnosis and treatment, whence the risk of staff losing any overall vision of how a vehicle functions and the maintenance operations to be carried out. This could lead to distinction of tasks, with humans being responsible for their performance without necessarily identifying overall coherence. At present, such a risk seems limited by a general determination to preserve employees' autonomy with regard to a vehicle's overall maintenance and not focus on specialising on specific tasks which may later be automated. Increasing skills is

therefore essential if this overall approach is to be maintained, despite vehicles' growing complexity and dissemination of new prescriptive tools.

Lastly, organisation of work at a maintenance centre is likely to be affected by predictive maintenance, which will enable better forecasting of workloads as well as limiting activity peaks. This could lead to more evenly paced and routine days, making the profession less attractive into the bargain.

4. Scenarios according to activity

The transport sector includes too many different activities for a single scenario to apply.

The disruption scenario cannot be excluded, as can be seen from the "taxi" activity. Turning to another segment, the SNCF found that its main competition on certain routes did not come from some hypothetical operator on the competitive market, but from long-distance coaches and the Blablacar carpooling service[1]. This example once again illustrates how technology coupled with new social practices can suddenly threaten what might appear to be the very archetype of natural monopolies, the railway. In the case of taxi and chauffeur-driven car activities, the expected advent of fleets of autonomous vehicles comprises a direct threat to the employment of tens of thousands of drivers. And all this in the short-term: General Motors aims to have its first fleet of automated taxis on the road in 2019. A number of studies nonetheless suggest it will take longer, ten years or more, before autonomous vehicles are capable of performing in dense urban environments. How quickly the transition will take place depends partly on technology, but most probably on a combination of social acceptance and political will. If the public authorities decide to prohibit non-autonomous vehicles from entering city centres, and only allow shuttles in, the transition could take place relatively abruptly in some cities.

Risks of a disruptive scenario in road freight transport

The same goes for road freight transport: given the percentage of total costs accounted for by drivers along with ongoing pressure from the competition, the transition may well come about rapidly once the technology has been adequately developed. All the more so as the technology involved will probably be tested out first abroad, in countries where safety imperatives are fewer and environments less

[1] Épaulard A. and Guilleminot L. (2016), "Autocars interurbains : un bilan après 6 mois d'ouverture" (Intercity coaches; an assessment after 6 months of opening), *La Note d'analyse*, no.44, France Stratégie, February.

complex. Arizona's long straight desert roads, which are used for testing autonomous lorries, are one example of suitable terrain. If the technology is adequately tested abroad, it will be possible to provide a reasonably accurate assessment of its degree of maturity, and obtaining regulatory authorities' agreement should not be an insurmountable obstacle. The European single market also encourages regulatory competition between certification authorities, which inevitably favours rapid deployment.

However, if automation of heavy goods vehicles is carried out stage by stage, we are likely to witness a progressive transformation in road freight transport. Initially, driving will only be automated on motorways, with the introduction of convoys enabling drivers to rest between whiles. Long-distance drivers would spend increasingly less time driving on motorways, and more time on driving the final kilometre. This would certainly have a negative effect on employment for long-distance lorry drivers, as they would see much of their traditional activity disappear, but the decrease in overall costs would lead to increased recourse to road transport.

A rather more gradual scenario in public transport

In other segments such as autonomous trains and tramways, a progressive scenario would appear more likely, given regulatory constraints and institutional organisation with a monopoly (local in the case of urban rail transport), requiring social dialogue to accompany any such evolutions. We might call to mind the automation of new metro lines (VAL in Lille and line 14 à Paris) following a process planned over ten or more years and enabling advantage to be taken of departures due to retirement and conversion to such other professions as line supervision. Furthermore, lines in the Paris region have been automated in response to social demand for an increase in train capacities and regularity. The same will doubtless be true of the extension of the existing network by addition of autonomous shuttles providing "last kilometre" services in sparsely populated areas. This would be the only economically acceptable solution to serving areas that would otherwise be isolated.

Technology is therefore not always the driving force of transformations underway; it may provide a response to social demand and consequently be a cause of much less conflictual transformation of work.

IMPACTS IN THE BANKING SECTOR

Banking and insurance activities are ideal terrain for application of artificial intelligence. The sector is largely based on data exploitation and has long been subject to digitisation of processes, information exchanges and transactions. It is therefore by no means surprising that recent advances in AI are exploited for a range of activities. The France IA report provided a list of potential uses of artificial intelligence in the sector, including chatbots, predictive algorithms, orientation towards adapted products, customer relations management and customer service.

In order to analyse its effects on work, this Report has chosen to focus on retail banking activities, which account for a significant percentage of employment in the banking sector. According to the Observatory on Banking Professions (OMB), marketing and customer relations activities currently provide some 100,000 jobs, just over a quarter of the sector's employment.

Such other activities as merchant banking are also very much concerned in the advent of AI, but have already been significantly affected by recent transformations connected with automation without artificial intelligence: deployment of trading algorithms, for example, has resulted in traders giving way to engineers managing automatic systems[1]. Furthermore, professional conversion problems are not the same here as in retail banking, given the profiles of employees concerned.

1. The uses of artificial intelligence

Varied uses

The banking sector pioneered the adoption of IT tools for management of customer databases and setup of networks enabling online banking operations. It was also one of the first to implement "expert systems", software programmes designed to handle

[1] This transformation has taken place at Goldman Sachs, for example, which has switched from a 600-strong team of traders to 2 traders and 200 engineers; Byrnes N. (2017), "As Goldman embraces automation, even the masters of the universe are threatened", *MIT Technology Review*, 7 February.

technical operations by computer. De facto, AI solutions employed in banking cover a wide range of functions and technologies, which may be divided up into four categories[1]: applications for customer relations, back-office operations, trading and asset management applications, and applications designed for regulatory use.

As regards customer relations, the most developed artificial intelligence applications are to be found in the field of credit risk rating. Banks have long been able to analyse risks relating to loan applicants by using statistical models. These days, such models are extended by supplementary data sources that may require processing by artificial intelligence. Similarly, insurers use AI to improve the granularity of their offers and recommendations[2]. But the main field of application, the one that has the greatest potential for transforming work in the banking sector, is that of chatbots. Various back-office operations may be connected with banks' financial activities, including risk modelling and optimisation of use of capital. As for applications in the field of asset management, they are progressively focusing on analysis of weak signals providing information useful to investment choices. Lastly, as regards regulations, AI applications contribute to detection of irregular transactions and may also be of use in optimisation of customer knowledge management mechanisms – for example, using image recognition to automatically extract useful information from scanned ID document images.

Chatbots

One of the main uses of artificial intelligence in the banking sector is therefore implementation of chatbots, which are designed to provide answers to customers' questions on the basis of thousands of conversations that have been analysed and recorded. Such programmes hold the promise of faster and more available interfaces for bank customers, in particular for remote operations. Several operators are focusing on these technologies, including IBM with its Watson service and such startups as Abe.ai and Finn.ai.

Chatbots draw on advances in Natural Language Processing enabled by availability of large amounts of data to teach them. The first phase of chatbot deployment is accompanied by setup of a conversation interface on the bank's website or directly integrated into the user's messaging environment (WhatsApp, Facebook, Slack, WeChat, etc.). Following this collection phase, answers may be automated

[1] According to Financial Stability Board classification (2017), *Artificial Intelligence and Machine Learning in Financial Services*, November.

[2] International Association of Insurance Supervisors (IAIS) (2017), *FinTech Developments in the Insurance Industry*, 21 February.

progressively and the algorithm trained to recognise different ways of wording the same request.

Chatbots are still in their infancy. Orange Bank, a service launched in November 2017 which uses AI to manage customer relations, is a pioneer in France alongside Crédit Mutuel-CIC. The first transformation initiated by banks is adoption of such conversation interfaces, which are set to provide users with more direct and easier access to advice and customer service functions.

2. Determinants of dissemination

Major presence of structured data and dematerialisation of the vast majority of operations make the banking sector ideal ground for development of artificial intelligence solutions. But transformations also depend on other parameters.

Access to data

Banks have made major progress in their ability to process and exchange information. Along with the State, the banking sector's leading operators were the first to implement information systems (IS), as far back as the 1970s, alongside dematerialisation of financial transactions. Longstanding operators possess well-structured big data, but the problem arises of maintaining systems developed in the 1990s or 2000s and ensuring that they evolve at the same pace as technology. In order to develop AI, banks must be able to ensure interoperability between their information systems in order to exploit and crosscheck data. They must also pay special attention to cybersecurity: security requirements with regard to exchanges of banking data are greater than in classical industries.

Employment

The French Banking Association (AFB), which had a total of 195 member banks in 2016, records around 198,000 employees in total[1]. The sector is characterised by major concentration of employment: the 24 banks with over 1,000 employees each account for 86% of the total workforce. The sector's economic activity is concentrated in retail banking, which accounts for 67.2% of the net banking product (measurement of the banking sector's added value to the economy).

The sector is also marked by high average educational levels, with 93% of permanent-contract (CDI) recruitments at qualification levels higher than *Bac+2*

[1] AFB (2017), *Profil de branche* (Sector Profile), June.

(second-year university level). AFB members' sales forces account for 100,000 jobs (50%), with transaction processing accounting for some 55,000 jobs (27%) and support functions 40,000 (20.6%). Average seniority is higher than in other sectors, standing at 15.3 years as against 11.4 years for all French employees.

The banking sector's age pyramid is undergoing transformation. The downward trend in workforce size observable since 2012/2013 is the result of a peak in retirements of employees who joined the sector in the 1970s. Such departures, which will culminate in 2017/2018, will continue to have a widespread effect up until 2020. Following an annual rate of 1.5% in 2014 and 1.2% in 2015, the drop was of 0.6% in 2016. Numbers of management staff increased significantly over the same period, while there was an annual decrease of close to 5% in numbers of technicians. The profession's technical evolutions are tending to step up levels of qualification required at recruitment and consequent access to management status. The banking sector is faced with the need to recruit mainly highly qualified profiles.

Regulations

The banking sector is subject to strict regulations governing its activity, with regulation and control authorities keeping a close eye on proceedings and recognised qualifications required for the performance of a number of functions. These regulations constitute a major obstacle to entry onto the banking market.

Operators are also subject to prudential regulations that were tightened up following the 2007 financial crisis, with the Basel III Accords for banking activities and the Solvency II Directive for the insurance sector. These international obligations are coupled with national regulations. For example, since 2010, Financial Market Authority (AMF) regulations require investment service providers to certify employees responsible for carrying out transactions on financial instruments.

These regulations do not so much condition deployment of artificial intelligence as new actors' ability to provide services equivalent to those of existing banks. The sector's inflexibility makes it hard for such new actors to break into it and favours those already in place. According to the Financial Stability Council (CSF), the growing complexity of regulations in force, in particular with regard to combating money laundering and the funding of terrorism, is also encouraging operators to adopt AI in order to improve surveillance and monitoring of their activities. Such constraints are likely to limit possibilities of abrupt sector transformation, and contribute to progressive dissemination of artificial intelligence.

Acceptability

Deployment of AI also depends on customers' acceptance of a dematerialised interface.

In relations with users, artificial intelligence is set to take the form of increasing interaction with chatbots and automated interfaces. Such dematerialisation is becoming ever more widespread for simple operations: according to a survey carried out by the Deloitte agency[1], only 15% of customers consult their balances at their branches, as against 77% who do so on their bank's website. Similar percentages prevail for other operations, such as addition of a bank transfer recipient. The present trend is towards dematerialisation of most customer relations, characterised by the growing popularity of online banks[2] (Monabanq, B for Bank, Boursorama, Fortuneo Bank, etc.). Use of digital solutions is nonetheless limited as far as complex operations are concerned, where customers prefer to opt for a physical advisor and an appointment at their branch. Service quality is still the main criterion in customers' recommendations.

Although online services are becoming increasingly widespread, they do not meet everyone's requirements. The very high bank account penetration rate in France (99%), typical of a developed economy, tends to conceal the fact that the ways people access banking services vary greatly. A digital divide is in evidence[3]: 15% of the French population do not have fixed internet access[4]. And apart from the "non-connected", there are large numbers of "poorly connected" individuals, who have internet connection but do not have the skills to use it to best advantage. Depending on device (smartphone, computer or tablet), between 3 and 4 people in ten state that they lack competence in their day-to-day use[5]. Artificial intelligence may finally become more acceptable if it enables development of more intuitive interfaces – by incorporating voice recognition, for example. It may also risk further isolating these fragile sectors of the population if it leads to continued dematerialisation without improving accessibility.

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[1] Deloitte (2017), *Relations banques et clients* (Bank/customer relations) *– 7th edition*.

[2] The account-holding rate for online banks in France rose from 7.1% in 2014 to 10% in 2016 according to a survey carried out by Simon Kucher & Partners and Research Now, issued in March 2017.

[3] See the "Pauvreté et numérique" (Poverty and digital technology) meeting organised by France Stratégie, INRIA and the EHESS on 4 May 2017, as part of the "*Mutations sociales, mutations technologiques*" (Social Changes, Technological Changes) series of monthly debates.

[4] CRÉDOC (Research Centre for the Study and Monitoring of Living Standards) on behalf of the ARCEP, CGE and Digital Agency (2017), Digital Barometer.

[5] *Idem*.

3. Impacts on retail banking professions

Analysis of determinants suggests that the banking sector will adapt progressively to the emergence of AI. As it accounts for over two thirds of the sector's economic activity[1], retail banking concentrates the major issues involved.

Evolution of the advisor's profession

There are almost 35,000 individual account managers and bank advisors in the sector, accounting for almost 18% of its total workforce[2]. AI will bring about far-reaching changes in their professions. In the study it carried out for the Observatory on Banking Professions, Athling consultancy highlighted activities relating to compliance with regulatory, legal and fiscal evolutions specific to the banking sectors as being those most impacted by such changes[3]: these activities will be improved due to more relevant monitoring and more advanced and personalised recommendation tools – such as the Doctrine.fr legal search engine – which will enable "on request" access to such information. Building customer profiles with the help of AI tools will also enable advisors to examine loan requests more quickly and identify such financial risks as tax fraud and money laundering more efficiently.

Even independently of AI development, the fact that it is on its way, combined with new expectations on the part of consumers, is pushing banks to transform their activities and opt for round-the-clock service 7 days a week. Promising instantaneous service and top quality alike, they are set to respond via a combination of AI-based service for the request-sorting phase and management of the most frequently asked questions and remote human service, available round the clock. Some form of low-cost service may also make its appearance, with the consumer only having access to automated help and paying extra in order to interact with a physical person.

At Orange Bank, the solution introduced to filter requests to customer service succeeds in obtaining an 80% recognition and comprehension rate[4]. As artificial intelligence is not always able to provide an appropriate response, such a system finally requires customer service staff to handle around one in every two requests.

Staff mainly assigned to the platform's operation or resolution of any technical problems encountered during its use may see their professions progressively

[1] Source: Prudential Supervision and Resolution Authority (ACPR).

[2] *Profil de branche,* AFB 2016.

[3] Athling, on behalf of the Observatory on Banking Professions (OMB) (2017), *L'IA dans la banque : emploi et compétences* (AI in banking: employment and skills), December.

[4] Interview with Orange Bank.

impacted by a dual effect: decrease in numbers of dedicated employees and increase in the complexity of tasks that they still need to handle.

AI's growing efficiency in answering questions (on availability of an offer or on different options, for example) connected with the online banking platform, which has already become customers' preferred way of interacting with their bank, will leave such staff with more time and facilitate their work by filtering numbers of requests. Banks may then decide to train customer service staff to respond to requests that traditionally fall within the bank advisor's purview. This evolution is very much in line with customers' expectations, as they are increasingly coming to regard their advisors not so much as the people who share the responsibility of managing their portfolios, but rather as assistants whose job it is to help them navigate the complexities of the banking system by making themselves permanently available in order to unblock this or that situation.

The sector will also see new actors appear who possess one of the key resources for implementation of AI-based systems. Integrated service groups specialising in customer relations, and which have access to large quantities of data in the context of customer service operations on behalf of third-party companies, will finally provide a replacement offer managed solely by a robot – "botshoring" – which could reduce their costs drastically.

Availability of AI technologies facilitating the bank advisor's profession and decreasing the amount of knowledge required by making it more available may also encourage such employees' evolution towards greater knowledge of their customers. Advisors would then be able to take greater responsibility in management of their customers, devoting more time to recommending investments or sources of funding. In this scenario, social and decision-making skills will be of major importance, and bank branches may well decide to prioritise training in dialogue and negotiation capacities.

Depending on the choices made by the sector's companies, artificial intelligence may help optimise service and continue with its dematerialisation, or increase the importance of advisors by providing them with greater autonomy.

Transformation of support functions

Transformation of banking sector professions connected with support functions will follow on from earlier evolutions observed when the digital environment first took shape. With artificial intelligence, various tasks, including the most repetitive, will disappear altogether, in particular those connected with data collection, which will be

optimised or speeded up. New work methods will emerge, with actors having to learn to interact with the new AI-based system to help it advance.

As regards information systems, the advent of methods resulting from artificial intelligence should not lead to any major organisational changes. Advances made will continue on from Robotic Process Automation (RPA) – an IT project for automation based on non-learning algorithms, implemented in the 1990s and continuously being developed. For other tasks, such as compliance activities, AI tools may lead to increased value of transferable skills such as those identified in France Stratégie's work: bank employees show responsiveness, an ability to adapt, and skills in office automation and data processing[1]. Highlighting such skills may well increase their employability.

In the special case of human resources, a great many AI-based tools are already available on the market, mainly designed for recruitment and in-house career management purposes. Such tools suggest the possibility of improving the quality of recruitment and increasing candidacy processing capacities. As regards work within actual human resources departments, there is no threat of it being fully automated but there should be an increase in productivity through implementation of assistants for all repetitive tasks, along with extension of its field of analysis and availability of new tools for assessment of tools and careers.

One point in particular should be stressed. The emergence of AI-based recommendation tools for recruitment raises new ethical questions on what value should be placed on choices made by algorithms. The quality of such systems depends on the training base on which the algorithm was constructed. In particular, if training data is biased in some way (with regard to gender, location, qualifications, etc.), the resulting algorithm will naturally reproduce such biases in its recommendations. At the same time, it is possible to use algorithms to neutralise various human biases, for example by prohibiting use of certain kinds of information. This subject has been much discussed, and not only in the banking sector[2].

The evolutions we have described with regard to these functions present a number of risks identified by banking sector actors heard for the purposes of this Report. First of

[1] Lainé F. (2018), "Situations de travail, compétences transversales et mobilité entre les métiers" (Work situations, crosscutting skills and mobility between professions), *Document de travail* no.2018-03 and *Note de Synthèse*, France Stratégie, February.

[2] France Stratégie took part in the debate on "*L'éthique dans l'emploi à l'ère de l'intelligence artificielle*" (Ethics in employment in the era of artificial intelligence) organised by Renaissance Numérique in September 2017.

all, there is a risk that tasks to be carried out will become increasingly complex, with a consequent risk of increased work intensiveness, with the disappearance of simpler and more “restful” tasks. There is also a risk of worker isolation insofar as AI will enable workers to access information required for their activities via an application rather than human contact.

Evolution of skills specific to artificial intelligence

Needs specifically connected with development of AI in the banking sector should have no particular effect of the total volume of employment therein. Nonetheless, they require specific adaptions that should be emphasised.

Scarcity of available talent[1] is pushing companies that wish to implement AI-based solutions to call upon the services of specialised external bodies. Those wishing to create such skills in-house will be forced to make major changes in their work environment: AI projects, like advanced research projects, require a lengthy experimentation and preparation phase, which itself requires scientific rigour and patience as projects do not always result in direct improvements. Large digital technology groups have mostly chosen to open up their research departments to the outside world and conclude partnerships with universities or research bodies. Such peripheral transformations are a prerequisite for successful deployment of artificial intelligence.

4. Dissemination scenarios

The banking sector is often mentioned as being particularly vulnerable to the transformations brought about by artificial intelligence, which might well give weight to a scenario of disruption. This analysis is based on the highly automatable nature of so many present-day banking activities, which are largely to do with processing information. It also takes account of the importance of the FinTech ecosystem: rapidly growing technological companies that regularly announce their ambition of “disrupting banks”.

This analysis may be tempered down, however. As concerns FinTechs, it would appear that many of them are mainly looking to optimise various banking processes with a view to finally being taken over by existing banking operators, which would consequently add them to the latter’s current activity portfolios without their existence

[1] According to a survey carried out by EY in December 2017 among 200 AI professionals, 56% of whom estimated that a shortage of trained profiles was the main obstacle to development of AI.

being in any way threatened. BNP Paribas' takeover of the Nickel account and Crédit Mutuel / Arkéa's takeover of Leetchi are two examples of this trend.

In addition, as we have seen, the banking sector is highly regulated, in order to ensure economic and monetary system stability and combat fraud. The regulations in force are a major obstacle to entry, limiting innovative models' capacity to make any radical modifications to the market. Neobanks are often either subsidiaries of traditional banks (Boursorama is a subsidiary of Société Générale, for example, and Hello Bank a BNP Paribas subsidiary), or operators without banking licences and simply acting as payment operators, with fewer regulatory requirements certainly, but unable to provide credit services. Hence, any ability to effect transformation "from the outside" would seem diminished, at least as far as credit distribution activities are concerned. This is undoubtedly why payment activities are currently attracting more operators.

The retail banking sector has long experience of changes brought about by computer science, since the appearance of the first computers for computerisation of workstations and transactions. Every change so far has been accompanied by adaptation and training of staff rather than any massive destruction of jobs. Operators are therefore more inclined to see the advent of AI-based tools as a new step in digitisation rather than a revolution.

The banking sector also has a long tradition of professional training, partly due to the major regulatory constraints it is subject to and their regular evolution in the face of security requirements and the fight against fraud, money laundering and the funding of terrorism.

From the demographic point of view, the banking sector should see continuing departures due to retirement over the next few years, a consequence of the large-scale recruiting drives that marked the 1980s, a decade that saw major expansion of banking activities. Such departures should make it easier to manage reorganisations brought about by developments in AI.

Hence, the most likely scenario in the banking sector is one of progressive, trend-based evolution. Nonetheless, the extent of changes to come should not be underestimated: AI should bring radical changes to customer advisors' activities, by relieving them of a good many monitoring and simple customer management tasks. The future of bank branches, numbers of which started to decrease well before deployment of AI, as a result of changes in customer behaviour due to the digital revolution, will largely depend on existing demand for local services and their complementarity with ever more efficient online services (chatbots, messaging, etc.).

For a disruptive scenario to predominate, there would have to be a combination of significant innovations enabling development of a high value-added service to which customers would switch en masse, lack of anticipation on the part of operators in place that would accelerate customer loss, and easily overcome regulatory obstacles. Such a combination is not altogether impossible; it might even come about without AI, whether with payment platforms that manage to gain a foothold as intermediaries in the majority of transactions, or with new payment systems such as some form of cryptocurrency that solves the fatal flaws in currently existing solutions with Bitcoin[1].

Whatever happens, we should be seeing increased demand for staff capable of solving customers' more complex problems, as indicated by online and traditional banks alike. Simple problems will be handled quickly and efficiently by automatic services. The need for technical skills may therefore decrease in favour of interpersonal skills and the ability to advise on and provide an overall analysis of a situation.

[1] See France Stratégie's soon to be published report on issues involved in blockchains.

IMPACTS IN THE HEALTH SECTOR

Health is often presented as one of the sectors where artificial intelligence could produce major transformations in work. Medico-technical robotisation is already well established in the fields of biology, pharmaceutics and surgery. Software designed to assist prescription and even medical decision-making – such as the Watson Healthcare software developed by IBM – is continually improving thanks to AI. A number of observers have even gone so far as to foresee the prospect of "*medicine without doctors"*[1], with the emergence of "media-medicine" likely to bring about radical changes in medical practice and the organisation of our healthcare system. This "mediatised"[2], even "Watsonised" – to use the neologism coined by the National Council of the Order of Physicians[3] – would draw on smart use of data to improve the health system's efficiency.

Almost all fields of artificial intelligence – image and video recognition, natural language processing, automatic learning, robotics, etc. – can find applications with regard to health. It is already the case for diagnosis and treatment recommendations; surgery, personalised monitoring, the medico-social sphere, rehabilitation, prevention and clinical research. Artificial intelligence not only enables automation of simple tasks such as measurement of weight or blood pressure, but also of complex tasks such as medical diagnosis and treatment recommendations.

Currently, however, concrete applications of artificial intelligence in healthcare facility organisation are still very limited. A few examples – assistance with diagnosis and treatment recommendations, connected monitoring of patients, and robotics – nonetheless bear witness to its major potential. AI may progressively bring about far-

[1] Vallancien G. (2015), *La médecine sans médecin? Le numérique au service du malade* (Medicine without doctors? Digital technology at the service of the patient), Paris, Gallimard, *Le Débat* series, April.
[2] *Id.*
[3] National Council of the Order of Physicians (2018), *Médecins et patients dans le monde des data, des algorithmes et de l'intelligence artificielle* (Medicine and patients in the world of data, algorithms and artificial intelligence), White Paper, January.

reaching modifications to medical treatment of patients and so transform the work carried out by health professionals, from specialists to auxiliary nurses.

1. Applications of artificial intelligence and impacts on work

Diagnostic assistance and treatment recommendations

There are a great many AI tools on the health market, with a wide variety of current applications in the area of medical diagnosis. They are to be found in such medical specialisations as oncology (which covers all medical specialisations, studies, diagnosis and forms of treatment of cancers), cardiology, ophthalmology, radiology, detection of specific illnesses (diabetes, Alzheimer's, etc.) and mental health (detection of depression and other psychological disorders). Whatever the field, the principle is always the same: algorithms provided with and trained on big data (medical image recognition, medical research results, etc.) are programmed to detect pathologies in accordance with protocols predefined by the medical world.

The emblematic tool here is IBM's Watson software, which was introduced onto the health market in 2005. Watson has been used, for example, at the Memorial Sloan Kettering Cancer Centre[1], an American institute specialising in medical research on and treatment of cancer, in order to assist with diagnosis and therapeutic recommendations. This type of software, designed as a "smart" tool for assisting with medical decision-making, synthesises a mass of information taken from millions of medical reports, patient files, clinical trials and knowledge resulting from medical research. Various upcoming software tools will soon be able to diagnose a cancer just as well as or even better than a specialist. According to a recent study[2], artificial intelligence was able to carry out automated detection of breast cancer with a 92% success rate, almost equivalent to that achieved by specialists (96%). When a physician's analyses are combined with automated software's diagnostic methods, the success rate rises to 99.5%, with much lower risk of error.

Evolution of professions

Medical imaging professionals will be particularly affected by the foreseeable universalisation of automated image interpretation. If AI enables automation of a

[1] www.mskcc.org/about/innovative-collaborations/watson-oncology.

[2] Wang D., Khosla A., Gargeya R., Irshad H. and Beck A.H. (2016), *Deep Learning for Identifying Metastatic Breast Cancer*, Beth Israel Deaconess Medical Center (BIDMC) and Harvard Medical School.

proportion of conventional radiology, in specific clinical fields and situations, there will be a resulting decline in this radiological activity, despite growing needs due to an ageing population and chronification of diseases. Eventually, the question may be raised as to whether radiologists are required in order to make a diagnosis. This automated step might well be carried out by a radiographer trained in making diagnoses. It might also be carried out by a non-radiologist physician equipped with a medical-image interpretation tool. Such evolutions assume adaptation of the current regulatory framework[1]. Radiologists themselves would devote their time to interpretation of complex cases. As regards interventional imaging, however, there will be growing needs in almost all medical specialisations. The radiologist's profession may evolve towards increased specialisation in interventional radiology for diagnostic purposes (punctures, biopsies, etc.) in complex cases or for the purposes of medical image-guided therapy. This evolution towards interventional activities has already been integrated by the profession, according to the National Federation of Radiologists (FNMR).

New electrocardiogram (ECG) interpretation services are being developed in the field of cardiology, no longer provided by cardiologists but by software. Based on machine learning drawing on big data, such software detects pathologies with a degree of efficiency comparable to and possibly even better than a cardiologist's. For emergency physicians and general practitioners in particular, such services, mobilisable round the clock, would save precious time and provide assistance in patient orientation. The software in question, capable of detecting unusual or silent cardiac anomalies such as mitral insufficiency or cardiac arrhythmias that a specialist is sometimes hard put to detect, would provide physicians of whatever specialisation with gains in quality.

Such a service could transform ECG practice, making its use more frequent in more medical specialities (emergency physicians, general practitioners, geriatricians, etc.), and perhaps even eventually opening it up to non-physicians (nurses, firemen, etc.). It should give cardiologists more free time, if only by management of simple cases treated upstream without requiring their intervention. They might then be able to focus on more complex cases and further training, taking advantage of ongoing learning thanks to a software tool able to make use of the very latest clinical knowledge and medical practices.

[1] Refer in particular to Decree no.2016-1672 of 5 December 2016 bearing on acts and activities carried out by medical electro-radiological technicians.

For the 7,000 cardiologists currently in practice, AI may well accentuate the trend towards subspecialisation of their profession (coronary angiograms, arithmology, cardiopaediatrics, etc.), facilitated by increasing digitisation of various medical tools. In cardiology as in all other fields, the scale of the impact will depend on the quality of the tool. In parallel, AI will enable development of another type of service[1], consisting of interpreting ECG data recorded over a long period (several days): up until now, such readings are rarely carried out (long, delicate analysis required). For cardiologists, this brings the prospect of a new way to monitor their patients.

In general medicine, diagnostic assistance software has existed for several decades. Such tools are designed as "medical assistants". The latest versions integrate artificial intelligence, with improved capacities and greater speed. Based on a word, concept or combination of symptoms, the physician can view a range of hypotheses. If these new "medical assistants" win the trust of doctors and the public at large, they may have multiple impacts on the general practitioner's profession. Doctors will be able to take advantage of an aid to diagnosis of complex cases, with greater certainty in their decision-making. It will also lead to improved doctor/patient relations and dialogue, providing the information required for understanding of diagnoses. Use of artificial intelligence will lead to continuous improvement of physicians' levels of "technical" competence as they will be able to make a full exploration of the latest clinical knowledge and medical practices. Such improvement in competences will be all the more necessary as physicians must also be able to "challenge" software (and provide their own explanations of diagnosis and treatment).

Applications such as SymptoChec, DocForYou and Ada are available to anybody who wishes to have symptoms analysed or even dialogue with a virtual physician. Such products' effectiveness is yet to be assessed. If they prove adequate, general practitioners will have less of a role to play in diagnosis of minor ailments and referring patients to specialists, depending on evolution of the legal framework and reimbursement conditions.

Lastly, as regards medical analysis laboratories, AI is already up and running. It is very likely that we shall be seeing fully automated analyses of the more routine cases within the next five years. The biologist's profession will be called into question, as far as its participation in current medical analysis is concerned.

[1] Cardiologs, for example, provides these two types of services. In 2017, it obtained the FDA's (the USA's Food and Drug Administration) authorisation to market its platform for analysis of patients' electrocardiograms (recordings of heart activity).

Connected patient monitoring

With the development of artificial intelligence, connected health objects are opening up new perspectives with regard to patient monitoring. Apart from wellbeing gadgets and research[1], various objects are already integrated into overall treatment of patients, such as the smart pillbox that sends a signal if the patient forgets to take his pills, the blood pressure monitor permanently connected to a caregiver, the connected glucometer or the respiratory mask for monitoring sleep apnoea. Coupled with AI systems, such connected objects enable automated patient monitoring based on analysis of enriched data collected (contextual factors, cross-referencing of data, continuous collection, etc.).

Remote patient-monitoring platforms, in private practices and hospitals alike, should be able to predict risks of such inflammatory diseases as asthma being exacerbated, detect recurrence of lung cancer, and personalise diabetes treatment. By making patients “data rapporteurs” via connected objects and response to regular questionnaires, the aim is to improve their treatments along with the efficiency of AI algorithms that process the data provided. In hospitals, a medical monitoring platform connected to patients, prior to and following hospitalisation, enables centralisation of everything that a nurse would have been responsible for monitoring at the hospital, such as blood pressure and weight. Nurses consequently have more time to spend on analysing data and preparing treatment hypotheses for when they meet with physicians. In private practice, such platforms could take the form of social networks between general practitioners, specialists and coordinating nurses[2]. For general practitioners, facilitation of exchanges with other health professionals and home management of patients save time and helps with treatment of complex cases. In hospitals and private practice alike, sharing relevant information on patients improves cooperation between health professionals and coordination of decision-making and task scheduling processes. Artificial intelligence would enable optimisation of all such processes.

Applied robotics

There have been considerable advances in application of robotics to surgery since the early 2000s. Robotisation enables surgical interventions that reproduce the steps carried out in classical operations, but less invasively for the patient. The most developed system so far is the *Da Vinci* robot. New generations based on artificial

[1] 17% of French citizens already use eHealth applications, mainly to monitor their diet and keep a watch on their physical activity.

[2] Refer to the “Territoire de soins numérique" (Digital Care Territory) programme.

intelligence are currently emerging, with increased automation compared with the surgeon's role. This is the case with STAR (Smart Tissue Autonomous Robot), a robot which is not a total substitution for specialised surgeons, but provides them with a tool capable of greater accuracy in accomplishment of such acts as suturing[1].

Artificial intelligence coupled with pre-operative radiological exploration would enable on-screen simulation of the operation. For the surgeon, being able to perform on a virtual clone of the patient's organ would help make his practice safer.

Modern robotics incorporating AI, whether in sensor management or movement programming, seeks to develop as home assistance for individuals who are elderly or lack autonomy. In Japan, robots are already employed to help people carry out their everyday activities, helping them get around, from armchair to bed and vice versa. *Établissements d'Hébergement pour Personnes Âgées Dépendantes* (EHPADs – care centres for dependent senior citizens) could well be equipped with such types of robots within the next few years.

Robots already exist that provide solutions to problems in treatment of elderly patients suffering from cognitive or behavioural disorders (Alzheimer's, autism, etc.). Such robots are provided with artificial intelligence via numerous sensors and microphones that enable them to interact with their manipulators and respond to requests from elderly patients. Their physical presence and capacity for social interaction – via words, facial expression and gesture – make them ideal for working with individuals who have problems with verbal communication. A number of international journals specialising in the field have shown that such robots, animal robots in particular, enjoy adequate acceptability, with positive effects on patients' wellbeing[2]. The "Paro" robot, which reacts to its name, as well as to compliments and being touched, is the most often used in geriatric services across the world. For auxiliary nurses and nurses, integration of such machines would lead to a reduction in the physical and mental arduousness of their activities.

2. Determinants

Several factors should be taken into account before any attempt at considering AI dissemination scenarios in this sector.

[1] Shademan A., Decker R. S., Opfermann J. D., Leonard S., Krieger A. and Kim P. C. W. (2016), "Supervised autonomous robotic soft tissue surgery", *Science Translational Medicine*, 8(137), 4 May.

[2] See for example Shishehgar M., Kerr D. and Blake J. (2017), "The effectiveness of various robotic technologies in assisting older adults", *Health Informatics Journal*, September.

The situation regarding employment of health professionals

Almost 1.9 million health professionals were in practice in the healthcare sector in 2015 – 7% of the working population[1]. There is considerable diversity in the jobs concerned, not only in terms of training, manner of practice and remuneration, but also in terms of demographic situations. According to Directorate for Research, Studies, Evaluation, and Statistics (DREES) projections[2], the coming years will see relative stagnation in numbers of physicians (general practitioners and specialists alike) and a generally sustained increase in numbers of masseurs/physiotherapists, midwives and nurses. The ageing population of physicians combined with the aspirations of younger generations will most probably lead to a decrease in numbers and working hours of private practitioners over the next few years. Such a situation would bring the risk of an increase in territorial inequalities regarding access to care. Yet the scarcity of medical resources in a context of growing health needs is likely to spur development of innovative solutions. It is partly in order to provide better access to care across the territory that telemedicine, for example, is provided with support in France. In Japan, it is fear of staff shortages in the context of an ageing population that is given as the reason for introducing robot nurses into hospitals.

Increasing data quality

The second factor that needs to be taken into account is the increase in volume and quality of data, which favours dissemination of artificial intelligence. Big data is already available. *Assurance Maladie* (Social Security's Health Insurance branch) started setting up large-scale medico-administrative databases some time ago and now has access to data from 1.2 billion treatment forms, 500 million medical acts and 11 million hospitalisations, which could be added to by deployment of computerised patient records and pathology coding. Healthcare facilities possess large quantities of data, including on clinical trials. And this mass of health data is set to increase further. With the "Genomic Medicine France 2025" Plan, INSERM estimates that 12 sequencing centres would be able to decode 200,000 genomes[3] in 2015, a form of "big data in the self". Finally, connected objects, mobile apps, patients' comments left on medical forums and recurrent searches in search engines are all forms of information that AI will be able to analyse and so transform into big-data databases.

[1] Including 638,000 nurses, 416,000 auxiliary nurses and 222,000 physicians.

[2] Barle M. and Marbot C. (2016), *Portrait des professionnels de santé – édition 2016* (Portrait of Health Professionals– 2016 edition), "Panoramas de la DREES-Santé" series, April.

[3] Each individual's genome represents 3 billion pairs of bases, divided up into 23 chromosomes.

Social acceptability

Social acceptability is initially measured via the doctor/patient relationship. Major importance is still attached to patient/health professional dialogue during overall management of care pathways. This constitutes a limit to dissemination of artificial intelligence if the latter leads to "virtualisation" of doctor/patient relations. A limit perhaps, but one that by no means precludes it. The new digital context has led to changes in the way the doctor/patient relationship is perceived, as is illustrated by National Council of the Order of Physicians (CNOM) publications on connected objects and, more recently, on *Doctors and patients in the world of data, algorithms and artificial intelligence.* Patients, henceforth physicians' "committed or expert" partners, have become "neopatients"; patients in an era when knowledge is just a click away and in which, in France, 70% of them log onto the Internet for their or their loved ones' health issues, want doctors who welcome their questions and support their desire to understand medical decisions and even participate in making them"[1]. If software becomes more user-friendly, it may meet patients/citizens' aspirations. If not, if software tools continue to be types of black boxes, dissemination of AI will be held up by lack of social acceptability.

Acceptability is also measured by the trust that users themselves (i.e. health professionals) place in applications and tools. Such trust assumes that an ethical regulatory framework will be drafted to cover AI development and robotisation in the field of healthcare (see in particular the proposals for "positive regulation" put forward by the "academic and citizen" Ethik-IA initiative[2] in the context of the public consultation launched by Cédric Villani in 2017). But trust also comes with proof of AI's efficaciousness: new tools will be adopted if they reduce risks of error, speed up treatment processes, improve physicians' practices and are easy to use. Social acceptability will also depend on industrial concerns' ability to understand and meet these requirements.

[1] Extracts from the CNOM's White Paper (2018), *op.cit*. See also Gross O., Ruelle Y. and Gagnayre R. (2016), "Les patients enseignants, une révolution dans la formation des médecins" (Teacher patients, a revolution in training physicians), *Le Monde*, 12 September.

[2] The EthiK-IA initiative brings together a team of teachers and researchers in digital law, information and communication technology (ICT) and human and social sciences. It draws on work carried out in the context of Sciences-Po Paris' Health Chair, Paris-Descartes University's Law and Health Institute, the French Telemedicine Society (SFT) and the Association for the Development of Legal IT (ADIJ).

3. Dissemination scenarios

The sector is generally inclined to resist transformation

The examples of deployment of eHealth[1] and integration of ICTs illustrate a measure of resistance to innovation. The Interministerial Economic Change Forward-Planning and Forecasting Unit (PIPAME) classified France as "moderately advanced" in its deployment of eHealth, in comparison with a dozen other countries. Despite its assets, the good positioning of its startups in particular, France suffers from a highly fragmented eHealth industrial fabric, with equally fragmented innovation projects, leading to a stacking-up of networks created in universities and hospitals. Finally, the economic model is still too uncertain to support investments. As regards ICTs, the Court of Auditors[2] showed the problems France was having in integrating them into the healthcare system: low deployment of telemedicine (after thirty years of existence[3], its only accounted for 0.3% of consultations in 2015), failed deployment of the Shared Medical Record (DMP) (in 2016, less than 1% of the population had a DMP, although the scheme was launched as far back as 2004), low use of secure messaging (30% of private practitioners used it in 2016) and absence of dematerialised prescriptions[4].

One explanation for such resistance is the degree of regulation the health sector is subject to. First of all, it is closely supervised by the State, which, along with *Assurance Maladie*, funds 80% of expenditure on health, which came to a total of almost 270 billion euros in 2016, and sets pricing through reimbursement methods. Secondly, use of health data is highly regulated at national and European level alike. So-called "sensitive" personal data receives increased protection in relation to common law. Regulations governing it are all the more justified as there are now a great many parties that collect it: *Assurance Maladie*, physicians and healthcare facilities, and major digital platforms (Google, IBM, Microsoft, Apple, etc.). Progress has been made, with creation of a National Health Data System (SNDS) in 2017, which brings together a range of databases, changes in means of access and creation of an Expert Committee for Research, Studies and Evaluations in the Field of Healthcare (CEREES). However, in France, a framework enabling response to

[1] In other words, innovative use of ICTs in healthcare activities.

[2] See Court of Auditors (2017), *La Sécurité sociale*, Report on application of Social Security funding laws, September.

[3] The first international congress on telemedicine was held in Michigan in 1973.

[4] "However, France is currently one of the last five European Union countries in which secure electronic prescription of medicines and medical devices is not deployed. In contrast, 84% of prescriptions delivered in Spain are in secure electronic format", Court of Auditors (2017), *La Sécurité sociale*, *op. cit*.

growing needs with regard to access, sharing, protection and guaranteeing reliability of data is yet to be achieved. Difficulty of access to data has been identified as an obstacle to development of artificial intelligence, in particular as regards possibilities for transfer of research work[1].

Regulations will not prevent dissemination of artificial intelligence where actors foresee major gains

There are a good many signs that private actors and the public authorities alike are determined to make progress in deployment of eHealth. The former launched eHealth France Alliance in 2015, bringing together digital actors[2] with a view to increasing the sector's visibility, while the latter see eHealth as an opportunity to improve the health system's efficiency and are developing initiatives in this direction: launch of the Aviesan Alliance[3] in 2009 in order to strengthen synergies between UHCs, universities and research bodies, conventional negotiations in 2018 between the National Health Insurance Fund for Salaried Workers (CNAMTS) and private practitioners in order to define insurance cover for telemedicine, the first experiments with secure electronic prescriptions, etc.

In a shared ethical framework, regulations bearing on data access may become more flexible. The #FranceIA report made a number of recommendations in this direction. Health professionals, via the National Council of the Order of Physicians, also show themselves willing to make algorithms and artificial intelligence "their allies", "as an essential contribution to aid in decision-making and therapeutic strategy". In their eyes, "the medicine of the future is already here".

Such trends suggest a scenario of progressive evolution. Health professions and levels of AI and eHealth integration are currently highly diverse, and these innovations will not have the same impacts everywhere.

Conditions that could lead to a disruptive scenario

In the health sector, new arrivals on the healthcare "market" are controlled by the State (planning of the hospital offer, numerus clausus, etc.). But other actors are in competition at international level.

[1] #FranceIA report.

[2] eHealth France was created by four professional organisations representing companies providing eHealth solutions: LEEM, LESISS, the SNITEM and Syntec Numérique.

[3] National Alliance for Life and Health Sciences.

The medicine and medical apparatus industry acts as a vector for dissemination of AI in the health sector, in particular via mobile applications integrated into care protocols. Applications evidencing high added value in terms of gains in health and/or quality of life might well come to play key roles in patients' care pathways.

Another actor in the same situation as competitor at international level is complementary health insurance. New online consultation services, on platforms without physicians and managed by software could also gain ground if they provide adequate quality and, for example, reduce inequalities in access to care across the territory.

New arrivals providing new services could therefore lead to emergence of a disruptive scenario, provided that they meet a social demand and sector actors are convinced of their efficaciousness.

WHAT LESSONS FROM THE THREE SECTORS?

This Report aims to base itself on sectoral examples in order to draw more general lessons from them that might be applied to other activity fields. This chapter summarises the main lessons to be learned from sectoral analyses.

1. AI is part of the wider phenomenon of the digital transition

Artificial intelligence is an integral part of the digital transition underway. A good many earlier phenomena, including automation of various tasks, the role of data and development of platforms, have been extended thereby. Hence, in retail banking, computerisation is nothing new, and, over the last few decades, has led the sector to adapt its workforce's skills to the new tools concerned. In the health sector, attempts to deploy personal and shared medical records came well before the recent developments in AI. And the transformations in the taxi activity came about without AI being involved, but rather through universalisation of smartphones equipped with GPS and mapping systems, which handle contacts between drivers and customers via digital platforms and decrease drivers' need to have a thorough knowledge of their city and the best routes to take.

AI therefore comes into play in the context of a certain level of digitisation, which it also depends on. The availability of medical imaging data and correctly filled out patient files is an essential building block in development of diagnostic assistance tools. In the same way, accumulation of data on real-world driving conditions is essential to assuring adequate levels of robustness and reliability of autonomous driving software. The same training phase is required for chatbots and conversational agents in the banking sector. Levels of digitisation may be a factor in speeding up deployment in whatever sector, but the reverse may also be the case: AI may lead to digitising an activity that had remained manual as any gains in efficiency brought about by digitisation had previously not seemed sufficient to warrant it.

2. Transformation of tasks: substitution or complementarity?

The effects of artificial intelligence are first of all analysed with regard to transformation of tasks. This was the approach taken by the Athling consultancy in its sectoral study of banking professions[1].

First of all, AI enables performance of tasks that were previously impossible to carry out as they were either too time-consuming or not economically viable. One example drawn from the health sector would be analysis of electrocardiograms. In the banking sector, detection of anomalies in transactions is facilitated by AI-based systems. In urban transport, autonomous shuttles will soon be extending areas and times in which services are provided. Everywhere, AI-based systems would seem complementary to tasks carried out by human hands.

A second category is automation of tasks previously performed by human beings. This is by no means a new field: robotisation in the automotive industry and digitisation of banking operations have been with us for a long time now, and have led to repositioning workers to carry out supervisory tasks. AI is very much part of this dynamic. Driving as a human activity is on the way out over the long term due to the advent of the autonomous vehicle. And, more recently, such is also the case with activities for which specific qualifications are required, in medicine, for example, or provision of legal services.

The third type of task transformation brought about by AI concerns assistance in decision-making. Here, the human task is not modified but the individuals concerned can draw on systems that provide them with help: diagnostic assistance and therapeutic recommendations in the health sector, for example, or aid to customer advice in the banking sector.

Such categorisation is sometimes a little too simplistic. Chatbots, for example, are able to take initial action in handling customer service requests round the clock, so improving the service (Category 1 above), while, during opening hours, they act as replacements for traditional work (Category 2). Artificial intelligence's various capacities explain why its effects are to be seen with regard to workers' skills and work organisation alike.

[1] Athling, on behalf of the Observatory on Banking professions (2017), *L'IA dans la banque : emploi et compétences* (AI in the bank: employment and skills), December.

3. Transformation of qualifications: expert or generalist?

AI technologies are often heralded as being well suited to tediously repetitive tasks, obeying rules that a machine can "learn". This is only half the truth. AI is also able to handle complicated tasks – autonomous driving, for example.

When AI manages basic tasks, this may result in an increase in workers' qualifications. In customer relations, if simple requests are handled by AI, complex cases are then handed to human advisors. This transfer may lead to an increase in skills levels and a growing need for social skills, required for management of complicated interactions with customers, patients or users. This in turn may result in work intensification, as simple routine cases, previously in the majority, are replaced by cases requiring greater attention.

As regards banking, AI may lead to needs for specialisation, in order to provide the customer with up-to-the-minute expertise, as well as to development of a generalist status, capable of referring customers to the right specialist and solve such problems. In the health sector, artificial intelligence may bring about relative deskilling, when complex tasks traditionally performed by humans are automated. In contrast, nurses and radiographers operating AI-based systems may see their skills increased through use of assistance provided by diagnostic systems. This particular problem is not specific to AI, however, arising more generally from automation and digitisation that lead to workers taking on the role of system supervisors, which of course assumes their proficiency in the digital skills required.

What impact these various effects will have depends on the organisational choices that managements make, between advanced automation and human/machine complementarity.

4. Transformation of work organisation

A tool for improving in-house organisational processes

Deployment of AI systems leads to rethinking work organisation. Everything starts with collection of information on digital systems. Once digitisation is underway, AI systems are able to improve operational performances by contributing to information management, activity planning and actor coordination. Predictive maintenance in transport infrastructures and activity planning in hospitals are both emblematic examples of this. However, if it is to be fully efficient, such organisation assumes that

users can provide feedback on system operation. Assistance systems in the banking sector have sometimes had counterproductive results when responses were not adapted. This phenomenon is simply a continuation of the administrative overload that many organisations complain of, when activity coding takes precedence over the activities themselves.

As it is likely to foster better coordination of organisation, AI may also lead to greater isolation of workers. Such is the case, for example, when automatic systems transmit instructions to workers who have become simple "performers". This phenomenon started with platforms, and will undoubtedly become increasingly widespread when task supervision by AI is possible. We should therefore not underestimate the risks attached to deployment of AI tools as far as working conditions are concerned (loss of autonomy, work intensification, etc.).

Towards learning organisations?

AI tools foster dissemination of innovations and improve quality of customer/patient services. So-called "learning" organisations, based on a rationale of continuous organisational learning, could be particularly well adapted to the challenges raised by integration of artificial intelligence. Such organisations would enable response not only to technological issues but also to societal expectations as regards greater autonomy and wellbeing in the workplace.

The sectoral examples we have provided also show that crosscutting skills – the ability to communicate with others and influence decisions, to transfer skills and organisational knowhow, and to manage the unexpected – will take on greater importance with deployment of AI. Consequently, learning organisations which prioritise best use of such crosscutting skills and continuous learning may help ensure complementarity between machines and workers.

Unanticipated transformation of sectoral organisation

Anticipated in-house optimisation of processes within existing companies may not, however, be the only way in which transformation comes about. More radical changes brought about by new actors may take place. The emblematic example here is that of the autonomous vehicle, above all the robotaxi, which is bringing about radical modifications in the sector's organisation. Although less likely in the banking and health sectors, a similar revolution is nonetheless possible in various subsectors. If diagnostic systems for certain diseases show their worth, abroad in particular, without being deployed in France, it is possible that they will be used anyway, so bypassing the system in place. "Disruption" can occur in any sector.

Interaction with AI systems

Artificial intelligence affects three major categories of workers. First of all, production of AI services generates highly qualified work: researchers, data scientists, engineers and other specialised technicians. Having such qualified staff is crucial to successful integration of AI although only a limited number of jobs are involved. The main problem in this segment is that of training and keeping talents: a question examined in detail in the Villani report.

Secondly, large numbers of workers will be making use of AI-based systems without necessarily knowing that AI is involved: the issue here is that of training them to use such tools correctly. It concerns most bank advisors and medical staff, along with drivers and repairers.

Finally, AI is set to affect the relative importance of certain skills. Interpersonal skills, empathy, artistic and creative sensibilities and certain manual tasks will be reassessed upwards due to AI. As a result, activities not making use of AI will become proportionally more attractive. In customer relations, with technical skills being the purview of AI systems, interpersonal skills and dedication to customers, along with skills more to do with selling, are likely to see their importance increase.

Who is concerned?

Just as digitisation of society and the economy now affects all activity sectors, AI is likely to affect all professions, directly or indirectly, as regards their nature and/or the conditions under which they are practiced. Above all, tasks currently regarded as being highly skilled may well become automated: an innovation on the part of AI in comparison with forms of automation implemented up until now.

In the health sector, activities will be indirectly affected by development of AI-based monitoring and identification systems. Cameras will be able to measure such health parameters as fatigue, emotions, heart rate and pupil dilation. In the banking and transport sectors, AI building blocks may be included in a wide range of tasks. All these factors go to suggest that professions are more likely to be transformed than automated. Various forms of evolution are all the more probable in that successful deployment also depends on various non-technological factors.

Modes of deployment

Our sectoral examples enable identification of complementary factors affecting dissemination of AI. These include economic considerations, as regards automation for example; social acceptability, on the part of users and workers alike; available

skills, which may determine transformations; available data, on various pathologies for example; and the regulatory framework.

In conclusion, many activities will see progressive deployment of artificial intelligence tools. Their dissemination will lead to transformations in the world of work in the form of transformations of tasks and professions, and consequently of training needs. The stepping up of monitoring mechanisms brought about by AI may generate new risks for workers, and consequently adaptations will have to be the result of social dialogue.

However, the often hypothesised scenario of massive radical transformation of work would appear to be extremely unlikely, although disruptive scenarios are not to be altogether excluded in a few sectors and subsectors. They would only occur if there were a combination of several factors: AI's ability to provide a new service; strong demand on the part of users; an obsolete regulatory framework; and international competition and the arrival of new actors on the market.

ISSUES AND RECOMMENDATIONS

On the basis of the analysis presented above, the Report has identified three action focuses to respond to the issues raised by artificial intelligence in the world of work:

- carrying out forward studies on the potential of AI at industry or sector level, in order to ensure adequate levels of information and anticipation among actors;
- ensuring that workers receive training in the issues of tomorrow's world: training highly skilled workers for production of AI, and workers aware of the technical, legal, economic and ethical issues raised by the use of such tools;
- improving systems for securing the few sectors and subsectors that are set to be heavily impacted by automation risks.

1. Launching a forward-planning project to anticipate the effects of artificial intelligence and accompany operators

Although AI has made spectacular progress in the performance of a number of specific tasks, it is still a long way from possessing the general skills acquired by human beings. We speak of machine learning, yet such "artificial" learning is currently only carried out for certain tasks and in specific fields of application. This does not prevent the special skills associated with a task that follows a set of predetermined rules – whether simple or complicated – from eventually being downgraded by advances in AI. It will therefore be a matter of assessing such "automatable" tasks which would replace work, and identifying those that will be complementary. The actors concerned will have to bring this work to fruition by taking account of a number of aspects, including degrees of complexity of the tasks that make up a profession, the risk of AI error depending on field of application, and degree of interdependence between tasks and professions within an organisation. Such work requires launch of a forward-planning anticipatory project, complex perhaps but essential in order to make an objective assessment of the improvements that AI may bring about with regard to organisational efficiency.

The forward-planning project would aim to assist stakeholders to anticipate future scenario trajectories. Either a disruption scenario with no preparatory phase, along with everything that it would lead to in terms of abrupt adjustments (unemployment, professional retraining, deterioration of working conditions, etc.), or a progressive scenario in which forward-planning management would have been fully anticipated by the actors concerned (organisations, professional branches, the State, unions, associations, local authorities, etc.), enabling smooth adaptation of skills, professional retraining, organisational change and the continuing training system (evolution of training-course content in particular).

The project is one of the key focuses of the mission carried out by Cédric Villani. In addition, this Report proposes that accumulation and dissemination of work on AI's impact on professions and skills by sector be included in the Employment Skills Network (REC) agenda. The REC could also provide opportunities for trying out ways and means of developing the skills required in the face of deployment of artificial intelligence. Set up in 2014 in order to increase capacities for collective assessment of skills needs in France, the REC brings together actors in observation and forward studies of jobs by sector, profession, qualifications and skills. In 2017, it produced a shared diagnosis of crosscutting skills transferrable from one profession to another[1]. As it also focuses on sharing methodological approaches with a view to professionnalisation of actors in the field, the REC could well contribute to dissemination of work and methodological approaches already developed or under development by professional branches.

Such accumulation could:

- encourage industries, sectors and territories to carry out this sort of work, while drawing on methodologies already tested out during deployment of AI tools;
- foster sharing of information on various crosscutting professions in companies, such as those to do with administrative and financial services, which may be strongly impacted by AI.

It would also be of interest to repeat approaches similar to the "Shared forward-looking vision of jobs and skills[2]" implemented at the initiative of the National Council for Industry (CNI) and tested out within the REC. Such approaches draw on the complementary visions of a range of actors – companies, industries, actors in

[1] Lainé F. (2018), "Situations de travail, compétences transversales et mobilité entre les métiers", *op. cit.*

[2] France Stratégie and CÉREQ (2017), *Vision prospective partagée des emplois et des compétences. La filière numérique* (Shared forward-looking vision of jobs and skills. The digital sector), Report by the Employment Skills Network (REC), June.

employment and actors in provision of training – in order to shed light on the evolution of professions and skills over the short and medium term and identify methods of professionnalisation ensuring an increase in profiles suited to such professions.

Based on these analyses, it would seem necessary to help companies identify the exact skills they will have need of in the future (mapping of professions included in the company, for example, or formalisation of a skills reference framework) and provide them with tools for accurate assessment of job applicants' skills (use of skills-detection exercises during recruitment procedures).

The main difficulty in provision of such assistance is that of ensuring individualisation and objectivity with regard to each company's needs and problems. Yet taking full account of each company's (economic, territorial, technological, etc.) specificities is also what guarantees implementation of appropriate measures and actions[1].

French companies are currently having problems identifying the skills they need. Under 15% of them say they have introduced skills management in order to "identify the skills required for the activity", "check disparities between skills required to carry out the activity and employees' actual skills", or "implement actions designed to reduce disparities (via continuing training or recruitment)". Yet artificial intelligence risks bringing about greater disparities between actual skills and required skills. It may therefore provide an opportunity to raise awareness on the subject among companies, as is suggested in sectoral analyses, with regard to predictive maintenance for example.

Numerous human resources (HR) platforms already exist at territorial and sectoral level alike, with the aim of assisting companies in identifying their skills needs. HR platforms are single windows dedicated to human resources for very small companies (VSEs) in given areas or sectors. As local services, they aim to professionalise company directors as far as their function as employers is concerned, and safeguard employees' career paths. Where they exist, such services are funded or cofounded by Regional Directorates for Enterprises, Competition Policy, Consumer Affairs, Labour and Employment (DIRECCTEs), local authorities, professional branches or consular bodies.

HR platforms have three main action focuses: provision of advice on human resources management, information on the legal framework and judicial aspects, and help with recruitment. They may assist companies in formalisation of skills reference

[1] Michun S. (2007), "Petites entreprises et territoire, un lien surestimé?" (Small companies and territory, an overestimated link?), *Formation Emploi*, no.97, CÉREQ.

frameworks based on their activity benchmarks (job descriptions in particular) to ensure their full appropriation. For example, crosscutting skills are defined in a great many activity benchmarks, which makes appropriation difficult for companies wishing to identify their needs. Such platforms may provide them with methodological support, helping them to "sort through" activity benchmarks depending on expressed needs, identify tasks that require interpersonal skills, or general analytical or crosscutting skills (flexibility, adaptability, ability to solve problems, creativity, etc.). They may also help them in mapping automatable tasks, taking account of social acceptability. And finally, platforms may raise companies' awareness on AI's potential impacts on work conditions and organisation (work intensification, loss of autonomy, coordination and communication processes, etc.).

2. Ensuring that workers receive training in the issues involved in artificial intelligence

Training high skilled workers for production of AI

This Report does not go into any detail with regard to employment that may result from production of AI systems. This undoubtedly strategic subject finally concerns a relatively low volume of employment – some 5,000 individuals currently work in AI research [1] – with very different problems. Workers in this particular sector have major negotiating power given the shortage of highly skilled manpower. As the subject is included in the Villani mission's roadmap, we shall confine ourselves here to emphasising how essential it is to possess the talents required to carry out research work, deploy systems and develop an AI-based economic activity in France.

Even today, a fair number of these technologies seem largely inexplicable, with their dependence on training data and a generic character that makes proficiency in an entire sector essential, as regards the question of strategic and ethical independence, which is central to the mission entrusted to Cédric Villani. This question requires development of fundamental research, investment funds and institutional support giving researchers access to resources ensuring successful technology transfer and development of activities.

Alongside production of cutting-edge knowledge resulting from fundamental research, computer skills need to be developed in order to deploy AI-based systems. The "*Grande École du Numérique*" label is helping to meet this need.

[1] FranceIA report.

Training in these professions may, of course, take the form of initial training, but may also involve the training of individuals in more difficult situations, whether school dropouts or people undergoing professional conversion. The Simplon school[1], which has branches in France and abroad, meets this need by delivering free training programmes for professions in the digital sector. Efforts in this direction must continue, in particular with a view to identifying individuals who possess skills or are interested in making a career in the digital sector.

Again, we are not talking about any great number of job openings, but certain needs are acute nonetheless and information technology is highly generic: even if various specialised forms of knowledge are sure to become rapidly obsolete, they can be updated and reused in different functions. Faced with the challenge of successfully integrating digital tools into the workplace, having trained individuals available who have already had professional experience may be extremely rewarding. This point is not specific to AI, but concerns the digital transformation as a whole.

Training workers aware of the technical, legal, economic and ethical issues raised by use of AI tools

It is of key importance to integrate the skills required for use of the AI tools specific to different sectors into vocational training programmes (professionalising courses, Higher Technical Certificates (BTSs), professional baccalaureates, Master's degrees, doctorates, etc.). Such tools are very much part of the digital transition currently underway, marked by increasing digitisation of activities, new forms of work via platforms, use of users' data to help improve services and products, etc. All these tools participate in deployment of AI via creation of databases and training of algorithms. AI may well help speed up skills enhancement.

In whatever sector, it must also be possible to track back through AI-based software's decision-making processes in order to keep control of final decisions. Being able to call an AI tool's expert recommendations into question in order to make a decision with full knowledge of the facts is also a question connected with individual responsibility in a professional field. Such responsibility may be exercised to the full if algorithms are traceable through the entire decision-making process chain. Human regulation – understanding, checking data structuration and the criteria on which the machine's reasoning is based – is therefore necessary.

[1] https://simplon.co.

Organisations may also find it useful to develop their own decision-assistance tools. This would enable them to continuously extend their professional skills in use of AI tools, while improving their appropriation of decision-making processes. This is particularly useful in complex fields where errors may have major consequences – in making medical decisions in particular. As an example, members of the *Centrale Santé* (an open professional group belonging to the Centrale Alumni Association) founded the Bio-Modeling Systems company in 2004 in order to develop the CADI (Computer Assisted Deductive Integration) operational heuristic modelling platform, which seeks to foster continuous learning of professional skills important in medical research. Among other things, the platform has enabled training of "integrator" biologists, the aim being to provide them with increased capacities via algorithms developed by specialised computer scientists. This decision-assistance platform helps make professional skills central to the decision-making process, enabling them to generate new hypotheses and/or challenge existing programmes and recommendations of experts in their own field of biomedical research. It aims to develop medical practices in the form of protocols (descriptions of practices in a given field) overseen by professional skills, and then turn them into algorithms via multi-person decisions (specialised computer scientists, biologists, etc.). This type of tool therefore seeks to provide assistance with making "controlled", contextualised decisions adapted to users' needs and the complexity of their fields of application.

Better safeguarding of career paths in sectors and subsectors likely to be heavily impacted

The progressive transition scenario would appear to be the easiest to manage. It corresponds to an evolution in which skills, organisations and workers make use of AI tools in order to improve efficiency, free themselves from arduous tasks and perform new tasks that would not be possible without the help of such tools. This form of evolution is not the only scenario, however. Disruption may occur if advances in AI come sooner than expected, if new services make their appearance, or if there is strong social acceptance.

The driver's profession is eventually likely to disappear altogether. If the transition is progressive, retirements, and professional training in new transport professions or other activities may be enough to accompany it. If it happens more quickly, because, for example, a safe automatic lorry becomes available, authorised by the public authorities, accepted by road users and economically viable, major professional conversion problems may arise relatively quickly.

This Report does not make any new recommendations in this respect, but suggests that measures already undertaken be continued to protect individuals rather than jobs. The “skills blocks” approach that has been developing for several years now within the training system and among certifying bodies may well provide an answer to this major issue: a qualified or certified individual may only have to adapt his/her skills via a complementary training “module” without having to complete a whole qualifying or certifying programme[1].

This approach would have a dual advantage for organisation of the continuing training system, with regard to responsiveness in the face of technological changes as well as to financial cost. It would involve acceleration of the process of breaking down certifications – diplomas and titles listed in the National Directory of Professional Certifications (RNCP) – into skills blocks and reinforcement of Accreditation of Prior Experiential Learning (APEL). The “block” approach would also enable more rapid adaptation of skills reference frameworks (in as much as it would only be partial): even though it still remains to be tested, this hypothesis would contribute to ensuring the relevance of frameworks in the face of changes resulting from artificial intelligence.

[1] Employment Skills Network (REC) (2017), *Compétences transférables et transversales : quels outils de repérage, de reconnaissance et de valorisation pour les individus et les entreprises?* (Transferrable and crosscutting skills: what detection, recognition and valorisation tools for individuals and companies?), France Stratégie, April; see also, for examples of transferrable professions, Frédéric Lainé’s study (2018), “Situations de travail, compétences transversales et mobilité entre les métiers”, *op. cit*.

APPENDICES

MISSION LETTER

Liberté • Égalité • Fraternité
RÉPUBLIQUE FRANÇAISE

MINISTÈRE DU TRAVAIL
SECRÉTARIAT D'ETAT CHARGÉ DU NUMÉRIQUE

Paris, le 09 OCT. 2017

La Ministre
Le Secrétaire d'Etat

Monsieur le Commissaire général,

Les progrès récents de l'intelligence artificielle soulèvent de nombreux défis. Au-delà des enjeux scientifiques et économiques majeurs, les outils d'intelligence artificielle, notamment par l'automatisation accrue des tâches qu'ils permettent, sont porteurs de transformations du travail. Des impacts significatifs sont attendus sur les métiers et les besoins en formation des salariés tout au long de leur carrière. Ce débat appelle une réflexion approfondie des pouvoirs publics, de manière à ce que la France puisse pleinement profiter du potentiel de l'intelligence artificielle et anticiper les transformations induites.

Conformément aux engagements du Président de la République, le Gouvernement souhaite faire du développement de l'intelligence artificielle une priorité. Une mission a été confiée à M. Cédric Villani, député, afin de proposer des mesures de politique publique permettant de favoriser le développement d'acteurs français de l'intelligence artificielle, de déterminer les applications de ces technologies dans le secteur public et d'identifier les implications éthiques du développement de systèmes automatiques.

Je souhaite que vous examiniez, en articulation avec les travaux de cette mission, les impacts de l'intelligence artificielle sur les transformations du marché du travail. Ces transformations peuvent être progressives ou plus rapides, selon les secteurs considérés, les avancées technologiques, les modes d'organisation du travail et de la production, le cadre réglementaire et le contexte social et culturel. Elles offrent de nouvelles opportunités d'emploi pour les personnes, comme des risques qu'il s'agit d'anticiper en amont.

Monsieur Michel YAHIEL
Commissaire général
France Stratégie - Commissariat général
à la stratégie et à la prospective (CGSP)
18, rue de Martignac
75700 PARIS SP 07

.../...

127, RUE DE GRENELLE – 75007 PARIS
35, RUE SAINT-DOMINIQUE – 75007 PARIS

Pour éclairer la décision publique, vous établirez des scénarios de transformation du travail avec le développement de l'intelligence artificielle et formulerez des recommandations quant à l'adaptation des politiques publiques permettant de répondre à ces scénarios. Vous appuierez ces analyses sur un travail de comparaison internationale, en étudiant les actions mises en œuvre par les pays les plus avancés dans la réflexion sur ces sujets. Vous produirez enfin des examens sectoriels détaillés (ex. santé, banque-assurance, services à la personne) pour illustrer vos recommandations, qui devront guider l'action publique pour accompagner les transformations en maximisant le potentiel d'emplois qu'elles impliquent

Vous nous rendrez compte périodiquement de l'avancée des travaux et nous remettrez un premier document intermédiaire au début du mois de novembre, avant un rapport final pour le 15 décembre prochain.

Nous vous prions de bien vouloir agréer, Monsieur le Commissaire général, l'assurance de notre considération distinguée.

Muriel PENICAUD **Mounir MAHJOUBI**

127, RUE DE GRENELLE – 75007 PARIS
35, RUE SAINT-DOMINIQUE – 75007 PARIS

INDIVIDUALS HEARD

Sandrine André, Director of digital roadmap projects, Metropolis of Strasbourg

Pascal Avargues, Executive Director of Digital Technology and Information Systems, Bordeaux Metropolis

Marie-Anne Bacot, Mission Officer, RATP Administrator, General Council for the Environment and Sustainable Development (CGEDD), Mobility and Transport section

Laurent Baudart, Delegate General, Syntec Numérique

Raphaëlle Bertholon, National Delegate to the Economy, French Confederation of Management - General Confederation of Executives (CFE-CGC)

Pierre Blanc, Founding Partner, Athling

François Blanchecotte, National President, National Health Professions Centre (CNPS)

Richard Bonne, Permanent Secretary, French Confederation of Christian Workers (CFTC)

Hoang Bui, Head of the transport materials, mechanical engineering and production machines office, Directorate General for Enterprise (DGE)

Yves Caseau, Director of Information Systems, Michelin Group, member of the National Academy of Technologies of France (NATF)

Emeric Chaize, Chief Digital Officer, Orange Bank

Béatrice Clicq, Deputy Central Union Representative (DSC), Orange, Workers' Force (FO)

Philippe Cortale, Director of the Professions and Skills Committee, Automobile Sector Platform (PFA)

Deborah Cvetojevic, Office Manager at the Directorate General for Health Services (DGOS), Ministry for Solidarity and Health

Arnaud Delaunay, Head of the Bancfin 4 Office, Directorate General of the Treasury

Jean-Louis Denis, Professor and researcher, University of Montreal Hospital Centre

Françoise Diard, Employment Skills Manager, Metallurgy Observatory

Corinne Dromer, Chairperson, Financial Sector Advisory Committee (CCSF)

Louis Fernique, Head of the Smart Transport Mission, Ministry for the Ecological and Inclusive Transition

Thibaut Ferreira, Mission Officer, Automotive Industry Office, Directorate General for Enterprise (DGE)

Pascale Finkelstein, Head of the Professional Development Department, AP-HP

Yann Fleureau, CEO, Cardiologs

Marie de France, Manager of the International Relations, General Directorate, INRS

Patrick Gasser, President, Confederation of French Medical Unions (UMESPE-CSMF)

Manuel Gea, Co-founder, CEO, & EVP R&D IT and Systems, Bio-Modelling Systems

Pascal Genet, Sales Executive France for IBM, Watson

Émilie Gerbaud, Directorate for Innovation and Economic Action, Greater Lyon

David Giblas, Director of Innovation, Digital Data, Malakoff Médéric

Jocelyn Gombault, Project Leader, Automobile Observatory

Thomas Gouritin, journalist, founder and CEO of Tomg Conseils

Pierre Grauby, VP Customer Relations, Orange

David Gruson, member of the Sciences Po Paris / Ethik IA Initiative Health Chair's Executive Committee

Enguerrand Habran, Director of the FHF Research & Innovation Fund, French Hospital Federation

Neila Hamadache, Training delegate, Syntec Numérique

Michel Héry, National Institute of Scientific Research (INRS)

Marie Houssel, Manager of the Hospital Human Resources Centre, French Hospital Federation

Denis Huneau, Engineer General of Bridges, Waters and Forests, General Council for the Environment and Sustainable Development (CGEDD)

William Joubert, Secretary General of the National Union of Health Professionals (UNPS)

Cécile Kanitzer, Paramedical Advisor, French Hospital Federation

Gautier Lalande, Digital Data, Malakoff Médéric

Edwina Lamoureux, Confederal Secretary, French Democratic Federation of Labour (CFDT)

Pierre Laplane, Managing Director of Eurometropolis Services, Metropolis of Strasbourg

Didier Lassauzay, Engineer, member of the Economic Division, General Confederation of Labour's (CGT)

Philippine Lefèvre, Institutional Relations Delegate, Syntec Numérique

Claude Leicher, President, MG France

Mikaël Louadoudi, Social Prospects and HR Innovation, Agirc-Arrco

Antoine Malone, Director for forward planning and research, French Hospital Federation

Françoise Manderscheid, Director of the Master's in Rail and Urban Transport Systems (STFU), National School of Bridges and Roads, ParisTech

Gérard Mardiné, National Secretary, French Confederation of Management - General Confederation of Executives (CFE-CGC)

Jean-Michel Masson, President of the National Federation of Radiologists (FNMR)

Delphine Mayrargue, Deputy Director, change and communication management, responsible for the autonomous train project, SNCF

Bénédicte Moutin, Mission Officer, Life at work/social dialogue, French Democratic Federation of Labour (CFDT)

Jean-Paul Ortiz, President, Confederation of French Medical Unions (CSMF)

Cécile Potters, Confederal Assistant to the Economy Sector, Workers' Force (FO)

Jérôme Reboul, Assistant Director of Banks and Financing of General Interest - Bancfin, Directorate General of the Treasury

Daphné Salon-Michel, Head of the Secretariat-General, Financial Sector Advisory Committee (CCSF)

Jean-Charles Samuelian, CEO, Alan

Alain Sauvant, Director, Transport Service Quality Authority (AQST)

Claude Sicotte (PhD), Professor at the University of Montreal's School of Public Health, responsible for the PhD programme's "Health Services Management" option

Aurélien Soustre, member of the Financial Sector Advisory Committee (CCSF), General Confederation of Labour (CGT)

Edgar Steimer, Deputy Secretary General, French Democratic Federation of Labour (CFDT), Transport

Jean-François Thébaut, President of the High Council for Continuing Professional Development (HCDPC)

Guy Vallancien, Honorary Professor**,** Paris-Descartes University

Hubert Viot, CEO, Maela Platform

Publication Director
Gilles de Margerie, Commissioner General
Managing Editor
Fabrice Lenglart, Deputy Commissioner General

Press Contact
Jean-Michel Roullé, Director of the Publication/Communication/Events Dept.
+33 (0)1 42 75 61 37, jean-michel.roulle@strategie.gouv.fr

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FRANCE STRATÉGIE – 20, AVENUE DE SÉGUR – TSA 90725 – 75334 PARIS CEDEX 07 – TÉL. 01 42 75 60 00