3 | 2021

AGS PUBLICATIONS

ISSN: 2696-1083

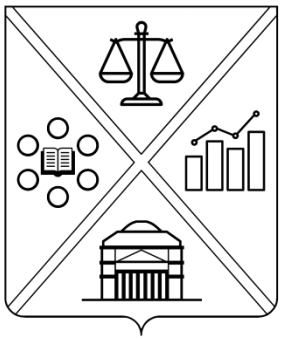
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More robots are coming. Where should I go?

A comparative study of forecasts on automation

ARNAU GUIX SANTANDREU



AGS Publications / Arnau Guix Santandreu
No. 3 / August 2021.
ISSN: 2696-1083
Website: https://ags.cat

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Recommended citation:

GUIX SANTANDREU, Arnau (2021): "More robots are coming. Where should I go? A comparative study of forecasts on automation". *AGS Publications*, No. 3, pp. 1-51. Accessible online at: www.ags.cat

More robots are coming. Where should I go?

A comparative study of forecasts on automation

ARNAU GUIX SANTANDREU

ABSTRACT

[ENG] The future of work remains nowadays uncertain. Before the Covid-19 pandemic, forecasts on automation presented in certain cases a tragic scenery at the beginning of the 2020s. However, at the moment such expectations have not arrived yet, in spite of the digital acceleration caused by the lockdown and the generalised restrictions to mobility. What is clear is that technology is transforming labour and will continue to do so in the next decade, distributing wealth in irregular concentrations all over the world. We can imagine a displaced worker looking for a job in an area of the globe with more opportunities and economic stability, thinking: «Where should I go?».

By analysing recent scientific publications on the subject, the present study is structured into two great axes. First of all, it is determined a general overview of the main magnitudes related to automation that put in evidence the current transformations on the labour market. Afterwards, the inquiry depicts an accurate overview of the experts' literature on the international forecasts of computerisation, which allows defining what areas of the planet appear to be safer to preserve the own professional future during this historical transition.

Keywords: robots, automation, employment, digital transformation, technological unemployment, computerisation, future of work.

***

[CAT] Actualment, el futur laboral continua sent incert. Abans de la pandèmia Covid-19, les previsions sobre automatització presentaven en certs casos un escenari tràgic a principis de la dècada del 2020. Tot i això, de moment aquestes expectatives encara no han arribat, malgrat l'acceleració digital provocada pel confinament i les restriccions generalitzades a la mobilitat. El que està clar és que la tecnologia està transformant la mà d'obra i ho seguirà fent en la propera dècada, distribuint la riquesa en concentracions irregulars a tot el món. Ens podem imaginar un treballador desplaçat que busca feina en una zona del globus amb més oportunitats i estabilitat econòmica, pensant: «A on he d'anar?».

En analitzar publicacions científiques recents sobre el tema, el present estudi s'estructura en dos grans eixos. En primer lloc, es determina una visió general de les principals magnituds relacionades amb l'automatització que posen en evidència les transformacions actuals del mercat laboral. Després, la investigació mostra una visió general exacta de la literatura dels experts sobre les previsions internacionals d'informatització, que permet definir quines zones del planeta semblen més segures per preservar el propi futur professional durant aquesta transició històrica.

Paraules clau: robots, automatització, ocupació, transformació digital, atur tecnològic, informatització, futur del treball.

***

[CAS] El futuro del trabajo sigue siendo incierto hoy en día. Antes de la pandemia de Covid-19, los pronósticos sobre la automatización presentaban en ciertos casos un escenario trágico a principios de la década de 2020. Sin embargo, de momento tales expectativas aún no han llegado, a pesar de la aceleración digital provocada por el confinamiento y las restricciones generalizadas a la movilidad. Lo que está claro es que la tecnología está transformando el trabajo y lo seguirá haciendo en la próxima década, distribuyendo la riqueza en concentraciones irregulares por todo el mundo. Podemos imaginarnos a un trabajador desplazado que busca trabajo en una zona del globo con más oportunidades y estabilidad económica, pensando: «¿Adónde debo ir?».

Analizando las publicaciones científicas recientes sobre el tema, el presente estudio se estructura en dos grandes ejes. En primer lugar, se determina un panorama general de las principales magnitudes relacionadas con la automatización que ponen en evidencia las transformaciones actuales en el mercado laboral. Posteriormente, la investigación presenta un acertado panorama de la literatura de expertos sobre los pronósticos internacionales de informatización, que permite definir qué áreas del planeta parecen más seguras para preservar el propio futuro profesional durante esta transición histórica.

Palabras clave: robots, automatización, empleo, transformación digital, paro tecnológico, informatización, futuro del trabajo.

***

[FRA] L'avenir du travail reste aujourd'hui incertain. Avant la pandémie de Covid-19, les prévisions sur l'automatisation présentaient dans certains cas un cadre tragique au début des années 2020. Cependant, pour le moment, de telles attentes ne sont pas encore arrivées, malgré l'accélération numérique provoquée par le confinement et les restrictions généralisées à la mobilité. Ce qui est clair, c'est que la technologie transforme le travail et continuera de le faire au cours de la prochaine décennie, distribuant la richesse en concentrations irrégulières partout dans le monde. On peut imaginer un travailleur licencié à la recherche d'un emploi dans une région du globe avec plus d'opportunités et de stabilité économique, se disant : « Où dois-je aller ? ».

En analysant les publications scientifiques récentes sur le sujet, la présente étude se structure en deux grands axes. Tout d'abord, il est déterminé une vision générale des principales magnitudes liées à l'automatisation qui mettent en évidence les transformations actuelles sur le marché du travail. Ensuite, la recherche dresse un panorama précis de la littérature d'experts sur les prévisions internationales de l'informatisation, qui permet de définir quelles zones de la planète semblent plus sûres pour préserver son avenir professionnel au cours de cette transition historique.

Mots-clés : robots, automatisation, emploi, transformation numérique, chômage technologique, informatisation, avenir du travail.

***

[ITA] Il futuro del lavoro rimane oggi incerto. Prima della pandemia di Covid-19, le previsioni sull'automazione presentavano in alcuni casi uno scenario tragico all'inizio degli anni 2020. Tuttavia, al momento tali aspettative non sono ancora arrivate, nonostante l'accelerazione digitale causata dal confinamento e le restrizioni generalizzate alla mobilità. Quello che è chiaro è che la tecnologia sta trasformando il lavoro e continuerà a farlo nel prossimo decennio, distribuendo la ricchezza in concentrazioni irregolari in tutto il mondo. Possiamo immaginare un lavoratore dislocato in cerca di lavoro in un'area del globo con maggiori opportunità e stabilità economica, pensando: «Dove devo andare?».

Analizzando le recenti pubblicazioni scientifiche sull'argomento, il presente studio è strutturato in due grandi assi. Innanzitutto si determina una panoramica generale delle principali grandezze legate all'automazione che mettono in evidenza le trasformazioni in atto sul mercato del lavoro. In seguito, la ricerca traccia un'accurata panoramica della letteratura degli esperti sulle previsioni internazionali dell'informatizzazione, che permette di definire quali aree del pianeta appaiono più sicure per preservare il proprio futuro professionale durante questa transizione storica.

Parole chiave: robot, automazione, occupazione, trasformazione digitale, disoccupazione tecnologica, informatizzazione, futuro del lavoro.

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[OCC] Actuauments, eth futur laborau contunha d'èster incert. Abans dera pandèmia Covid-19, es previsions sobri automatizacion presentauen en cèrti casi un scenari tragic a principis deth decènni deth 2020. Totun, peth moment aguestes expectatives encara non an arribat, maugrat l’acceleració digitau provocada peth blocatge e es restriccions generalisades ara mobilitat. Çò qu'ei clar ei qu'era tecnologia transforme era man d’òbre e ac seguirà en tot hèr en pròplèu decènni, en tot distribuïr era riquesa en concentracions irregulares en tot eth mon. Mos podem imaginar un trabalhador desplaçat que cerque trabalh en ua zòna deth mon damb mès oportunitats e estabilitat economica, en tot pensar: «A on è d’anar?».

En analisar publicacions scientifiques recentes sobri eth tèma, eth present estudi s’estructure en dus grani èishi. Eth prumèr lòc, se determine ua vision generau des principaus magnituds restacades damb era automatizacion que meten en evidéncia es transformacions actuaus deth mercat laborau. Dempús, era investigacion mòstre ua vision generau exacta dera literatura des expèrts sobri es previsions internacionaus d’informatització, que permet definir quines zònes dera planeta semblen mès segures entà preservar eth pròpri futur professionau pendent aguesta transicion istorica.

Paraules claus: robòts, automatizacion, aucupacion, transformacion digitau, caumatge tecnologic, informatització, futur deth trabalh.

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ABBREVIATIONS

AI	Artificial Intelligence
EaSI	Programme for Employment and Social Innovation of the European Union
EU	European Union
EURES	European Employment Service
GDP	Gross Domestic Product
ICTs	Information and Communication Technologies
ILO	International Labour Office
IoT	Internet of Things
ISO	International Organisation for Standardisation
LFS	Labour Force Survey
ML	Machine Learning
MOOCs	Massive Open Online Courses
OECD	Organisation for Economic Co-Operation and Development
PIAAC	Programme for the International Assessment of Adult Competencies
PISA	Programme for International Student Assessment
PPS	Purchasing Power Standard
R&D	Research and Development
SMEs	Small and Medium Enterprises
UBI	Universal Basic Income
UK	United Kingdom
UN	United Nations
US	United States
WEF	World Economic Forum
WHO	World Health Organisation

The situation will have been made the more serious by the advances of automation. The world of A.D. 2014 will have few routine jobs that cannot be done better by some machine than by any human being. Mankind will therefore have become largely a race of machine tenders. Schools will have to be oriented in this direction (...) It is not only the techniques of teaching that will advance, however, but also the subject matter that will change. Even so, mankind will suffer badly from the disease of boredom (...) The lucky few who can be involved in creative work of any sort will be the true elite of mankind, for they alone will do more than serve a machine.

Isaac ASIMOV, *Visit to the World's Fair of 2014* (1964)[1]

[1] In 2014 the exposed scenery has been notably diverse, with routine jobs still having an important share of the total employment. However, I. ASIMOV may have been visionary at addressing the current deep relationship of most of the humans with machines; at least, smartphones' dependency is a good example of it.



Chapter I / Introduction

CHAPTER I. INTRODUCTION

1.1. 100 YEARS OF ANALYSIS ESTIMATING THE IMPACT OF ROBOTS AND AUTOMATION

Sophisticated robots and algorithms have arrived to stay with us. Science-Fiction literature and films have depicted for decades a future where advanced technologies would help us in our daily tasks or, in contrast, would originate a global catastrophe. What is clear is that changes are currently irresistible and that a human-centred approach is necessary more than ever.

The Covid-19 outbreak in 2020 is an accelerator of the digital transformation. During this episode, workers had been classified into three main categories: essential personnel, remote employees and displaced workers. The first and second groups have preserved their occupation in a broad sense, but the last one has suffered disproportionately the consequences of the lockdown and the socioeconomic uncertainty[2]. Technological adoption and rapid automation have found in this crisis an optimal environment to intervene.

Before analysing the current scientific evidence on workforce replacement by automation and the related main magnitudes, it is important to acknowledge what have been the main estimations during the 20th Century, understanding the criteria of the greatest economists of that time. Furthermore, in the two decades before the «Great Recession» multiple papers were published on the issue and they deserve a special approach.

1.1.1. A NEOCLASSICAL APPROACH

In a book of 1930, the economist John Maynard KEYNES (1883-1946) referred to the circumstances of the «Great Depression» initiated in 1929 and intelligently pointed out that «we are being afflicted with a new disease of which some readers may not have heard the name, but of which they will hear a great deal in the years to come –namely, technological unemployment. This means unemployment due to our discovery of means of economising the use of labour outrunning the pace at which we can find new uses for labour»[3].

Nevertheless, J. M. KEYNES was confident about the progress of Humanity, expecting that living standards would rise incredibly over the following century. The British economist highlighted the role of the State in the moments of crisis, indicating the need of «socialising the investments» in such circumstances. The public sector appeared thus as a revulsive for maintaining the levels of investment and employment[4].

Another celebrated economist, Wassily LEONTIEF (1906-1999), detected similar trends in 1952 and exposed in an article that «labour will become less and less important… More and more workers will be replaced by machines. I do not see that new industries can employ everybody

[2] ZAHIDI, Saadia; RATCHEVA, Vesselina; HINGEL, Guillaume; BROWN, Sophie (2020): *The Future of Jobs Report 2020*. Cologny/Geneva, World Economic Forum, p. 16.
[3] KEYNES, John Maynard (1930): "Economic Possibilities for our Grandchildren", Chapter in *Essays in Persuasion*. New York, W. W. Norton & Company, pp. 358-373.
[4] FREEMAN, Chris; SOETE, Luc (1994): *Work for all or Mass Unemployment? Computerised technical change into the 21st Century*. London, Pinter Publishers Ltd. For the Castilian edition (1996): *Cambio tecnológico y empleo. Una estrategia de empleo para el Siglo XXI*. Madrid, Fundación Universidad-Empresa), pp. 50-54.

who wants a job»[5]. In 1983, W. LEONTIEFF compared the future role of humans in the industrial production with the transformation of rural work, transitioning from horses to tractors[6].

In the same time, the analysis of the economist Joseph Alois SCHUMPETER (1883-1950) can be traced inside the «Structuralist» School. The Austrian intellectual defended that the technological progress was the key element of the economic system. Innovations tend to concentrate on certain sectors and their immediate surroundings; this fact produces numerous imbalances. Therefore, the economic growth is related to «storms of creative destruction» with remarkable cyclical characteristics, called later on «Kondratieff cycles» in honour of the Russian economist[7]. For J. A. SCHUMPETER, technological unemployment was by far the most important typology of unemployment[8].

In 1966, the National Commission on Technology, Automation and Economic Progress of the United States, a body created specifically to study the issue, emitted a rigorous report[9] concerning possible public policies to affront the challenges of automation. The Commission was created on August 1964 and during two years elaborated a set of conclusions that nowadays are still valid for our present and future, in spite of the limited time horizon of their study, as was only projected for one decade after sight. Overall, the National Commission adopted a relatively balanced tone, among those who neglected the negative effects of technology over employment and those who required urgent public policy measures. Furthermore, the text attained a regional scope in the United States, considering divergent economic performances of territories and the need to expand prosperity among all.

Thus, the National Commission highlighted several recommendations for facilitating the appropriate adjustment of employment to technological changes. Such are described as follows, and deserve an accurate reading: «1. For those with reasonably attractive skills and no other serious competitive handicaps, ample job opportunities and adequate incomes can be assured by management of the total demand for goods and services. / 2. For those less able to compete in the labour market, productive employment opportunities adapted to their abilities should be publicly provided. / 3. Under the best of circumstances, there will be some who cannot or should not participate in the job economy. For them, we believe there should be an adequate system of income maintenance, guaranteeing a floor of income at an acceptable level»[10]. Besides, the Commission remarked the importance of having a computerised nationwide employment system[11], so as to improve the matching between labour demand and supply, offering detailed information of the job vacancies and the personal characteristics of jobs seekers[12].

1.1.2. A PRE-2008 CRISIS APPROACH

[5] LEONTIEF, Wassily (1952): "Machines and Man", *Scientific American*, Vol. 187, No. 3, pp. 150-164.
[6] JÁUREGUI, Ramón; EGEA, Francisco; DE LA PUERTA, Javier (1998): *El tiempo que vivimos y el reparto del trabajo. La gran transformación del trabajo, la jornada laboral y el tiempo libre*. Barcelona, Ed. Paidós, p. 50.
[7] FREEMAN, Chris; SOETE, Luc (1994): *Work for all or Mass (...) (op. cit.)*, pp. 54-56 (Castilian edition).
[8] FELDMANN, Horst (2013): "Technological unemployment in industrial countries". *Journal of Evolutionary Economics*, Vol. 23, Issue 5, p. 4.
[9] NATIONAL COMMISSION ON TECHNOLOGY, AUTOMATION AND ECONOMIC PROGRESS (UNITED STATES) (1966): *Technology and the American Economy*. United States Department of Health, Education and Welfare.
[10] NATIONAL COMMISSION ON TECHNOLOGY, AUTOMATION AND ECONOMIC PROGRESS (1966): *(...) (op. cit.)*, pp. 33-34.
[11] NATIONAL COMMISSION ON TECHNOLOGY, AUTOMATION AND ECONOMIC PROGRESS (1966): *(...) (op. cit.)*, p. 50.
[12] At the moment, in the public sphere, the EURES system in the European Union could be analogous to the exposed United States' inspirational initiative.

Christine GREENHALGH, Mark LONGLAND and Derek BOSWORTH examined in a study[13] of 2001 the relationship between technology and employment by using British data collected from 1987 to 1994. Instead of analysing the growing number of industrial robots, researchers focused on investment in research and development, intellectual property and trademarks. Overall, the analysis revealed positive effects of technology on employment, highlighting a particular increase of jobs in the technological sector. Authors recommended the deployment of R&D subsidies strongly. Similar outcomes were found in a paper[14] of 2005 elaborated by Mariacristina PIVA and Marco VIVARELLI: they examined the effects of technology on occupation by using a proxy that identified innovative investments in 575 Italian manufacturing companies during the period 1992-1997. Results indicated a little positive correlation among technology adoption and employment.

Very differently, Maarten GOOS and Alan MANNING analysed in a paper[15] of 2007 the effects of technology over the British labour market and concluded that a process of «job polarisation» was on the move. Relative demand in well-paid and skilled jobs (the so-called «lovely jobs») was increasing, thus requiring non-routine cognitive skills; besides, relative demand in low-paid and least-skilled jobs (also named «lousy jobs») was experiencing an increment, requiring non-routine manual skills. However, demand for jobs situated in the middle of the skills spectrum and requiring routine manual and cognitive skills was falling, accentuating by these means the polarisation effect. As will be commented in the next sections, this phenomenon has been analysed broadly by the recent scientific literature.

1.2. OBJECTIVES

The present analysis aims at understanding the magnitudes that shed light over the current impact of robots and automation processes on the future of employment. Besides, the study will address the recent scientific forecasts about the incidence of automation on occupation levels, comparing countries where more data has been accessible. Thus, it is possible to estimate in a broad sense where can be «safer» to work and live in a near future, answering by these means the question: «Where should I go?» (That is, a possible inquiry presented by a technologically displaced migrant in search of work opportunities, or a citizen concerned by the future of his/her children).

1.3. METHODOLOGY

The methodology used in the present research is characterised by a systematic literature review of 25 scientific publications issued during the last decade related to the impact of robots and automation on employment, among other sources. Qualitative content analysis and close reading has allowed identifying the drivers and associated magnitudes of technological unemployment and the expectations of the future of work in developed countries, classifying the mentioned publications in distinct theoretical categories. To allow a better comprehension of the subject, the analysis is accompanied by several illustrations created by the author using data from official sources and recent pieces of research.

[13] GREENHALGH, Christine; LONGLAND, Mark; BOSWORTH, Derek (2001): "Technological Activity and Employment in a Panel of UK Firms. *Scottish Journal of Political Economy*, Vol. 48, No. 3.
[14] PIVA, Mariacristina; VIVARELLI, Marco (2003): "Innovation and Employment: Evidence from Italian Microdata". *IZA Discussion Papers*, No. 730.
[15] GOOS, Maarten; MANNING, Alan (2007): "Lousy and lovely jobs: The rising polarization of work in Britain". *The Review of Economics and Statistics*, No. 89, pp. 118-133.



Chapter II / Main magnitudes related to automation

CHAPTER II. MAIN MAGNITUDES RELATED TO AUTOMATION

2.1. IS IT A ROBOTS' UPRISING? THE FAST TECHNOLOGICAL DIFFUSION

It is fundamental to assess the availability of industrial robots to understand what the next trends are going to be. According to the International Organisation for Standardisation (ISO), an industrial robot is a machine «automatically controlled, reprogrammable, multipurpose manipulator, programmable in three or more axes, which can be either fixed in place or mobile for use in industrial automation applications»[16]. The International Federation of Robotics (IFR) restates the mentioned definition[17]. The number of robots is rising continuously and they represent the principal threat to manufacturing workers. However, industry has been basic to assure stability and prosperity in advanced economies. In fact, the bargain between elites and organised labour in factories has fostered the development of democracy and welfare States[18].

Nowadays, after a sustained period of delocalisation to countries where the labour force implied less costs, some factories are returning to the West, literally in-shoring the production, but completely automated: the so-called «lights out» or «lights off» manufacturing processes. This fact allows them to be more competitive and nearer to the final consumer markets in a more agile supply chain, but employment opportunities are not generated anymore, affecting mostly middle and low-income countries. Compared to the costs of the low-skilled labour force working there, installing a robot implies much greater costs[19]. This means that the gap between developed and emerging countries will be amplified. However, China is the exception to this trend. For example, Chinese manufacturers like Foxconn, which is Apple's largest manufacturing contractor, are right now global leaders in the implementation of completely automated production centres[20].

On October 2018, Francesco CARBONERO, Ekkehard ERNST and Enzo WEBER issued a study[21] under the ILO auspices analysing the effects of industrial robots in developed and developing countries. This is relatively innovative, as precedent research has focused mainly on advanced economies. Their results assess a statistically significant negative impact of robots over employment, with a particular incidence over emerging economies, where employment has suffered a -14% fall between 2005 and 2014 by the effects of new technologies. On advanced economies, the impact of industrial robots appears to be lesser, at -0.54%. Therefore, re-shoring processes spurred by the diffusion of robots in developed countries cause a strong impact over emerging economies integrated in the global supply chain.

During the economic and social crisis of the Eurozone concerns about the preservation of the employment capacity lead at broadening the debate to the impact of robots and automation. On

[16] INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (2020): *ISO 8373:2012(en). Robots and robotic devices – Vocabulary*.
[17] INTERNATIONAL FEDERATION OF ROBOTICS (2017): *World robotics 2017. Industrial robots*. Frankfurt am Main, International Federation of Robotics, p. 32.
[18] RODRIK, Dani (2016): "Premature deindustrialization". *Journal of Economic Growth*, Vol. 21, No. 1, p. 29.
[19] UNITED NATIONS CONFERENCE ON TRADE AND DEVELOPMENT (2016): *Robots and industrialization in developing countries*. Policy Brief, No. 50, p. 3.
[20] JINGLI, Song (2019): *With its 'lights-off factory', iPhone manufacturer Foxconn leads in Industry 4.0*. KR-ASIA, Press release, 28.01.2019. Accessible Online [Last consultation on 30.08.2021].
[21] CARBONERO, Francesco; ERNST, Ekkehard; WEBER, Enzo (2018): "Robots worldwide: The impact of automation on employment and trade". *International Labour Organisation Working Papers*, No. 36.

December 2011, Georg DÜRNECKER published an interesting paper[22] analysing the relationship among the adoption of new technologies and the unemployment rates after 1970. The study compares the performance of the United States and Europe, revealing that relatively generous unemployment benefits in Europe are not necessarily the cause of greater unemployment levels, thus contrasting with an extended hypothesis. Several European countries have strong protective systems while they enjoy low unemployment rates. According to the author, the cause can be found in high technology adoption. Economies with notable technological gaps are the most affected, as faster technical change provokes a greater depreciation of skills among unemployed workers. Therefore, higher training costs for undertakings discourage job creation. The mentioned increment in costs can explain an important part of the higher unemployment levels[23].

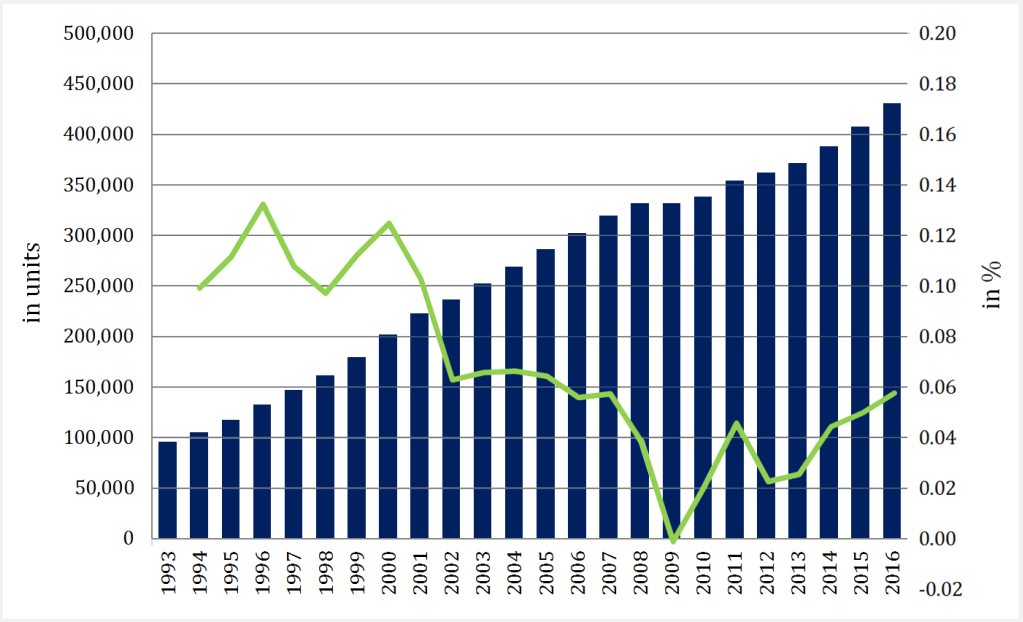


Figure 1. Operational stock of robots in the EU-28 and annual variation[24] (1993-2016)[25].

The operational stock of robots has increased during the last three decades in the European Union. Nevertheless, annual increments have suffered a sustained decrease from the beginning of the millennium to 2009, the next year after the explosion of the financial crisis. Since 2010, the trend has experienced a moderate recovery. Overall, during the period 1993-2016, the operational stock of robots has more than quadrupled and has been oriented in the industrial sector, arriving at more than 431,000 units. Germany, with a high automated automotive sector, has the largest proportion of robots in the EU. In 2007, 52% of all the industrial robots located in Europe were devoted to the automobile industry[26]. Another important aspect to be assessed is the greater sophistication of robots over time. The advancements in AI are providing more autonomy and capabilities to industrial robots, multiplying their productivity.

[22] DÜRNECKER, Georg (2011): "Technology Adoption, Turbulence and the Dynamics of Unemployment". University of Manheim, Department of Economics, *Working Paper Series*, No. 11-2.
[23] DÜRNECKER, Georg (2011): "Technology Adoption, Turbulence and the Dynamics *(...) (op. cit.)*, p. 40.
[24] The figure misses data from Cyprus and Luxembourg.
[25] Graph created by the author. Source of data: EUROPEAN COMMISSION (2018): *Employment and Social Developments in Europe. Annual Review 2018.* Brussels, Directorate-General for Employment, Social Affairs and Inclusion. Doi: 10.2767/875456, p. 63. Dataset originally generated by the International Federation of Robotics.
[26] CHIACCHIO, Francesco; PETROPOULOS, Georgios; PICHLER, David (2018): "The Impact of Industrial Robots on EU Employment and Wages: A Local Labour Market Approach". *Bruegel Working Papers*, Issue 02, 18.04.2018, p. 5.

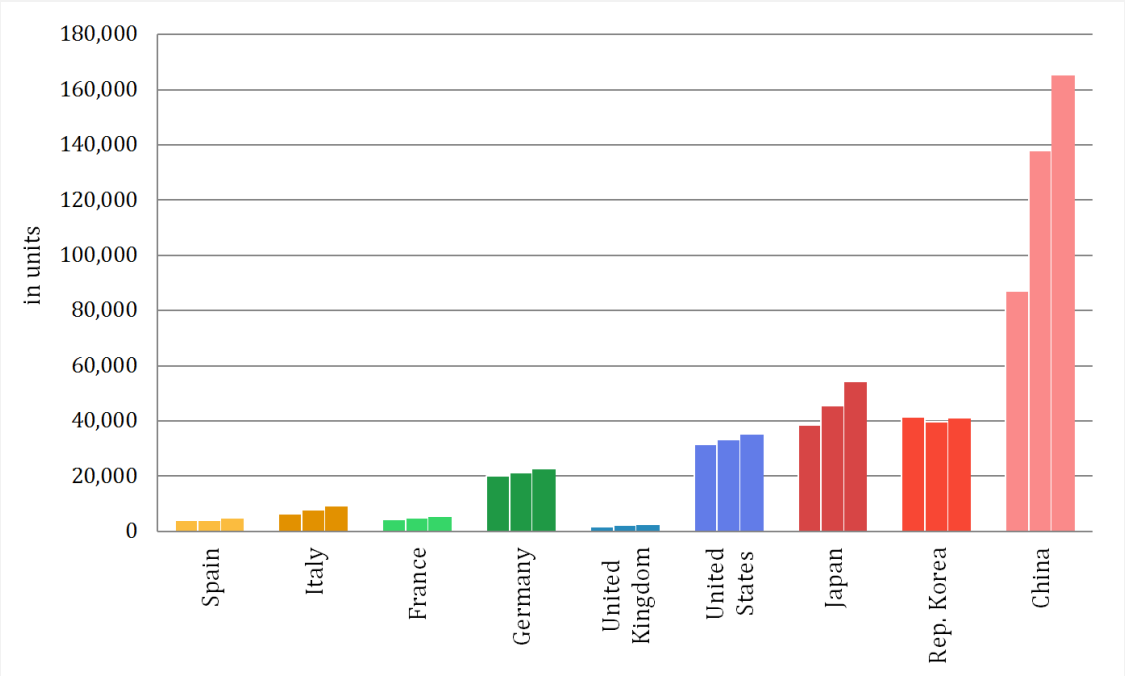


Figure 2. Estimated annual sales of multipurpose industrial robots (2016, 2017 and 2018)[27].

As the figure presented above depicts well, the specific cases of Germany in Europe and China in Asia cannot be neglected. The divergent path of the European economies will be intensified for sure in the next decades, as Germany is producing and stocking an important amount of industrial robots. This fact will allow the «Bundesrepublik» to increase its competitiveness and take advantage of the continental markets, whilst other European countries will not be able to compete in this technological scenery and will suffer the «pains» of free trade[28]. It is estimated that in 2018 there were approximately 22,500 industrial robots operating in Germany, while the United Kingdom there were only 2,400. In spite of not being covered during the «Brexit» debate, this situation may have exerted an important influence in pushing the withdrawal of the UK, promoting the construction of a greater financial centre.

However, the indicated robots in Europe are located mainly in the aeronautics and car manufacturing industries, which do not represent an attractive option for the future in the global post-pandemic scenery. Besides, electric vehicles and car sharing consumer patterns push downwards the demand for automobiles. Since the beginning of the Millennium, Germany and French manufacturers have invested in Central and Eastern Europe countries, where they can find a skilled labour force with low wages. Robotised factories suppose nowadays a threat of re-shoring such outsourced production processes[29], causing an important damage over current employment levels. Moreover, electric cars require less human intervention in industrial production processes and the post-sales related maintenance.

[27] Graph created by the author. Source of data: INTERNATIONAL FEDERATION OF ROBOTICS (2018): *World Robotics 2018. Industrial Robots*. Executive Summary, p. 21. Online [Last consultation on 30.08.2021].
[28] The «Brexit» could help the United Kingdom to protect the remaining industries from the mentioned impact.
[29] CSÉFALVAY, Zoltán (2020): "Robotization in Central and Eastern Europe: catching up or dependence?". *European Planning Studies*, Vol. 28, No. 8, pp. 1534-1553.

The greatest concern for the West is located in Asia. Japan and the Republic of Korea are investing in new technologies and are not losing employments in industry thanks to their high competitiveness. And China has opted for a clear expansionist strategy: in only three years, the millenary country has acquired an amount of robots equivalent to the whole European operational stock of 2014. Chinese authorities have planned to expand their operating robots under a target of 100,000 new units per year by 2030[30]. Before, by 2025, the «golden years» for foreign companies to invest in the country will have ended, as Chinese producers will have learnt from them how to be competitive in China (and abroad)[31].

The Asian giant is not an ordinary «follower»; the main objective of the country is to become the global leader. The «Triad» is being replaced by a multipolar world order, with a gravity centre at the Asia-Pacific region. In 2018, the International Federation of Robotics predicted that between 2019 and 2021 the global growth rates of industrial robot sales would have increased to 14%, on average per year. In Europe, this increment would be of 10%, in the Americas by 13% and in Asia by 16%[32], with China retaining the largest share.

The Covid-19 pandemic supposes a huge shock over investments in robotics. Many large companies with high expectations could be in financial trouble and would postpone the implementation of new technologies. However, industries located in less affected countries would have a greater capacity to deploy the exposed investments and increase their competitiveness. This circumstance benefits corporations situated mainly in East Asia, where there is still a significant domestic demand for their products.

2.2. RELATED EVIDENCES OF THE CURRENT IMPACT OF AUTOMATION

Statistics collected over the last decades allow tracing the effects of automation over employment. The main factors that evidence the trend of computerisation are the generalised decrease in labour hours, the increment of inequality in developed countries and the progressive polarisation of the labour market. It shall be indicated that there are two indicators that at first sight would illustrate a direct impact of automation over employment, which are the unemployment rate and the labour productivity index, but they do not have the appropriate design to describe the exposed phenomenon accurately.

Regarding unemployment, certain governments have used the categories of invalidity, illness, retirement or training as means to diminish the official unemployment counts[33]. And naturally, the expansion of precarious forms of work and part-time contracts is not comparable to full-time occupations, affecting the comparability of data over time. In terms of labour productivity, also, over the last decades the indicator has experienced a timid growth in most of advanced countries, not reflecting for example certain aspects of the diffusion of ICTs.

[30] CARBONERO, Francesco; ERNST, Ekkehard; WEBER, Enzo (2018): "Robots worldwide: The impact of automation on employment and trade". *International Labour Organisation Working Papers*, No. 36, p. 3.
[31] WÜBBEKE, Jost; MEISSNER, Mirjam; ZENGLEIN, Max; IVES, Jaqueline; CONRAD, Björn (2016): "Made in China 2025. The making of a high-tech superpower and consequences for industrial countries". *Merics papers on China*, No. 2. Mercator Institute for China Studies, p. 57.
[32] INTERNATIONAL FEDERATION OF ROBOTICS (2018): *World Robotics 2018 (...) (op. cit.)*, p. 21.
[33] FREEMAN, Chris; SOETE, Luc (1994): *Work for all or Mass Unemployment? Computerised technical change into the 21st Century*. London, Pinter Publishers Ltd. For the Castilian edition (1996): *Cambio tecnológico y empleo. Una estrategia de empleo para el Siglo XXI*. Madrid, Fundación Universidad-Empresa, p. 30.

2.2.1. LABOUR HOURS ARE DECREASING

Most of developed countries have experienced an important decrease of labour time since 1977. When observing the reduction of labour time, it is clear that two factors are key for this change: at first, the openness of international trade has allowed that countries that were kept only as reserves of commodities until the 70s, had entered to the global value chain providing low cost labour force and had absorbed part of the production of goods, that previously was concentrated in the so-called «Triad» (Europe, North America and Japan)[34].

And secondly, new technologies had increased the general productivity of workers, and by these means the same output is produced consuming less units of time. It is estimated that 36.1% of the global workforce works more than 48 hours per week, mainly in developing countries. Such long hours are motivated by low wages, which oblige to work more to attain a minimum income level. Instead, in advanced economies, it is in certain groups of professional workers and managers where the disproportionate working hours are placed[35].

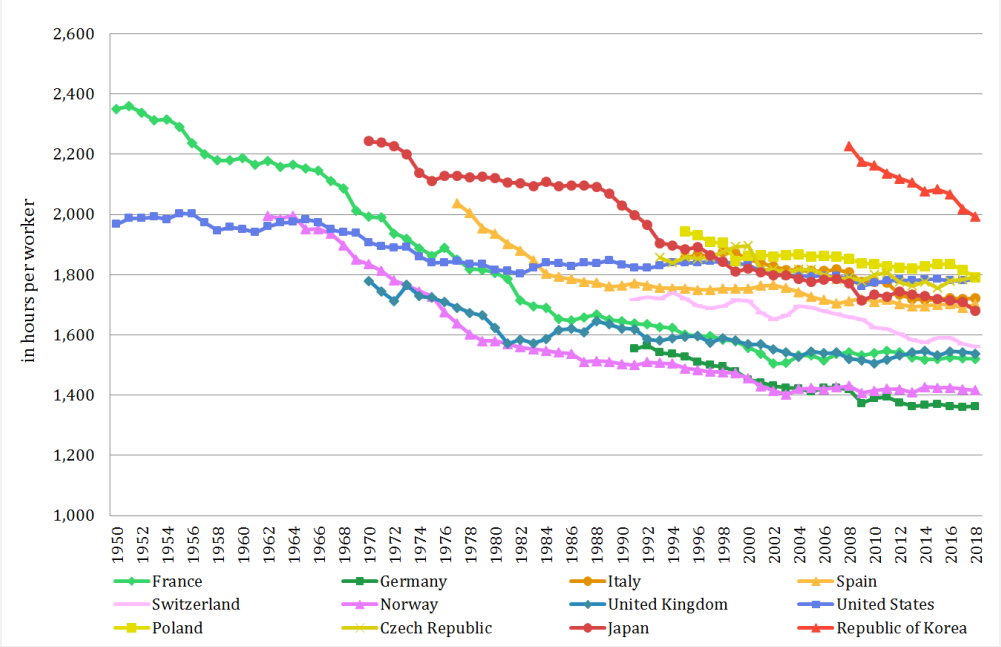


Figure 3. Annual labour hours per worker (1950 – 2018)[36].

Eastern and Southern Europe countries studied here are close to Japan and remain at high levels of labour hours per worker. However, it shall be considered the fact that extra hours are not counted in most of the cases, and the Nippon country would be for sure an international champion in this matter[37].

[34] MUNCK, Ronaldo (2002): *Globalisation and Labour*. Delhi, Madhyam Books. London, Zed Books. For the Castilian edition (2008): *Globalización y trabajo. La nueva "Gran Transformación"*. Vilassar de Dalt, Ediciones de Intervención Cultural / El Viejo Topo, pp. 59-67.

[35] MESSENGER, Jon (2018): "Working time and the future of work". *Future of Work Research Paper Series*, No. 6. Geneva, International Labour Office, p. 3.

[36] Graph created by the author. Source of data: OECD (2020): *Hours worked* (indicator). DOI: 10.1787/47be1c78-en

[37] In Japan, extra hours are called «Zangyo» (残業). Since 2018, the Government has limited them by law: 100 hours monthly and 720 hours annually, in order to affront the negative effects over health and the «Karoshi» (過労死) (death produced by work overload), that is publicly recognised since the end of the 1980s.

This magnitude does not consider the productivity of each worker, only measures the average time officially dedicated to labour activities. In practice, it is a myth that long working hours result in high productivity, as greater fatigue and decreasing job satisfaction and motivation reduce the workers' performance[38]. In 2008, the first year with data from the Republic of Korea, the country appears to be at the same levels of the 1970s in the other OECD countries, a fact that indicates that legislative standards there are set far from European social protections. Germany and Norway are at the lowest levels of labour hours per worker, following a quite stable pattern during the last decade.

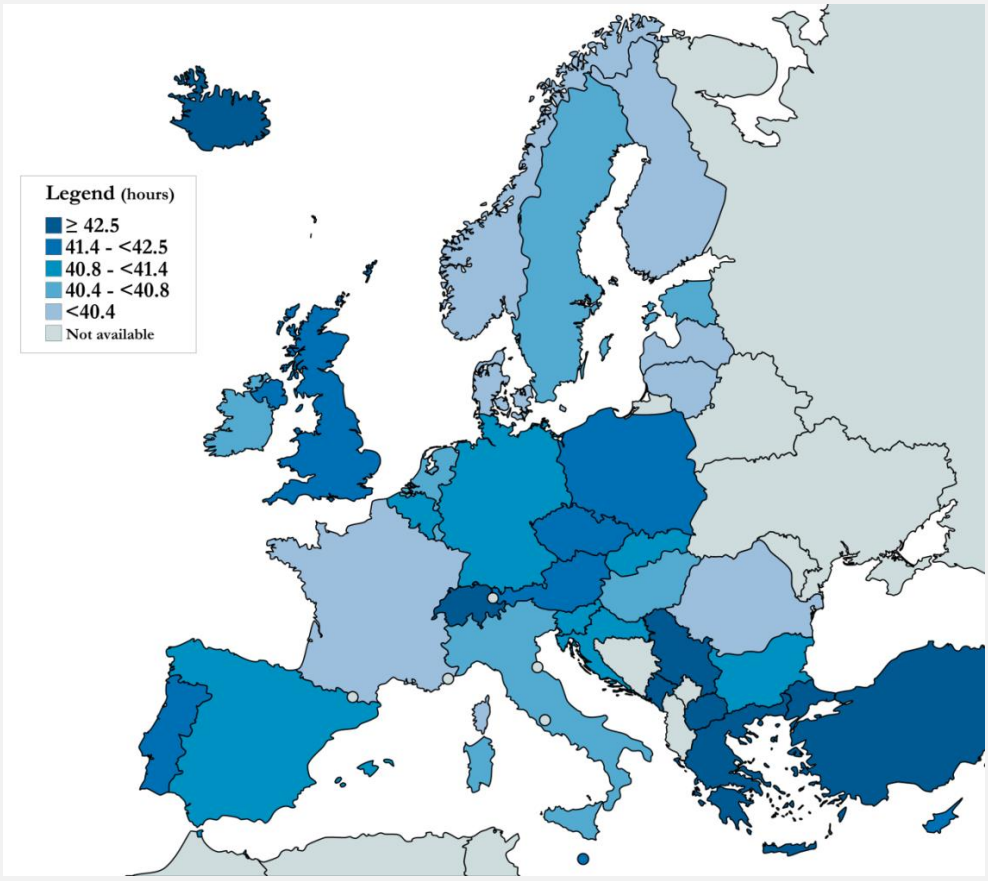


Figure 4. Estimated weekly labour hours per worker in Europe (2018)[39].

The previous map illustrates the number of hours worked per single week[40], of full-time employment, based on the data gathered by EUROSTAT. The average of the EU-28 Member States is situated at 41.2 hours per week, and exist remarkable regional differences among countries.
Quite surprisingly, in Greece the value is placed at 44.2 hours, arriving at the top of the ranking in the European Union and being notably superior to the cases of Germany (41 hours) and France (40.4 hours).

[38] MESSENGER, Jon (2018): "Working time and the future of work" *(...) (op. cit.)*, p. 13.
[39] Graph created by the author using the software *mapchart.net*. Source of data: EUROSTAT (2020): *Hours worked per week of full-time employment.* Code: tps00071.
[40] Number of hours that the person normally works. It includes extra hours, either paid or unpaid, but excludes the travel time between home and the place of work, as well as the meal breaks.

Naturally, this is not an equivalent value of productivity, but allows us to consider the current social prejudices[41]. According to EUROSTAT, the lowest measures are encountered in Denmark (38.6 hours) and Norway (38.9 hours), countries that have strong social models and a higher concern for family and work conciliation.

In contrast, Turkey is placed at the opposite site, at 48.9 hours per single week. The exposed value has decreased progressively over the last decades. In 2007, Turkey attained 53.9 labour hours per week, very distant from the standards in Western Europe. The first international labour treaty, the ILO Hours of Work Convention of 1919 (No. 1), established a 48-hour weekly limit on working time, in an age when workweeks of more than 60 hours were notably extended. However, it is striking to observe that one hundred years after its approval there are countries that maintain excessive long working hours[42]. In 1935, was approved the ILO Forty-Hour Week Convention (No. 47), a standard that nowadays seems very distant in most of the world.

In the period between 1965 and 2003, leisure time[43] has increased notably in the United States. In the case of men it has increased by more than six hours per week, fostered by a decline in labour hours. Regarding women, the magnitude has augmented by more than four hours per week, encouraged by a decline in home production work hours. Low-skilled adults have experienced the largest increments on leisure[44], possibly because living conditions have improved and their departing circumstances were set notably far from the current average.

In this scenery of reduction of labour hours in advanced economies are becoming diffused the so-called «non-standard forms of employment». This is sometimes a euphemism to refer to precarious labour conditions, a «just-in-time workforce» in the «gig-economy». For example, the so-called «microtasks» are highly parcelled activities that involve human judgement beyond the capabilities of AI[45]. However, their practical recognition as «working time» is inexistent nowadays; such are only mere «tasks» or other designations that are far away from a labour context[46]. And they contribute to an extreme commodification of human beings, literally: «Humans-as-a-service». There is no human contact in most of the crowdwork transactions, enacting a silent group of «invisible workers»[47] with an ultra-flexible schedule.

2.2.2. INEQUALITY IS SOARING

The evolution of the income distribution among adults across the globe has followed a curious pattern in the period 1980-2018, with the academic-wide denomination of the «elephant curve». In emerging countries, mainly China and India, an important fraction of the poor citizens have improved their living conditions and have become «middle» class, while in developed regions,

[41] STIGLITZ, Joseph (2016): *The Euro. How a Common Currency Threatens the Future of Europe*. New York, W. W. Norton & Company. For the Castilian edition (2016): *El Euro. Cómo la moneda común amenaza el futuro de Europa*. Barcelona, Penguin Random House Grupo Editorial, p. 93.
[42] MESSENGER, Jon (2018): "Working time and the future of work" *(…) (op. cit.)*, p. 25.
[43] The definition of «leisure» is more complex that it can be at first sight. We expect that leisure produces a certain utility to the individual that experiences it. However, would everybody agree that this magnitude has to include child care or even garden activities?
[44] AGUIAR, Mark; HURST, Erik (2007): "Measuring trends in leisure: the allocation of time over five decades". *The Quarterly Journal of Economics*, Vol. 122, No. 3.
[45] DE STEFANO, Valerio (2016): "The rise of «just-in-time workforce»: On-demand work, crowdwork and labour protection in the «gig-economy»". *Conditions of Work and Employment Series*, No. 71. Geneva, International Labour Office, p. 2.
[46] For example, «favours», «gigs», «services» and «rides», among others.
[47] DE STEFANO, Valerio (2016): "The rise of «just-in-time workforce»: On-demand work *(…) (op. cit.)*, p. 4.

the intermediate and popular groups had not experienced a significant variation in their income, remaining stagnant in progress. Globally, the bottom 50% has captured 12% of the total growth in real income[48]. Nevertheless, the greatest increment has been observed in the top percentile of all income groups, which has absorbed 27% of the total growth in world's income. Overall, it can be inferred that the global economic growth has not been in the exposed period «a rising tide that lifts all boats», only in certain emerging economies[49].

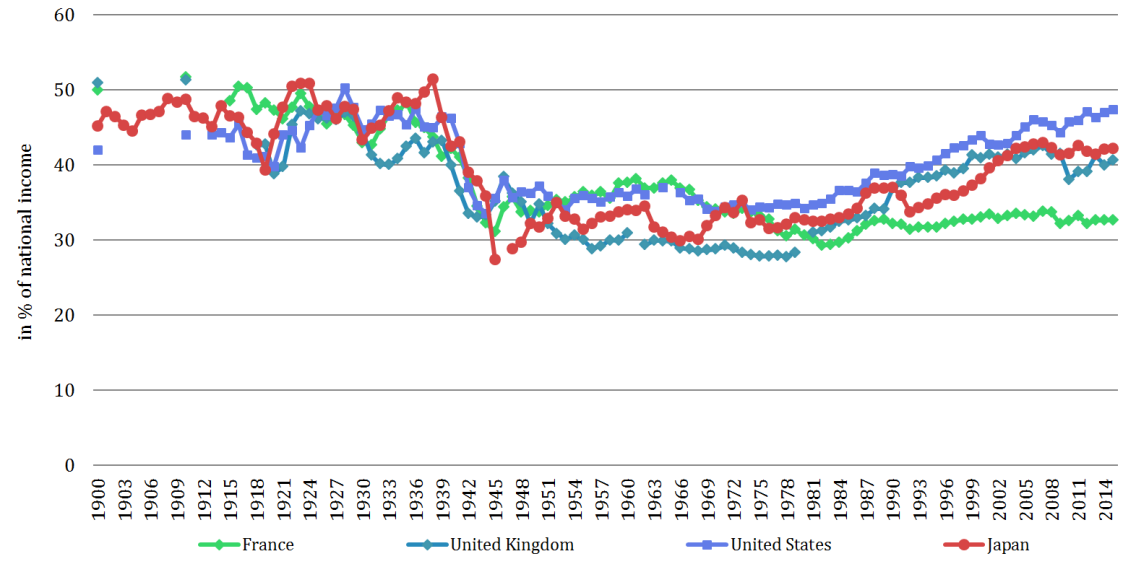


Figure 5. Participation of the highest decile in the total national income, as a measure of inequality in France, the United Kingdom, the United States and Japan (1900-2015)[50].

However, when analysing the distribution of income in each country it is better to understand the participation of the richer fraction in the total national income using a «longue durée» perspective. The evolution from 1900 to 2015 depicted in the previous illustration shows in the «Triad» the pendulum of history. During the Second World War, the top 10% in income experienced a remarkable fall in participation, which stabilised after the global conflict and until 1980. After this period, the United States has been the country where inequalities have suffered a greater expansion. The highest decile of income is approaching to 50% of the total wealth of the country.

Nevertheless, income inequalities had been present in this nation for a long time. The famous speech pronounced by Reverend Martin Luther King Jr. in 1963 illustrates well the racial segregation, also represented in socioeconomic terms apart from justice[51]. Nowadays, income inequality has increased for all ethnicities and the white-coloured middle-class is not protected against the effects of automation and the derived social exclusion.

[48] ALVAREDO, Facundo; CHANCEL, Lucas; PIKETTY, Thomas; SAEZ, Emmanuel; ZUCMAN, Gabriel (Coords.) (2018): *World Inequality Report 2018*. WID.world, pp. 50-51.
[49] PIKETTY, Thomas (2019): *Capital et idéologie*. Paris, Éditions du Seuil. For the Catalan edition (2019): *Capital i ideologia*. Barcelona, Edicions 62, pp. 38-39.
[50] PIKETTY, Thomas (2019): *Capital et idéologie (...) (op. cit.)*, p. 45 (Catalan edition). Dataset accessible Online [Last consultation on 30.08.2021].
[51] This speech is remembred as «I have a dream…», pronounced by Reverend Martin Luther King Jr. at the «March of Washington» on 1963.

European countries, instead, have followed a more moderate trend. The top decile holds more than 30% of the total income and France and 40% in the United Kingdom. Japan is placed in an intermediary location between the UK and the United States, relatively flat during the last decade. The reason of the exposed variations is found in the modifications of the marginal top level of the income tax, which has evolved in the United States from 23% in the period 1900-1932, to 81% in the period 1932-1980, and 39% in the period 1980-2018, on average. The UK, Germany and France have also similar trends[52]. Instead, in the Middle East, Brazil and sub-Saharan Africa, inequality has remained relatively stable in the last decades, but at extremely high levels: the top 10% of income shares surpasses in such regions the frontier of 50% of the national income. Therefore, it appears that world inequality is moving towards a high-inequality strip[53].

At the global level, the labour share has experienced a notable decrease and scientific evidence supports that efficiency gains in capital, in the context of the computer age and the decline in relative prices of investment goods, have induced firms to shift from labour to capital[54]. This trend is going to be consolidated in the following decades, favouring a pattern of «winner takes all» and the success of globalised firms. Technology and trade are the main factors that explain the rise in power concentrated in the hands of superstar firms[55].

The new forms of work contribute to increase the gap between stable workers and the rising «precariat». Platform «collaborators», among others, suffer high uncertainty, requiring constant availability to work and downwards competition in remunerations. Even public employment has not escaped from this trend. Since the «Great Recesion», the introduction of functional flexibility and the transfers of public services to NGOs and the civil society have increased. However, the erosion process began many years before 2008[56]. It is very difficult that «on demand» workers are a well organised force: they need a basic allocation of income for their survival and their claims can derive into effective and easy reprisals from platform companies, like account suppression or less assignments[57]. This phenomenon of «middle class» disappearance has a strong ideological content, as the working class is usually identified with the so-called «middle class» to enhance its sense of individuality and competitiveness[58].

The «Matthew effect» is a religious concept that can be well applied to social sciences when referring to inequality[59]. The Gospel according to Saint Matthew proclaims that «for whoever has, to him will be given, and he will have abundance, but whoever does not have, from him will be taken away even that which he has» (Matthew, 13:12). In this sense, the most powerful retain more wealth and the poor suffer a greater impoverishment. The dissatisfaction of increasingly vulnerable collectives can be expressed in the streets and when exercising the democratic rights, sometimes with unpredictable outcomes for the destiny of nations.

[52] PIKETTY, Thomas (2019): *Capital et idéologie (...) (op. cit.)*, p. 46 (Catalan edition).
[53] ALVAREDO, Facundo; CHANCEL, Lucas; PIKETTY, Thomas; SAEZ, Emmanuel; *(...) (op. cit.)*, pp. 42-43.
[54] KARABARBOUNIS, Loukas; NEIMAN, Brent (2014): "The global decline of the labor share". *The Quarterly Journal of Economics*, Vol. 129, No. 1, pp. 61-103.
[55] AUTOR, David; DORN, David; KATZ, Lawrence; PATTERSON, Christina; VAN REENEN, John (2017): "The Fall of the Labor Share and the Rise of Superstar Firms". *NBER Working Papers*, No. 23396, pp. 23-25.
[56] STANDING, Guy (2011): *The Precariat. The New Dangerous Class*. London and Oxford, Bloomsbury Academic. For the Castilian Edition: *El Precariado. Una nueva clase social*. Barcelona, Ediciones de Pasado y Presente, pp. 91-96.
[57] ÁLVAREZ CUESTA, Henar (2017): *El futuro del trabajo vs. el trabajo del futuro. Implicaciones laborales de la industria 4.0*. A Coruña, Editorial Colex, p. 156.
[58] MORENO, Luis; JIMÉNEZ, Raúl (2018): *Democracias robotizadas. Escenarios futuros en Estados Unidos y la Unión Europea*. Madrid, Los Libros de la Catarata, p. 85.
[59] MORENO, Luis; JIMÉNEZ, Raúl (2018): *Democracias robotizadas. Escenarios futuros (...) (op. cit.)*, p. 75.

2.2.3. EMPLOYMENT IS BECOMING MORE POLARISED

The graph presented *infra* shows a job polarisation trend affecting all European Member States and the United Kingdom, measured in purchasing power standard to allow better comparability. Low and high-paying jobs continue to increase, whilst the proportion of middle wage workers is diminishing without a clear regional and income divide in the continent. High-paying occupations are represented by corporate managers, engineering and health professionals, and other associate professionals, among others. Middling occupations are characterised by office clerks, machine operators and assemblers, and drivers, among others. Low-paying occupations are exemplified by construction workers and sales persons, among others[60].

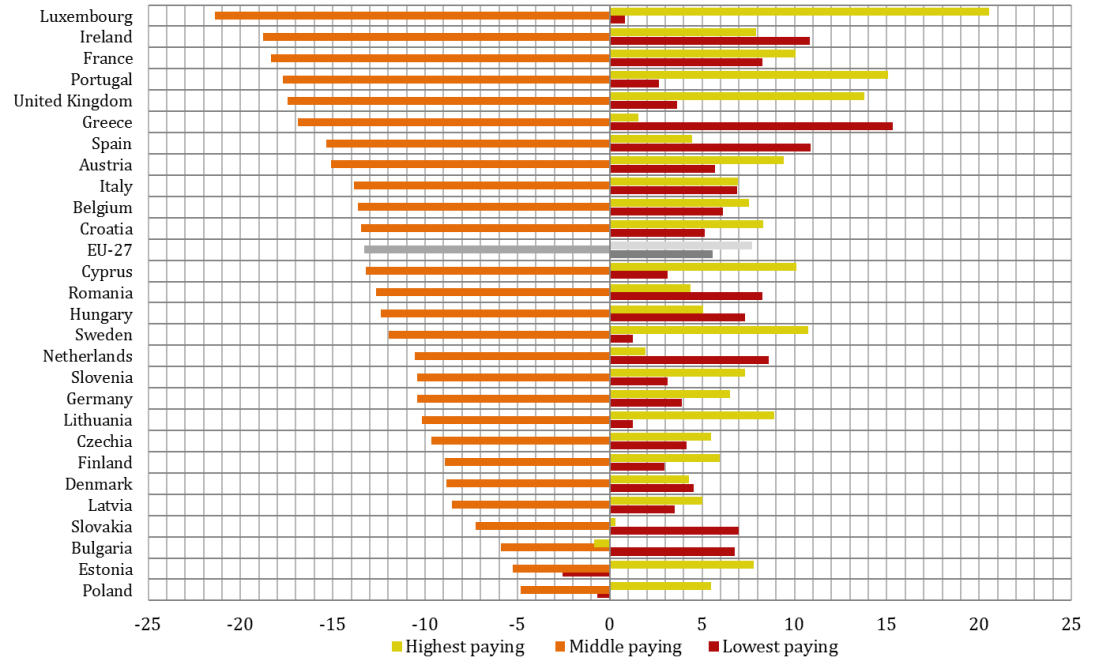


Figure 6. High, middle and low-paying jobs in the EU. Change from 2002 to 2016, in PPS[61].

There are several evidences that illustrate the shrinking process of middle-paid occupations. Current automation processes affect middle-skilled jobs that traditionally have allowed the deployment of the «middle class», like bookkeeping, clerical work and routine production processes. The spectrum of the occupational skills is altered, sustaining employment possibilities on the extremes of the distribution[62]. On the one side appear «abstract» tasks, which require creativity, persuasion, intuition and problem-solving capacities. On the other side, «manual» tasks require visual and language recognition, situational adaptability and personal interaction.

Such tasks become engineering bottlenecks and thus are very difficult to become automated, but most of the humans can success on it, at least with the basic or appropriate training. Hence, here is the reason for the low wages in their usual remuneration. However, it is estimated that in the next decade the effects of artificial intelligence will modify the exposed pattern, affecting more low-skilled workers than in previous technological waves, and therefore the curve will be

[60] EUROPEAN COMMISSION (2018): *Employment and Social Developments in Europe (…) (op. cit.)*, p. 60.
[61] Graph created by the author. Source of data: EUROPEAN COMMISSION (2018): *Employment and Social Developments in Europe (…) (op. cit.)*, p. 60.
[62] AUTOR, David; DORN, David (2013): *Technology Anxiety Past and Present (…) (op. cit.)*, p. 3.

re-shaped towards a negative monotonic relationship between the probability of automation and the level of education attainment and skills[63].

In spite of the current scientific evidence of job polarisation, there are several authors that argue that there are other types of middle-skilled jobs that are currently expanding and require postsecondary education or training, for example, phlebotomists and x-ray technicians in health care, mechanical maintenance and repair technicians, paralegals, retail managers and sales representatives[64]. According to several inquiries, the effects of automation in this polarisation trend appear to be much stronger than those of offshoring[65].

The phenomenon of employment polarisation can be tracked in certain periods with wage polarisation. In the United States and in the decade of the 1990s, the extremes of the skill spectrum experienced a notable increment in salaries, while the middle-skilled jobs obtained more modest gains. This situation can be explained by the incidence of ICTs in routine tasks. In the decade of 2000s, the wage increment in a logarithmic scale was anaemic, but followed a similar u-shaped pattern in favour of the extreme categories[66].

Another important aspect has been that high-skilled workers have moved down to the occupational ladder, absorbing jobs that were performed by middle and low-skilled workers previously, pushing them even downwards or ousting the low-qualified workers out of the labour market[67]. «Generic individuals», who are replaceable by new technologies or imported labour from other parts of the globe, lose their capacity to negotiate. This phenomenon can be explained, literally, by the phrase: «if you don't want, look at the queue that is waiting for it»[68]. In the United States and in the period 1990-2000, college graduates shifted towards high-skill jobs, usually with high retributions. However, in the period 2000-2010 the trend suffered a «great reversal» yet before the financial crisis exploded, and high-skilled workers moved to perform jobs traditionally assigned to lower-skilled workers[69].

According to Professor David AUTOR, the declining employment in middle-skilled and routine task-intensive jobs produced a movement of middle-skilled workers to manual task-intensive occupations, instead of going to high-skilled occupations[70]. The «Great Recession» and the need of resources to cover the basic necessities may have spurred this process in the decade of the 2010s, instead of encouraging a re-training trend in favour of attaining high-skilled employments. Besides, the sectors of construction and manufacturing are very sensitive to economic cycles and the crisis has shrunk the availability of middle-wage jobs, with losses partially permanent after companies have changed their production methods and their internal organisation.

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[63] NEDELKOSKA, Ljubica; QUINTINI, Glenda (2018): "Automation, skills use and training". *OECD Social, Employment and Migration Working Papers*, No. 202. Paris, OECD Publishing, p. 8.

[64] HOLZER, Harry (2015): *Job Market Polarization and U.S. Workers Skills: A Tale of Two Middles*. The Brookings Institution, p. 2.

[65] GOOS, Maarten; MANNING, Alan; SALOMONS, Anna (2009): "Job polarization in Europe". *The American Economic Review*, Vol. 99, No. 2, pp. 58-63.

[66] AUTOR, David (2015): "Why Are There Still so Many Jobs? The History and Future of Workplace Automation". *Journal of Economic Perspectives*, Vol. 29, No. 3, pp. 17-18.

[67] BERGER, Thor; FREY, Carl Benedikt (2017): "Structural Transformation in the OECD: Digitalization, Deindustrialization and the Future of Work". *OECD Social, Employment and Migration Working Papers*. Paris, OECD Publishing, p. 27.

[68] BUTTIGLIERO, Diego (2012): "Globalització i mercat laboral". In GÁLVEZ MOZO, Ana María; TIRADO SERRANO, Francisco (Editors): *Capitalisme i treball. Problemàtiques socials del món contemporani*. Barcelona, Editorial UOC, p. 129.

[69] BEAUDRY, Paul; GREEN, David; SAND, Benjamin (2013): "The great reversal in the demand for skill and cognitive tasks". *NBER Working Papers*, No. 18.901, p. 26.

[70] AUTOR, David (2015): "Why Are There Still so Many Jobs? The History and Future *(...) (op. cit.)*, pp. 18-19.

The coronavirus multi-crisis could be a major halt to advanced re-skilling and by these means would incentivise the labour supply in manual and low-skilled tasks. However, the strong limitations in interpersonal and physical contact produced by the pandemic suppose an important barrier to allow this flow in employment and are going to reinforce long-term unemployment and poverty rates[71]. There are sufficient concerns to consider that if the middle-skilled jobs disappear or are transformed abruptly by new technologies, then the mechanism to access and continue in the «middle» class will get severely affected[72].

Job polarisation is manifested also in regional terms. New jobs have been created in cities with an important concentration of highly-skilled workers, while in other urban agglomerations there has been a displacement or job losses[73]. Municipalities with reduced revenues will cut provisions of public services, and by these means will accelerate the urban decay, as has happened in Detroit for the last two decades. All the initiatives aimed at regenerating the city had failed, severely impacted by the automation of industry and the entry of highly competitive imports. When Barack Obama left office, he pronounced accurately: «The next wave of economic dislocations won't come from overseas. It will come from the relentless pace of automation that makes a lot of good, middle-class jobs obsolete»[74].

On March 2018, Carl Benedikt FREY, Thor BERGER and Chinchih CHEN published an interesting paper[75] in the framework of Oxford University, analysing the impact of automation over the 2016 presidential elections in the United States. The Industrial Revolution has not been a sustained increase in economic and social progress; in fact, the first three generations in the UK did not experience its benefits. The study depicts the victims of the current age of automation: real wages of the vast majority of US citizens have stagnated or even declined since the 1980s, in a context of job polarisation. Low-skilled men employed in routine occupations appear to be the most vulnerable. After the «Great Recession», technology has driven a jobless recovery[76].

Researchers have analysed 722 commuting zones in the United States, understanding their exposure to automation using data from the International Federation of Robotics and comparing their vote orientation in the presidential elections of 2016 with those of 2012. By employing counterfactual sceneries, the study discovered that with a reduction in 10% to the exposure to robots, Michigan would have swung in favour of the Democratic candidate. Besides, with a reduction of 75% to the exposure to robots, Wisconsin would have turn Democrat. And finally, with a reduction of 95%, Pennsylvania would have changed colour and Hillary Clinton would have arrived at the White House instead of Donald Trump. This piece of research evidences that electoral districts with a high exposure to robots (and therefore, with more victims of the present industrial revolution) have more propensity «to opt for radical political change»[77].

[71] For example, during the «Great Recession», an unemployed office worker would decide to open a restaurant or a barber's, financing the costs by accumulating all the unemployment benefits allocation. However, the coronavirus outbreak supposes a great restriction over concentrations in public spaces and face-to-face interpersonal relations, therefore «going digital».
[72] WORLD BANK (2016): *World Development Report 2016: Digital Dividends*. Washington D. C., p. 119.
[73] BERGER, Thor; FREY, Carl Benedikt (2017): "Structural Transformation *(...) (op. cit.)*, pp. 38-39.
[74] FREY, Carl Benedikt; BERGER, Thor; CHEN, Chinchih (2018): "Political machinery: did robots swing the 2016 US presidential election?". Oxford Martin School, University of Oxford.
[75] FREY, Carl Benedikt; BERGER, Thor; CHEN, Chinchih (2018): "Political machinery: did robots swing the 2016 US presidential election?". Oxford Martin School, University of Oxford.
[76] FREY, Carl Benedikt; BERGER, Thor; CHEN, Chinchih (2018): "Political machinery: *(...) (op. cit.)*, p. 10.
[77] FREY, Carl Benedikt; BERGER, Thor; CHEN, Chinchih (2018): "Political machinery: *(...) (op. cit.)*, p. 26.



Chapter III / Comparative analysis of recent estimations on automation

CHAPTER III. COMPARATIVE ANALYSIS OF RECENT ESTIMATIONS ON AUTOMATION

3.1. A GENERAL OVERVIEW

What is the future of work in the next twenty years? Professor Jeremy RIFKIN presented a book[78] in 2014 explaining that the digital transformations of the present moment will derive in a society that will enjoy abundance. According to him, the fundamental division among «owners and workers» or «sellers and consumers» is becoming eroded and in the future automation will replace most of the existing jobs, therefore maintaining part of the original thesis presented in «The End of Work»[79]. Nevertheless, in this new publication Professor RIFKIN explained that the replaced workers will find occupations in the social economy and in the «prosumer» collaborative framework. The new paradigm will be characterised by an IoT globally interconnected economy where the costs of producing every good will become marginal[80]; that is, the shift of human beings towards the «Homo empathicus» denomination and the eclipse (or eventual end) of capitalism[81].

However, the author does not address properly what will happen with the power of large corporations in the information age, and specific measures to tackle the massive unemployment that will arise during this hypothetical historical transition. In this aspect, Professor Xavier FERRÀS shares likewise the opinion of a future society living in the abundance, but expresses concerns about the raising inequality and social conflicts. The current «winner takes it all» trend would urge the creation of better redistribution mechanisms. However, the system is currently designed to redistribute the benefits over shareholders and financial investors, applying a short term sight, and to stimulate the development of bubbles relying on excessive expectations[82]. And we cannot set aside the possibility of a generalised global impoverishment, as natural resources are limited and humans are generating an ecological footprint that largely surpasses the Earth's capacity of recovery.

The impact of automation has been studied by economic researchers, exhibiting three quite different orientations. First of all, several studies support that new technologies can make redundant an important fraction of the labour force, even superior than 30% of the total number of employees. Secondly, some researchers identify in robots and algorithms a threat mainly directed to low-skilled workers or certain automatable occupations, thus representing a total probability of automation near 10% of all jobs. Finally, some academics consider that new professions will appear in other sectors and that this process will be capable to offset the employment losses without any difficulties, in a context of «creative destruction», or even that there is no significant association between the diffusion of innovations and unemployment. The present Chapter assesses all perspectives, summarised in the following table:

[78] RIFKIN, Jeremy (2014): *The Zero Marginal Cost Society*. Hampshire and New York, Palgrave Macmillan. For the Castilian edition (2014): *La sociedad de coste marginal cero*. Barcelona, Editorial Paidós – Espasa Libros.
[79] RIFKIN, Jeremy (1994): *The end of work. The decline of the global labour force and the dawn of the post-market era*. New York, Putnam Berkley Group. For the Castilian edition (1996): *El fin del trabajo. Nuevas tecnologías contra puestos de trabajo: el nacimiento de una nueva era*. Barcelona, Editorial Paidós.
[80] RIFKIN, Jeremy (2014): *The Zero Marginal Cost Society (...) (op. cit.)*, p. 23 (Castilian edition).
[81] RIFKIN, Jeremy (2014): *The Zero Marginal Cost Society (...) (op. cit.)*, p. 368 (Castilian edition).
[82] FERRÀS, Xavier (2018): "Digital Capitalism. The Paradox of Inequality in the Age of Disruption". *3r Congrés d'Economia i Empresa de Catalunya – Full Papers*, No. 41, p. 5.

Recent scientific evidence on the impact of automation on employment					
Large impact over employment		Impact concentrated over low-skilled workers or certain occupations		No impact at all or compensation by estimated new jobs in the long run	
2013	C. B. FREY and M. OSBORNE (OXFORD)	2016	M. ARNTZ, T. GREGORY and U. ZIERAHN (OECD)	2013	P. GORLE and A. CLIVE (International Federation of Robotics)
2014	M. PAJARINEN and P. ROUVINEN	2016	WORLD ECONOMIC FORUM (WEF)	2013	H. FELDMANN
2015	D. BRANDES and L. ZOBRIST (DELOITTE)	2017	D. ACEMOGLU and P. RESTREPO	2015	J. INSALL and A. BORTHAKUR (DELOITTE)
2016	C. B. FREY, M. OSBORNE(OXFORD) and CITIBANK.	2017	W. DAUTH, S. FINDEISEN, J. SÜDEKUM and N. WÖßNER	2016	T. GREGORY, A. SALOMONS and U. ZIERAHN
2016	C. LAMB (BROOKFIELD INSTITUTE)	2018	L. NEDELKOSKA and G. QUINTINI (OECD)	2017	J. MANYIKA, S. LUND, M. CHUI, *et. al*. (MCKINSEY GLOBAL INSTITUTE)
2016	A. MORRON SALMERON (CaixaBank Research)	2018	F. CHIACCHIO, G. PETROPOULOS and D. PICHLER (BRUEGEL)	2017	K. MATUZEVICIUTE, B. MINDAUGAS and A. KARALIUTE.
2017	G. LORDAN and C. JOSTEN (EUROPEAN COMMISSION)	2019	S. WHITE, A. LACEY and A. ARDANAZ-BADIA (OFFICE FOR NATIONAL STATISTICS, UK)	2017	T. BERGER, C. CHEN and C. B. FREY (about the «Uber effect») (OXFORD)
2017	J. MANYIKA, M. CHUI, M. MIREMADI, *et. al*. (MCKINSEY GLOBAL INSTITUTE)	2021	S. LUND, A. MADGAVKAR, *et. al.* (MCKINSEY GLOBAL INSTITUTE)		
2018	J. HAWKSWORTH, R. BERRIMAN and S. GOEL (PWC)				
2019	G. LORDAN and C. JOSTEN				

3.2. ESTIMATIONS ABOUT A LARGE IMPACT ON EMPLOYMENT

3.2.1. C. B. FREY AND M. OSBORNE (2013). RELATED ACADEMIC INFLUENCE

Very logically, concerns about the effects of automation tend to expand in periods of economic downturn. In fact, the economic and social crisis that started in 2008 has coincided with an unprecedented epoch of increased robotisation and digitalisation. In this context, Carl Benedikt FREY and Michael OSBORNE, both researchers at the UNIVERSITY OF OXFORD, published a seminal paper in 2013[83]. They predicted a high risk of computerisation of 47% of the United States' jobs in a period going from ten to twenty years.

[83] FREY, Carl Benedikt; OSBORNE, Michael (2013): "The future of employment: how susceptible are jobs to computerisation?". *Technological Forecasting and Social Change*, Vol. 114 (text re-issued in 2017), pp. 54-280.

Both researchers also referred to the specific occupations that could be automated, establishing a ranking covering 702 of them based on the most recent American Dictionary of Occupational Titles (O*NET). They detected important risks in transportation and logistics, administrative support and manufacturing employments. On the other side, the authors studied specific engineering bottlenecks to computerisation, a sort of bastions for the maintenance of employment. In seventy hand-labelled occupations they identified three broad categories related to O*NET variables: perception and manipulation[84], creative intelligence[85] and social intelligence[86].

Most of the homes have unstructured spaces, thus inhibiting the mobility of wheeled objects, but supermarkets, factories, warehouses, airports and hospitals have the appropriate design for wheeled robots to move easily and perform non-routine manual tasks[87]. In this new economic scenery, researchers recommend that low-skilled workers reallocate themselves to tasks that are not susceptible to become computerised, like occupations requiring creative and social intelligence. However, redundant workers will have to acquire the appropriate skills before.

The study discovered a strong negative relationship comparing wages and educational attainment with probability of computerisation. Finally, C. B. FREY and M. OSBORNE predicted that as robots costs decrease and technological capabilities in mobility and dexterity expand, robots will substitute labour gradually in a wide range of low-wage service occupations, precisely the areas where most job growth has occurred in the United States over the present century.

On January 2016, C. B. FREY, M. OSBORNE and C. HOLMES, all from OXFORD MARTIN SCHOOL, in collaboration with researchers from Citibank, published a report[88] re-considering the occupation-based methodology used in the previous research of 2013. Furthermore, they expanded the analysis to more than 50 countries and regions by employing World Bank data and considering other variables. On average, they estimated that 57% of jobs in OECD member countries were susceptible to be automated, becoming a benchmark for the World Bank research[89]. Besides, this estimation could forecast important affectations in India (69%), Thailand (72%), China (77%) and Ethiopia (85%), where digitalisation is less implemented.

The original methodology of C. B. FREY and M. OSBORNE has been replicated in various pieces of research. Here will be commented a sample of them. The first one was published in 2014 focusing on Finland. This paper[90] was elaborated by Mika PAJARINEN and Petri ROUVINEN, who reported a high susceptibility to computerisation over one third of the Finnish employment. Results appear to be approximately 10% lower than in the case of the United States. Researchers acknowledged that such results do not mean that in the future there would be a mass unemployment scenery. They estimated that the task content within occupations may evolve, and relied that Finland would be able to reap the benefits of the «knowledge» economy better than other countries.

[84] Including: Finger Dexterity, Manual Dexterity and Cramped Work Space / Awkward Positions.
[85] Including: Originality and Fine Arts.
[86] Including: Social Perceptiveness, Negotiation, Persuasion and Assisting / Caring for Others.
[87] FREY, Carl Benedikt; OSBORNE, Michael (2013): "The future of employment *(...) (op. cit.)*, p. 25.
[88] FREY, Carl Benedikt; OSBORNE, Michael; HOLMES, Craig; RAHBARI, Ebrahim; CURMI, Elizabeth; GARLICK, Robert; CHUA, Johanna; FRIEDLANDER, George; CHALIF, Peter; MCDONALD, Graeme, WILKIE, Martin (2016): *Technology at Work v2.0: The future is not what it used to be*. Citi GPS: Global Perspectives & Solutions.
[89] WORLD BANK (2016): *World Development Report 2016: Digital Dividends*. Washington D. C., p. 126.
[90] PAJARINEN, Mika; ROUVINEN, Petri (2014): "Computerization Threatens One Third of Finnish Employment". *ETLA Muistio (ETLA Briefs)*, No. 22.

In 2015, Dennis BRANDES and Luc ZOBRIST, researchers at DELOITTE, issued a brief study[91] of the impact of robots and automation in the Swiss employment market. They combined data of the Federal Statistical Office from 1990 and 2013, covering 528 job categories. In terms of probability of automation, results are quite similar to the seminal paper of 2013, identifying in Switzerland an average potential for automation of 48%.

In their estimations, administrative and secretarial occupations appear to be the most affected group, with a probability of automation of 94%, and followed by skilled agricultural, forestry and fishery work, at 73%. In contrast, psychologists and doctors exhibit the lowest potential to become automated, at rates of 1% and 2%, respectively. The study concludes that the exposed circumstances are an «opportunity instead of a risk», as Switzerland «is in an excellent position to benefit from automation due to its good education system and advanced technological base»[92]. Furthermore, the authors identify creativity and inter-personal relationships as a source for non-replaceable jobs, being «excellent customer service» of remarkable importance.

On February 2016, researchers at CAIXABANK emitted a brief paper[93] about the probability of automation of jobs in Spain. They used data gathered by the Spanish Institute of Statistics. According to their estimations, 43% of labour posts in the country have a high risk to become automated in the mid-term (with a probability superior of 66%). The rest of the employment is divided into similar fractions, of 29% and 28%, for jobs that have a low risk (probability of less than 33%) and a medium risk (probability between 33% and 66%) to become automated.

On June 2016, Creig LAMB, researcher at The BROOKFIELD INSTITUTE in Canada, elaborated a report[94] on the probability of automation of employment in his country, by using the methodologies presented by C. B. FREY and M. OSBORNE and also those of McKinsey & Company. The analysis discovered that approximately 42% of the employed Canadian labour force was at high risk[95] of being affected by automation in the next 10 to 20 years. The sectors that could be more impacted were retail sales persons (656,000 employees) and administrative assistants (329,000 employees). The provinces more susceptible to suffer the effects of automation were Prince Edwards Island (45%) and Alberta (43.1%). The study assessed a disproportionate impact of automation in workers aged between 15 to 24 years old. The exposed document highlighted the benefits of increased education and training.

On March 2018, the Economic Observatory of BBVA RESEARCH issued a paper[96] analysing the vulnerability of Spanish employment to automation processes. The document uses the methodology of 2013 combined with data from the Spanish Institute of Statistics[97], concluding that 36% of jobs suffer a high risk of digitalisation. The study acknowledges the polarisation of employment in Spain, observing that less vulnerable jobs are found in management, engineering, education and health. This fact apparently benefits qualified women, who often work in occupations related to the last two sectors. When analysing the territorial impact, Murcia and the Balearic and Canary archipelagic autonomous communities face a higher automation risk.

[91] BRANDES, Dennis; ZOBRIST, Luc (2015): *Man and Machine: Robots on the rise? The impact of automation on the Swiss job market*. Zurich and London, Deloitte LLP.
[92] BRANDES, Dennis; ZOBRIST, Luc (2015): *Man and Machine: Robots on the rise? (...) (op. cit.)*, p. 7.
[93] MORRON SALMERON, Adrià (2016): "¿Llegará la Cuarta Revolución Industrial a España?". *Informe Mensual*, No. 398. Barcelona, CaixaBank Research, pp. 36-37.
[94] LAMB, Creig (2016): *The Talented Mr. Robot. The impact of automation on Canada's workforce*. Toronto, The Brookfield Institute for Innovation + Entrepreneurship.
[95] A high risk of automation corresponds to a job with a probability between 70 to 100% of becoming automated.
[96] DOMÉNECH, Rafael; GARCÍA, Juan Ramón; MONTAÑEZ, Miriam; NEUT, Alejandro (2018): *¿Cuán vulnerable es el empleo en España a la revolución digital?* Observatorio Económico, BBVA Research.
[97] More concretely, the «Encuesta de Población Activa» (EPA) deployed in the period 2011-2016.

3.2.2. OTHER FORECASTS ABOUT A LARGE IMPACT ON EMPLOYMENT

Several recent publications have raised concerns about the critical probability of automation in numerous jobs. They have used a distinct methodology than the one present by C. B. FREY and M. OSBORNE, and are studied in the present Section. The MCKINSEY GLOBAL INSTITUTE (MGI) presented in 2017 two reports referred to the challenges of automation over employment. In the document[98] presented on January, the text assessed the automation potential of the current technologies in 46 countries, representing about 80% of the global labour force. The report disaggregated occupations into 2,000 distinct activities that are rated against human performance in 18 capabilities. In the case of Europe, estimates of automatibility oscillated between 42% in Norway and 52% in Czech Republic. The United States adopted an intermediate position at 47%. However, the greatest possibilities are found in Asia, with a potential for automation of 56% in Japan, 52% in the Republic of Korea and India, and 51% in China. The publication estimated that more than 60 million workers in the five largest Western Europe economies have occupations related with technically automatable activities[99].

In spite of the negative possibilities, the study expected that the pace and extend of automation may vary in the next decades by five key factors: technical feasibility, cost of developing and deploying, labour market dynamics, economic benefits and regulatory and social acceptance[100]. In this sense, the MGI estimated that the adoption of automation technologies would be faster in advanced economies than in emerging ones. For example, wages are higher in OECD members, and the replacement of a worker with a machine is refunded more rapidly there, compared for example to India or China, where salaries are lower and thus these countries could delay the massive adoption until the cost of the solutions drops sharply[101]. Overall, the report considered that the creation of new employments in new sectors or professions may offset the losses that could arise, in spite of the current unknown nature of the net impact on employment[102].

In 2017, considering the polemic generated by the paper elaborated by C. B. FREY and M. OSBORNE and the will of the EUROPEAN PARLIAMENT to investigate the future impact of automation, the EUROPEAN COMMISSION entrusted Professor Grace LORDAN to elaborate a report[103] on the automatable employment shares in Europe. The result is an analysis that compares a previous research of Professors David AUTOR and David DORN (2013)[104] with another inquiry of G. LORDAN herself, in collaboration with Professor Cecily JOSTEN (2017)[105]. The final document was published in 2018 and covers 24 countries. Later on, results were issued at the «Employment and Social Developments in Europe. Annual Review» of 2018, elaborated by the EUROPEAN COMMISSION[106].

[98] MANYIKA, James; CHUI, Michael; MIREMADI, Mehdi; BUGHIN, Jacques; GEORGE, Katy; WILLMOTT, Paul; DEWHURST, Martin (2017): *A Future that Works: Automation, Employment and Productivity*. McKinsey Global Institute.

[99] MANYIKA, James; CHUI, Michael; MIREMADI, Mehdi; BUGHIN, Jacques; *(…) (op. cit.)*, pp. 46-48.

[100] MANYIKA, James; CHUI, Michael; MIREMADI, Mehdi; BUGHIN, Jacques; *(…) (op. cit.)*, pp. 65-69.

[101] MANYIKA, James; CHUI, Michael; MIREMADI, Mehdi; BUGHIN, Jacques; *(…) (op. cit.)*, p. 83.

[102] In this publication, the McKinsey Global Institute does not establish any magnitudes for the compensation. Therefore, this analysis has been placed in the category of large impact over employment expectations. Other reports released by the MGI have been classified in the mentioned group.

[103] LORDAN, Grace (2018): *Robots at work. A report on automatable and non-automatable employment shares in Europe*. Brussels, European Commission, Directorate-General for Employment, Social Affairs and Inclusion.

[104] The document misses the reference details of such piece of research.

[105] LORDAN, Grace; JOSTEN, Cecily (2017): "Technology at Work: Occupations and Skills that may be replaced by technology in the next decade". London, London School of Economics.

[106] EUROPEAN COMMISSION (2018): *Employment and Social Developments in Europe. Annual Review 2018.* Brussels, Directorate-General for Employment, Social Affairs and Inclusion, pp. 65-66.

This piece of research distinguished among three distinct categories of jobs: non-automatable, «polarised» automatable and «fully» automatable. The last two groups compound together the «recently» automatable share. In the category of non-automatable employment, authors have included aerospace engineers, mathematicians, hairdressers, nurses, teachers, economists and psychologists, estimating that such occupations are unlikely to become automated.

In the group of «polarised» automatable occupations, authors have identified jobs that require interpersonal interaction but are characterised by several predictable tasks that nowadays can be automated. For example, machines can substitute certain activities deployed by lawyers, like synthesising jurisprudence or filling forms, but cannot intervene during a trial[107]. Other jobs that fall inside this category are sales demonstrators and library assistants. Finally, «fully» automatable jobs may disappear by technological replacement effects and most of the customers could be unconcerned about it, for example: power plant operators, vehicle drivers, packers, mail carriers and bank tellers[108].

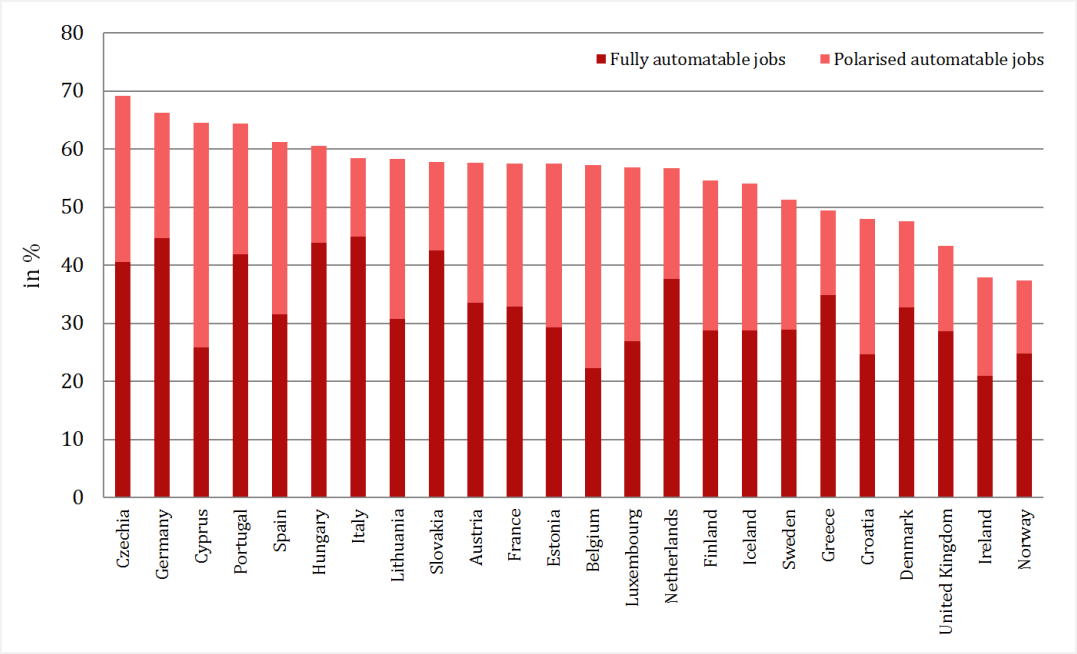


Figure 7. Estimated fully and polarised automatable jobs, according to G. LORDAN and C. JOSTEN (2017) and reproduced by G. LORDAN in 2018[109].

The graph presented above summarises the results for the European countries, distinguishing among «fully» and «polarised» automatable jobs. Czech Republic attained the highest share of automatable employment, at 69.2% of the total. The ranking is followed by Germany (66.3%) and Cyprus (64.5%). Nevertheless, Italy is the country with the highest share of fully automatable jobs, at 44.9% of the total. By uniting both categories, Spain surpasses the barrier of 60%, but attains a relative balance between those. Norway and Ireland are located the bottom of the classification, expecting an overall possibilities for automation above 37%.

[107] At least, it is curious that G. LORDAN and C. JOSTEN have opted to consider lawyers to be partly automatable, but instead economists (their own profession) are placed in the category of non-automatable jobs.
[108] LORDAN, Grace (2018): *Robots at work. A report on automatable and non-automatable (...) (op. cit.)*, pp. 6-7.
[109] Graph created by the author. Source of data: LORDAN, Grace (2018): *Robots at work. A report on automatable and non-automatable (...) (op. cit.)*, p. 23.

In 2019, Professors G. LORDAN and C. JOSTEN issued a second paper[110] re-evaluating the methodology previously used[111] in 2017 by regressing data from the EU's Labour Force Survey between 2013 and 2016. Results attain significant variations in some European countries and deserve specific considerations[112]. The text also produces country estimations based on the methodology of D. AUTOR and D. DORN in 2013, modifying the results published in the EUROPEAN COMMISSION's report of 2018. Overall, Professors G. LORDAN and C. JOSTEN estimate that 47% of jobs can be automated in the EU over the 2020s decade[113], with 35% of all jobs being fully automatable. However, authors recall that such estimations result from static models and that increased demand in goods and services will foster the deployment of other occupations, associated to less automatable skills.

The process of automation can be analysed in the form of successive waves. In 2018, PricewaterhouseCoopers published a report[114] elaborated by John HAWKSWORTH, Richard BERRIMAN and Saloni GOEL, presenting three overlapping impacts. The first one, now on the move, is qualified as «algorithm wave». Simple computational tasks and analysis of structured data thus become automated. The sectors that appear more affected are finance[115], insurances, information and communications.

The second period is called the «augmentation wave», and focuses on automation of repeatable tasks, like filling forms, exchanging and communicating information through dynamic technological support, and analysing unstructured data in semi-controlled environments (for example, aerial drones and warehouse robots). Here, the sectors more impacted will be the public administration, manufacturing and storage. This wave could reach the moment of plenitude in the mid-2020s. And finally, the last period is the so-called «autonomy wave», based on the robotisation of physical labour and manual dexterity. Construction and transport, areas which require responsive and adaptable actions from professionals, will be the most affected sectors. This wave would attain an important level of maturity in the 2030s[116].

The figure shown *infra* illustrates the estimated impact of new technologies over employment in European countries, according to the report of PricewaterhouseCoopers. Unfortunately, the estimation has not covered all the States, but is sufficient to depict an initial picture of automation. The countries that would experience the greatest effects are three Eastern EU Member States: after the three waves, the accumulated share of jobs at high risk is of 44% at Slovakia, 42% at Slovenia and Lithuania, and 40% at Czech Republic. The cause can be traced in the large proportion of employment associated to manufacturing activites.

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[110] JOSTEN, Cecily; LORDAN, Grace (2019): "Robots at Work: Automatable and Non Automatable Jobs". *IZA Discussion Paper Series*, No. 12520. Bonn, Institute of Labour Economics (IZA).

[111] Fortunately, authors have avoided the terminology of «recently automatable» used in 2017, which was confusing, and have substituted it for just «automatable», thus integrating the «full» and «polarised» automatibility probabilities.

[112] For example, in Spain, the probability of «full» automatibility increased from 31.6% in 2017 to 34.3% in 2019, thereby reporting a low variation. In contrast, Italy experienced an outstanding sharp fall comparing both pieces of research, from 44.9% of «full» automatibility in 2017 to only 13.4% in 2019.

[113] Therefore, coinciding with the estimations of C. B. FREY and M. OSBORNE in 2013 relating to the probability of automation in the United States, which was precisely set at 47%.

[114] HAWKSWORTH, John; BERRIMAN, Richard; GOEL, Saloni (2018): *Will robots really steal our jobs? An international analysis of the potential long term impact of automation*. London, PricewaterhouseCoopers.

[115] In fact, between the end of 2007 and 2017, the Spanish banks have closed 18.000 offices, that is, 39.6% of the total, and had reduced their workers in a remarkable proportion of 30.5%. Source: SERVIMEDIA (2018): *El sector financiero español ha perdido 85.000 empleos y ha cerrado 18.000 oficinas en una década*. Press release, «20 Minutos» newspaper. Accessible Online [Last consultation on 30.08.2021].

[116] HAWKSWORTH, John; BERRIMAN, Richard; GOEL, Saloni (2018): *Will robots really steal our jobs? (...) (op. cit.)*, p. 6.

The next positions are occupied by the three largest economies of the Eurozone: Italy (39%), France and Germany (both at 37%)[117]. Then, the United Kingdom and the economies with a «peripheral» nature continue the enumeration. In contrast, Russia and Greece, at 23%, and Finland (22%) and other Nordic States, are the cases with better expectations. The extraction of commodities, tourism and the knowledge economy, respectively, seem to be the causes of this better scenery for the future.

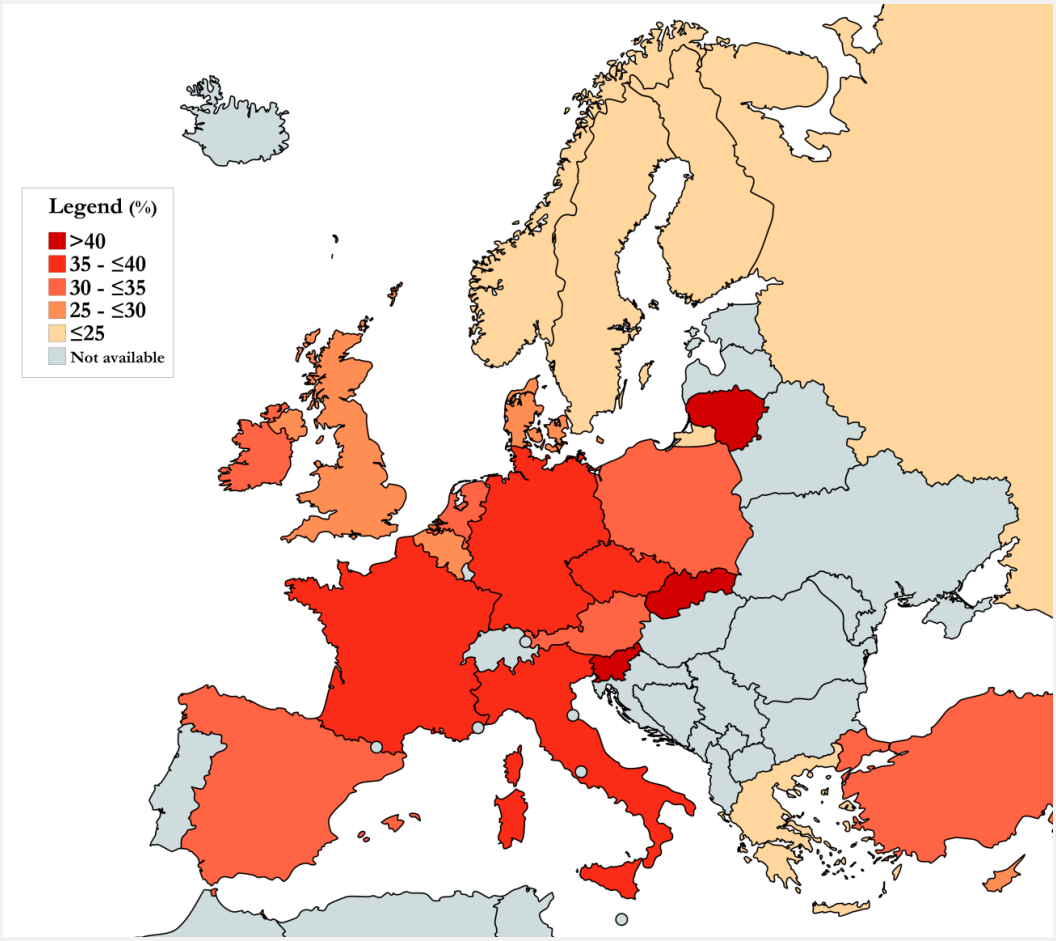


Figure 8. Estimated share of jobs at potential high risk of automation across countries after the effects of the «third wave» (impacts accumulated), according to J. HAWKSWORTH, R. BERRIMAN and S. GOEL[118].

Is the public administration different than other sectors? In 2019, Professor Carles RAMIÓ published a book[119] containing an estimation of the employment destruction at the Spanish public administration by the incidence automation. According to his study, in the decade of the 2020s could disappear a million of public employees in the country, which represents 30% of the total number.

[117] It can be criticised the similar evaluation of the Franco-German axis: Germany has a larger industrial muscle than France, becoming more susceptible to attain higher levels of automation.

[118] Graph created by the author. Source of data: HAWKSWORTH, John; BERRIMAN, Richard; GOEL, Saloni (2018): *Will robots really steal our jobs? (...)* (*op. cit.*), p. 16.

[119] RAMIÓ, Carles (2019): *Inteligencia artificial y Administración pública. Robots y humanos compartiendo el servicio público*. Madrid, Los Libros de la Catarata.

This impact would have a positive incidence over public finances, resulting in a reduction of 25% at the human resources budget[120]. However, in spite of the large losses in public employment, C. RAMIÓ presented the transition in a positive sense: he considers that new technologies may foster transparency in bureaucracies and that this process can be smoothed by the considerable aged personnel of public administrations, ready to retire[121] and thus become easily substituted by robots and algorithms[122].

3.3. AUTOMATION AS A DANGER FOR LOW-SKILLED WORKERS

Some researchers maintain that automation is a threat directed to low-skilled workers. Instead, medium and high-skilled workers have more resources and capabilities to re-skill themselves and switch more comfortably to other occupations. In 2016 was published a significant paper[123] elaborated by Melanie ARNTZ, Terry GREGORY and Ulrich ZIERAHN that analysed the potential for automation in 21 OECD countries. Categorically, this text issued by the OECD rejected the methodology used by C. B. FREY and M. OSBORNE in 2013, by admitting that it is preferable to adopt a task-based approach, instead of generalising the automation potential of occupations[124].

In this sense, as there are numerous tasks that require face-to-face interaction and engineering bottlenecks, the estimated incidence of automation over employment decreases sharply. In the United States, for example, only 9% of jobs appear to be at high risk of automation, compared to 47% in the study elaborated by C. B. FREY and M. OSBORNE. Results have a limited range, from 5.9% in the Korean Republic to 12.2% in Austria and Germany. Spain is also in a dangerous place, at 11.8%. East Asian countries appear remarkably better.

Overall, the study by M. ARNTZ, T. GREGORY and U. ZIERAHN is optimistic about a possible «adjustment» that may counteract the negative effects of automation. At first, they expect that labour-saving technologies will create demand for human labour in new sectors and occupations, for example, in ICTs. Secondly, they consider the productivity increase of undertakings as a source of greater competitiveness and product demand, and by extension, of labour demand. And finally, the authors evaluate positively the increment in labour productivity caused by new technologies, expecting that it can be transferred to salaries or even higher employment levels[125]. Besides, the exposed piece of research evaluates the risk of automation in tasks deployed by low-qualified workers[126], recommending re-training policies that are powerful enough to keep the fast pace of the transition. In 2015, the MCKINSEY GLOBAL INSTITUTE issued another report[127] analysing the effects of automation, but using also a task-based approach. They expressed that only less than 5% of jobs could be automated in the near to medium term, concentrating the impact on low-skilled workers.

[120] RAMIÓ, Carles (2019): *Inteligencia artificial y Administración pública. (...) (op. cit.)*, pp. 142-144
[121] It is estimated that in Spain there will retire 1 million civil servants until 2030.
[122] RAMIÓ, Carles (2019): *Inteligencia artificial y Administración pública (...) (op. cit.)*, p. 25.
[123] ARNTZ, Melanie; GREGORY, Terry; ZIERAHN, Ulrich (2016): "The risk of automation for jobs in OECD countries. A comparative analysis". *OECD Social, Employment and Migration Working Papers*, No. 189.
[124] Authors used the PIAAC database elaborated by the OECD in 2012, which focuses on adult competencies.
[125] ARNTZ, Melanie; GREGORY, Terry; ZIERAHN, Ulrich (2016): "The risk of automation for jobs *(...) (op. cit.)*, pp. 23-24.
[126] For example, authors estimate that in Spain individuals with an educational attainment of only UNESCO's ISCED 1 (less than primary education) will face a high risk of automatibility in 56% of the cases.
[127] CHUI, Michael; MANYIKA, James; MIREMADI, Mehdi (2015): *Four Fundamentals of Workplace Automation*. McKinsey Global Institute.

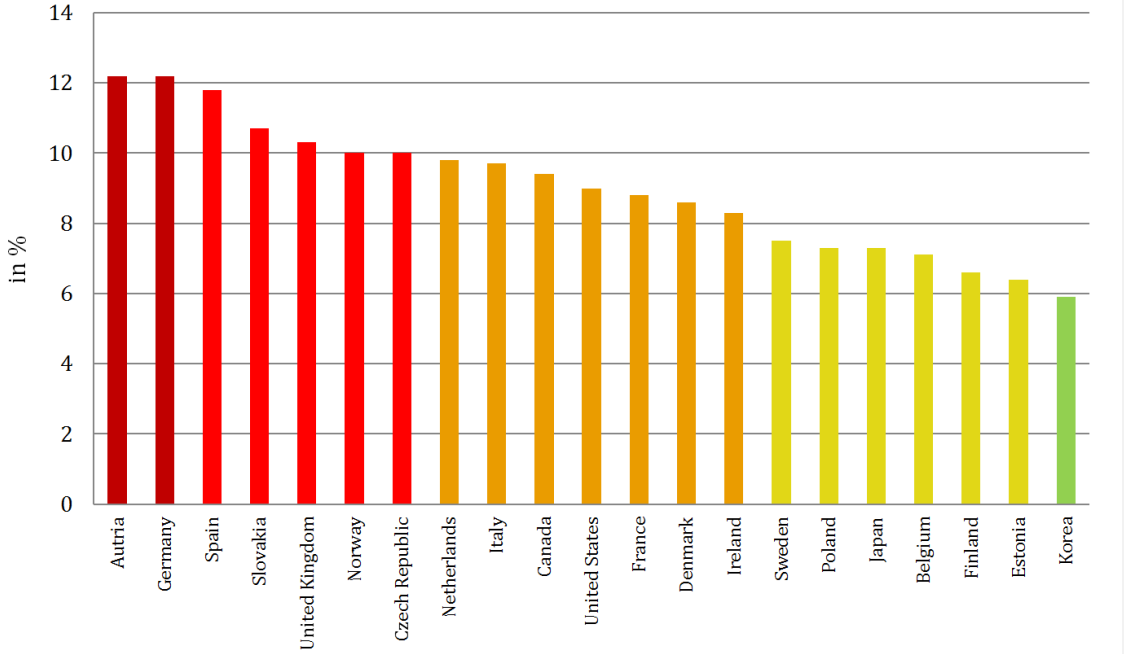


Figure 9. Estimated share of workers with high automatibility, according to M. ARNTZ, T. GREGORY and U. ZIERAHN (2016)[128].

The WORLD ECONOMIC FORUM (WEF) issued a report[129] on January 2016 analysing 15 major developed and emerging economies, forecasting the effects of disruptive technologies for the period 2015-2020. The document reported the disappearance of 7.1 million jobs, affecting mainly office and administrative occupations, while 2 million labour posts could be created, mainly in the technological and financial arena. Thus, the net employment impact in the mentioned period would be of more than 5.1 million jobs lost. The report estimated that by 2020 autonomous vehicles would be circulating more extendedly in the roads of the developed world. Besides, the study highlighted the importance of social and interpersonal skills, as a fundamental supplement to technical skills.

On December 2016, the EXECUTIVE OFFICE of the Presidency of the United States issued a report[130] analysing the effects of artificial intelligence and automation over the economy. The document referred to many of the investigations mentioned previously and lay out the main public policies for the future in the United States, having in mind the preferences of the Obama's administration but recognising that the challenges of automation would have to be assumed in the following presidencies. Artificial intelligence was viewed in a favourable light, considering that the United States should put more efforts at maintaining the global leadership in the subject. Besides, education and training at all levels were place at an important position in the document, considering that they were paramount in the transition towards future occupations.

[128] Graph created by the author. Source of data: ARNTZ, Melanie; GREGORY, Terry; ZIERAHN, Ulrich (2016): "The risk of *(...) (op. cit.)*, pp. 17 and 33.
[129] WORLD ECONOMIC FORUM (2016): *The future of jobs: Employment, skills, and workforce strategy for the fourth Industrial Revolution*. Cologny and Geneva.
[130] EXECUTIVE OFFICE OF THE PRESIDENT (UNITED STATES) (2016): *Artificial Intelligence, Automation, and the Economy*. Washington D. C.

The EXECUTIVE OFFICE of the President expressed commitment to «modernize and strengthen the social safety net», but rejected replacing the current mechanisms[131] with a universal basic income that provided «a regular, unconditional cash grant to every man, woman, and child in the United States»; the Administration acknowledged that «[t]he issue is not that automation will render the vast majority of the population unemployable. Instead, it is that workers will either lack the skills or the ability to successfully match with the good, high paying jobs created by automation»[132]. Immediately afterwards, the document counterbalanced this confident perception of the role of education and asserted the necessity to increment the minimum wage, strengthen the bargaining power of workers and increase the progressiveness of the tax system, among other aspects, usually referring to the «middle class» concept.

On March 2018, Researchers Ljubica NEDELKOSKA and Glenda QUINTINI issued a paper[133] under the OECD publications framework and with the financial help of the EaSI Programme of the EU, analysing the relationship between the risk of automation and skills in 32 OECD member countries. The main source of data was the PIAAC survey, elaborated by the mentioned organisation, and the methodology relied on previous contributions by C. B. FREY and M. OSBORNE in 2013 and M. ARNTZ, T. GREGORY and U. ZIERAHN in 2016. According to their findings, approximately 14% of jobs in OECD countries were highly automatable[134], a magnitude equivalent to 66 million workers. Additionally, another 32% of jobs suffered a risk of automation situated between 50 and 70%. There were notable differences among countries. In Slovakia were registered the top levels of automatibility, at 33% of jobs, while in Norway it reached only 6% of them. Overall, Anglo-Saxon and Nordic countries had better expectations for the future of work.

The document acknowledged the trend in labour market polarisation experienced during the last decades. However, researchers pointed out that Artificial Intelligence will play an important role in the displacement of more low-skilled jobs than in previous technological transitions, creating a linear downwards dynamic between the risk of automation and the educational/skills attainment. About a possible gender bias in computerisation, women tend to work in occupations that have a lower risk to be automated. Nevertheless, within these jobs they often execute specific tasks characterised by more automatibility[135].

With the exception of the Russian Federation, younger workers appear in a more vulnerable position than their senior counterparts, as entry-level jobs are characterised by more routine and predictable tasks. However, young workers show nowadays more adaptability to acquire the appropriate skills[136]. L. NEDELKOSKA and G. QUINTINI expressed concerns about what group of workers are currently most vulnerable to automation, defining them as employees with multiple barriers to participate in adult learning, like low basic skills, time limitations or motivation below the average. In this sense, they considered that it is important that public policies address adult learning adequately to prepare better the workers for the shift in job requirements.

[131] Such mechanisms are the Temporary Assistance to Needy Families (TANF), the Supplemental Nutrition Assistance Programme (SNAP) and Medicaid.
[132] EXECUTIVE OFFICE OF THE PRESIDENT (UNITED STATES) (2016): *Artificial Intelligence (…) (op. cit.)*, p. 40.
[133] NEDELKOSKA, Ljubica; QUINTINI, Glenda (2018): "Automation, skills use and training". *OECD Social, Employment and Migration Working Papers*, No. 202. Paris, OECD Publishing.
[134] «High» automatibility means in this piece of research a probability of automation of over 70%.
[135] NEDELKOSKA, Ljubica; QUINTINI, Glenda (2018): "Automation, skills use and training" *(…) (op. cit.)*, p 53.
[136] NEDELKOSKA, Ljubica; QUINTINI, Glenda (2018): "Automation, skills use and training" *(…) (op. cit.)*, pp. 56-57.

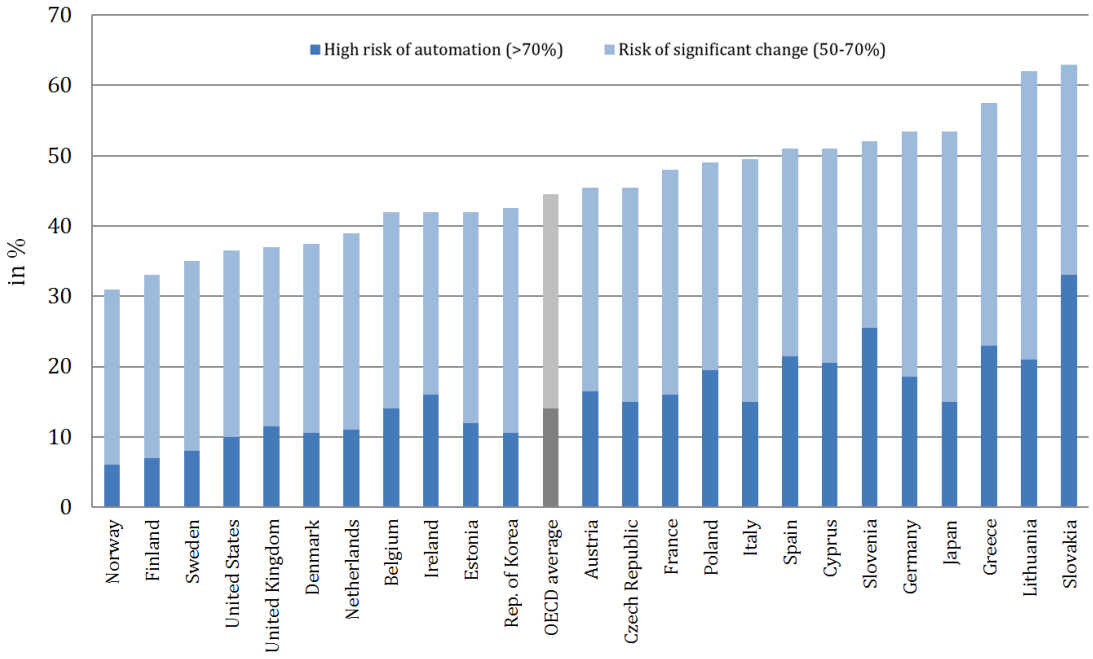


Figure 10. Estimated share of job automatibility according to L. NEDELKOSKA and G. QUINTINI (2018), considering the degree of risk[137].

In 2017, Wolfgang DAUTH, Sebastian FINDEISEN, Jens SÜDEKUM and Nicole WÖßNER published a paper[138] of the impact of industrial robots over employment in Germany. Researchers did not find that robots were the cause of a fall in total employment, but they pointed out to variations in the composition of aggregate employment, based on the creation of jobs in the services sector and the public administration, which were able to offset the losses in industry (being automobile production the largest one). The study revealed that every robot was responsible for the destruction of 2.12 manufacturing jobs. This was the cause of almost 23% of the overall decline in German manufacturing employment in the period 1994-2014, affecting 275,000 jobs, and also explained the reduction of the labour income share.

Furthermore, the introduction of robots was the cause of fewer new vacancies in industries and omitted replacements in staff when a vacancy arose, which limited the entry into the manufacturing sector for young workers[139]. New technologies produce significant earnings in medium-skilled workers who conducted routine and manual tasks. Negotiations among trade unions and companies facilitated such outcomes, as their agreements broadly consisted at preferring the preservation of high employment levels at the expense of flexible wage setting arrangements and wage restraints. Germany is an exceptional country in terms of robots' production.

[137] Graph created by the author. Source of data: NEDELKOSKA, Ljubica; QUINTINI, Glenda (2018): "Automation, skills use and training" *(...) (op. cit.)*, p. 49.
[138] DAUTH, Wolfgang; FINDEISEN, Sebastian; SÜDEKUM, Jens; WÖßNER, Nicole (2017): "German robots: The impact of industrial robots on workers". *IAB Discussion Papers*, No. 30/2017.
[139] DAUTH, Wolfgang; FINDEISEN, Sebastian; SÜDEKUM, Jens; WÖßNER, Nicole (2017): "German robots: The impact of industrial robots *(...) (op. cit.)*, p. 33.

In the «Robotics World Rankings», among the ten largest firms there are eight Japanese companies and two producers with a German origin[140]. Besides, the country is home of important car manufacturers with an export orientation, which have large centres in the areas of Wolfsburg and Dingolfing-Landau. Nevertheless, researchers have found that «direct employment gains from the concentration of robotic production seem to be absent, possibly reflecting the fact that robot production is itself not very labour-intensive»[141].

On March 2017, Professors Daron ACEMOGLU and Pascual RESTREPO published an influent paper[142] centred in the United States. Researchers evaluated the diffusion of new technologies in the period 1990-2007 by regressing the increment of industrial robots with the variations in employment and wages, also controlling the incidence of Chinese and Mexican imports in the economy, among other factors. The study concluded that excluding trade between commuting zones[143], each additional robot per thousand workers would reduce the aggregate employment to population ratio by 0.37% and diminish the aggregate wages by about 0.73%. If the estimation considered trade between commuting zones then magnitudes decreased, forecasting that one additional robot per thousand workers would reduce the aggregate employment to population ratio by 0.34% and lessen the aggregate wages by 0.5%. Overall, the study estimated an approximate loss of 360,000 to 670,000 jobs in the US economy between 1990 and 2007.

Using the mentioned methodology of D. ACEMOGLU and P. RESTREPO, on April 2018 Francesco CHIACCHIO, Georgios PETROPOULOS and David PICHLER, Researchers at BRUEGEL, published a paper[144] covering the impact of industrial robots on employment and wages in six EU countries. This analysis allows thus the comparability with the United States. Researchers concluded that one additional robot per thousand workers reduced the employment rate by 0.16 to 0.20%, confirming the hypothesis of the «displacement effect» and notably surpassing the productivity effects on job creation.

In the United States the impact appeared to be larger; this fact can be explained by a more liberalised labour market in America and the active labour market policies in Europe, which cushion the staff turnover dynamics. The youngest cohort of workers and employees with a medium educational attainment appeared to be the most affected collectives by the technological transition. Besides, wages were affected by robotisation: researchers estimated that one additional robot per thousand workers reduced wage growth by as much as 0.63%.

On March 2019, Sean WHITE, Andrea LACEY and Anna ARDANAZ-BADIA, from the OFFICE FOR NATIONAL STATISTICS of the United Kingdom, published on 2019 an article[145] comparing the probability of automation of 20 million English workers between 2011 and 2017. Their methodology combined the approaches introduced by C. B. FREY and M. OSBORNE and OECD's researchers releases.

[140] DAUTH, Wolfgang; FINDEISEN, Sebastian; SÜDEKUM, Jens; WÖßNER, Nicole (2017): "German robots: The impact of industrial robots *(...) (op. cit.)*, p. 7.
[141] DAUTH, Wolfgang; FINDEISEN, Sebastian; SÜDEKUM, Jens; WÖßNER, Nicole (2017): "German robots: The impact of industrial robots *(...) (op. cit.)*, p. 24.
[142] ACEMOGLU, Daron; RESTREPO, Pascual (2017): "Robots and jobs: Evidence from US Labor Markets". *NBER Working Papers*, No. 23.285.
[143] In this piece of research, «commuting zones» are equivalent to integrated local urban areas. As authors recognise, an estimation of no trade between commuting zones is an unrealistic assumption, but they overcome it later on in the paper.
[144] CHIACCHIO, Francesco; PETROPOULOS, Georgios; PICHLER, David (2018): "The Impact of Industrial Robots on EU Employment and Wages: A Local Labour Market Approach". Bruegel Working Papers, Issue 02, 18.04.2018.
[145] WHITE, Sean; LACEY, Andrea, ARDANAZ-BADIA, Anna (2019): *The probability of automation in England: 2011 and 2017*. London, Office for National Statistics.

Their findings reveal that 7.4% (1.5 million) of workers were citizens employed in jobs at high risk of automation[146]. In contrast, the number of employees that were in jobs with low risk of automation[147] was 27.7% (5.5 million) of the analysed workforce. In six years, employees were shifting progressively towards safer occupations[148].

The Covid-19 pandemic has supposed a disruptive scenery for technological change. The medical emergency has centred the attention of mass media during 2020 and also less publications of the future of work had been made in this period characterised by strong uncertainty. The MCKINSEY GLOBAL INSTITUTE has issued on February 2021 a report[149] that pretends to shed light over the issue, estimating that approximately 28% of the US workforce would experience a transition in occupation by 2030. In Spain, the forecast is settled much lower, at 7%. Predictions are based on various trends, where automation is integrated as another variable, and considering that the pandemic is an accelerator of technological change[150] and a halt on retraining possibilities.

3.4. FORECASTS ABOUT A COMPENSATING ADJUSTMENT ON EMPLOYMENT

Several pieces of research support that automation does not represent a peril over employment. They often rely on data gathered during periods of economic prosperity or illustrate notable expectations for new jobs, which are anticipated to emerge in the near future and offset the losses caused by technology. Their position is not controversial and is adjusted to the historical trends, thus meaning that mass media and the public opinion had been less interested in such findings.

In 2013, the INTERNATIONAL FEDERATION OF ROBOTICS (IFR) issued a report[151] elaborated by Peter GORLE and Andrew CLIVE with the aim to release the rising fears of automation over employment and highlight the positive outcomes of new technologies. The economic and social crisis had affected severely the «peripheral» economies in the Eurozone and investments in the implementation of industrial robots caused sceptical views by trade unions. The report estimated that, from 2008 to 2011, had been created between 500,000 to 750,000 new jobs worldwide due to robotics (directly and downstream[152] in each sector)[153]. Besides, the document highlighted the benefits of replacing humans in dangerous or unsatisfactory working conditions, for example, in foundries, chemical and food industries.

Also in 2013, Horst FELDMANN authored a paper[154] admitting that technological unemployment can be originated by the impact of automation and its effects can last for approximately three years.

[146] In other words, a probability of automation greater than 70%.
[147] That is, a probability of automation lower than 30%.
[148] WHITE, Sean; LACEY, Andrea, ARDANAZ-BADIA, Anna (2019): *The probability (…) (op. cit.)*, p. 5.
[149] LUND, Susan; MADGAVKAR, Anu; MANYIKA, James; SMIT, Sven; ELLINGRUD, Kweilin; MEANEY, Mary; ROBINSON, Olivia (2021): *The future of work after COVID-19. The postpandemic economy*. McKinsey Global Institute.
[150] The Covid-19 pandemic has supposed a multiple shock of accelerated automation, increased online commerce, greater remote work and restrained business travel.
[151] GORLE, Peter; CLIVE, Andrew (2013): *Positive Impact of Industrial Robots on Employment*. International Federation of Robotics and Metra Martech Limited.
[152] For example, distribution or retailing. However, nowadays precisely automation processes in logistics and online commerce platforms are considered to be an important threat over employment.
[153] GORLE, Peter; CLIVE, Andrew (2013): *Positive Impact of Industrial Robots (…) (op. cit.)*, p. 8.
[154] FELDMANN, Horst (2013): "Technological unemployment in industrial countries". *Journal of Evolutionary Economics*, Vol. 23, Issue 5.

However, after a period of adaptation, on average for a sample of countries there is no long-term effect. For example, increased exports may prevail in the long run, ensuring the decrease in unemployment levels. The model relied on data of 21 OECD economies for the period 1985 to 2009, regressing the unemployment rate with the triadic patent count[155]. The accurateness of the regression was controlled with 23 other variables.

Consulting firms have entered into the estimations of the future of work. In 2015, DELOITTE published a report[156] at which the firm identified that the occupations at a low risk of being automated increased by 3.5 million jobs during the period 2001-2015 in the United Kingdom. In contrast, in this timeframe there were 800,000 high-risk jobs that vanished. Therefore, the firm evaluated positively the impact of new technologies, considering that they can contribute to a significant employment growth if the right skills are provided to the workforce.

In 2016 was published a paper[157] about the incidence of routine-replacing technological change and focused on Europe. Terry GREGORY, Anna SALOMONS and Ulrich ZIERAHN used in this case data from the EU Labour Force Survey, provided by EUROSTAT and covering 238 regions of all Member States. The macroeconomic «adjustment» is viewed in a favourable light after studying the period 1999-2010[158]. In spite of the reduction of 9.6 million jobs across the continent by the incidence of technological capital, product demand and spillover effects were estimated to have increased labour demand by some 21 million jobs, therefore compensating the losses extensively. Authors remarked that public concerns should focus on the property of capital, rather than the substitution effect of new technologies over employment.

On December 2017, the MCKINSEY GLOBAL INSTITUTE presented a report[159] covering the effects of automation on jobs. In this case, contrasting with previous releases, the document highlighted the benefits of increased productivity and efficiency. The report expected that 3% to 14% of the global workforce (75 million to 375 million workers) would have «to switch occupational categories» by 2030. This magnitude is translated to one third of the labour force in countries like the United States or Germany, or even half of workers in Japan[160].

Nevertheless, the study expected that certain human activities would increase in this new scenery, which could be bundled into four categories: applying expertise, interacting with stakeholders, managing and developing people, and unpredictable physical activities, that could be source of new employment opportunities, sufficient to compensate the employment losses derived from automation[161].

[155] Triadic patents are registered in the main three major patent offices: the European Patent Office, the US Patent and Trademark Office and the Japanese Patent Office. In 2020, the Chinese and Korean patent offices are acquiring notable importance, thus symbolising a progressive technological shift towards the Pacific.
[156] INSALL, Jemma; BORTHAKUR, Ankur (2015): *From brawn to brains. The impact of technology on jobs in the UK*. London, Deloitte.
[157] GREGORY, Terry; SALOMONS, Anna; ZIERAHN, Ulrich (2016): "Racing With or Against the Machine? Evidence from Europe". *ZEW Discussion Papers*, No. 16-053.
[158] Naturally, this period of time is characterised by a generalised economic growth until 2008, when begins the «Great Recession». The cut of data in 2010 does not allow an adequate study of the economic and social crisis dynamics.
[159] MANYIKA, James; LUND, Susan; CHUI, Michael; BUGHIN, Jacques; WOETZEL, Jonathan; BATRA, Parul; KO, Ryan; SANGHVI, Saurabh (2017): *Jobs Lost, Jobs Gained: Workforce Transitions in a Time of Automation*. McKinsey Global Institute.
[160] MANYIKA, James; LUND, Susan; CHUI, Michael; BUGHIN, Jacques; WOETZEL, Jonathan; *(...) (op. cit.)*, p. 11.
[161] MANYIKA, James; LUND, Susan; CHUI, Michael; BUGHIN, Jacques; WOETZEL, Jonathan; *(...) (op. cit.)*, pp. 77-79.

Overall, the MCKINSEY GLOBAL INSTITUTE focused on six countries and detailed a range of possible outcomes derived from the incidence of new technologies by 2030, emitting relatively positive results[162]. In Germany and Japan, for example, the report considered a plausible increment in professional and medical occupations, like lawyers and business specialists, or surgeons and nurses, respectively. In India, China and Mexico, besides, the study contemplated a raise in employment related to building activities (construction workers, electricians) and customer interaction (retail sales workers, bartenders)[163], despite the growing evidence that such processes can attain an important level of automation. This report of December 2017 contrasted with a MCKINSEY's previous release of the beginning of the year.

On January 2017, Thor BERGER, Chinchih CHEN and Carl Benedikt FREY[164] presented a brief study[165] evaluating the recent introduction of UBER CORPORATION in 50 cities of the United States and the related consequences for employment in the taxi sector, using data from the AMERICAN COMMUNITY SURVEY. Quite surprisingly, researchers discovered an increment of 10% in the labour supply of wage-employed taxi drivers, whilst self-employed drivers (including UBER professionals) experienced a remarkable increment of 50%. Nevertheless, regarding hourly earnings, wage-employed drivers suffered declining profits after the introduction of the platform. In constrast, self-employed UBER drivers took advantage of the improved driver-passenger matching and thus enjoyed better earnings per hour. The authors recognised that results could not be generalised across countries and that further research centred in the called «sharing economy» was required, therefore assimilating it to the «platform economy».

Also in 2017 there was published a paper[166] by the Lithuanian economists Kristina MATUZEVICIUTE, Mindaugas BUTKUS and Akvile KARALIUTE. This piece of research analysed the unemployment levels of 25 European countries, estimating the effects of triadic patent families and expenditure on R&D. The study covered the period 2000-2012, controlling the stocks of foreign direct investment, among other factors. Researchers concluded that innovation did not had effects on employment levels, but acknowledged that a more detailed analysis was necessary, distinguishing among different types of unemployment and the introduction of certain innovations in the production processes.

[162] In this employment forecast, it is expected a positive net change in employment in India (+138 million workers), Mexico and the United States (+15 million workers at both). However, losses can be found in a quiet marginal proportion in China (-16 million workers), Japan (-4 million) and Germany (-3 million).
[163] MANYIKA, James; LUND, Susan; CHUI, Michael; BUGHIN, Jacques; *(...) (op. cit.)*, pp. 91-103.
[164] Quite stunningly, C. B. FREY is the co-author of this publication, when he previously alerted
[165] BERGER, Thor; CHEN, Chinchih; FREY, Carl Benedikt (2017): "Drivers of Disruption? Estimating the Uber Effect". University of Oxford, Oxford Martin School.
[166] MATUZEVICIUTE, Kristina; MINDAUGAS, Butkus; KARALIUTE, Akvile (2017): "Do Technological Innovations Affect Unemployment? Some Empirical Evidence from European Countries". *Economies*, No. 5, Issue 48.



Conclusions

CONCLUSIONS

Robots and algorithms are shaping our world and will continue to do so in the next decades. The diffusion of multipurpose industrial robots during the last decade has experienced an expansion concentrated in East Asia. The financial and economic crisis initiated in 2008 provoked a temporary halt in technological investments that has put most of the European countries as laggards in the long run, excluding the case of Germany. There are different magnitudes that evidence the impact of automation in developed nations. The count in annual labour hours per worker has experienced a downturn over years, coinciding with the globalised trade patterns. Inequality, in terms of the participation of the highest decile in the total country's income, has increased generally since the 1980s in key economies, coinciding with the diffusion of unstable forms of work and industrial robots. Moreover, the classification of occupations among the skills' spectrum has put in evidence a job polarisation trend, concentrating greater opportunities in the extremes, the so-called «lovely» and «lousy» jobs.

The present study has shown that scientific evidence among academics about the impact of automation on employment levels is a controversial issue that remains unresolved at present, as has been during the 20th Century. The analyses published in the previous years of the Covid-19 pandemic can be grouped into three broad categories: first of all, those that expose an important danger over approximately half of the labour force, at least in developed countries; secondly, those who point out a remarkable threat over low-skilled workers; an finally, those who consider that the current situation will not be different than in the past, as occupations will change and workers will have to switch from one job to the other with the appropriate training. It has to be said that certain institutions or *think-tanks* have opted to publish different analyses covering several of the exposed categories, thus guaranteeing a satisfactory approach to all readers. A common ground of all publications is the need of re-skilling and continuous training to ensure the employee's competitiveness.

When assessing what regions in the world are better to work and live in, it shall be considered that there are three aspects that can be key to address the coming technological challenges: at first, the capacity to redistribute efficiently the gains coming from innovations; secondly, the capacity to own and produce advanced devices; and finally, the sectorial structure of the economy, with a balance between hi-tech industry and tertiary occupations. The champions of both categories are found in Northern Europe and East Asia, and it is no surprise that estimations of employment levels have settled better grades in such countries. Notwithstanding this fact, considering the size of the populations, it can be observed a shift of the global economy towards the Pacific region.

Several studies had predicted a remarkable adoption of autonomous vehicles and automated warehouses in advanced economies by 2020. It shall be said that such technologies had not arrived at the expected levels of diffusion at the present moment. However, the coronavirus pandemic has spurred the introduction of other practices. During the lockdown period in 2020, ICTs had been paramount to assure a telework capacity. After attaining generalised levels of vaccination in developed countries during the summer of 2021 in most of the developed countries, employment relations have turned towards a hybrid modality of work. Employers have noticed the need to ensure a minimum level of human interaction to let their undertakings remain creative and productive at the long run. In spite of this trend, it is clear that remote digital tasks during the coronavirus waves have been an important source of data for algorithms and machine learning operations, which will show their effects on automation during the decade of the 2020s. Research that covers the recent shock on employment is just beginning to be published.



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More robots are coming. Where should I go?

A comparative study of forecasts on automation

ARNAU GUIX SANTANDREU

ABSTRACT

The future of work remains nowadays uncertain. Before the Covid-19 pandemic, forecasts on automation presented in certain cases a tragic scenery at the beginning of the 2020s. However, at the moment such expectations have not arrived yet, in spite of the digital acceleration caused by the lockdown and the generalised restrictions to mobility. What is clear is that technology is transforming labour and will continue to do so in the next decade, distributing wealth in irregular concentrations all over the world. We can imagine a displaced worker looking for a job in an area of the globe with more opportunities and economic stability, thinking: «Where should I go?».

By analysing recent scientific publications on the subject, the present study is structured into two great axes. First of all, it is determined a general overview of the main magnitudes related to automation that put in evidence the current transformations on the labour market. Afterwards, the inquiry depicts an accurate overview of the experts' literature on the international forecasts of computerisation, which allows defining what areas of the planet appear to be safer to preserve the own professional future during this historical transition.

Keywords: robots, automation, employment, digital transformation, technological unemployment, computerisation, future of work.

3 — 2021

AGS PUBLICATIONS

ISSN: 2696-1083

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