Changes in productivity and labour relations: artificial intelligence in the automotive sector in Portugal

António B. Moniz* and Marta Candeias

CICS.NOVA,
Nova School of Sciences and Technology,
Nova University of Lisbon,
Campus de Caparica, 2829-516 Caparica, Portugal
Email: abm@fct.unl.pt
Email: ms.candeias@campus.fct.unl.pt
*Corresponding author

Nuno Boavida

CICS.NOVA,
Nova School of Social Sciences and Humanities,
Nova University of Lisbon,
Campus de Campolide, 1070-312 Lisboa, Portugal
Email: nuno.boavida@fcsh.unl.pt

Abstract: New technologies, sustainability policies, protectionism and consumers preferences are pushing for the reorganisation of the automotive cluster. The emergence of artificial intelligence (AI) has the potential to create disruptive effects in the employment systems across the world. The future deployment of broad-spectrum algorithms capable of being used in wide areas of application (e.g., industrial robotics, software and data communication) can lead to considerable changes in current work patterns, swiftly render many unemployed across the globe and profoundly destabilise labour relations. In this paper, we identify the probable penetration of AI in the automotive sector and to study its effects on work organisation, employment, and industrial relations systems, in Portugal. These changes are put in place to enhance the product quality, control costs, and improve productivity. We study these implications on productivity and industrial relations collecting new data and obtain results based on secondary statistical analyses and case studies in the automotive industry. Finally, changes in the productivity and labour market will be discussed considering the employment and skills changes in the automotive sector when investment on automation becomes a clear trend in the automotive sector.

Keywords: artificial intelligence; automotive cluster; cyber-physical systems; automation; labour relations; Portugal; productivity.

Reference to this paper should be made as follows: Moniz, A.B., Candeias, M. and Boavida, N. (2022) 'Changes in productivity and labour relations: artificial intelligence in the automotive sector in Portugal', *Int. J. Automotive Technology and Management*, Vol. 22, No. 2, pp.222–244.

Biographical notes: António B. Moniz is a Professor at the Nova School of Sciences and Technology, where he coordinates the PhD in Technology Assessment. His research interests involve organisation of work processes, sociology of technology and human factors in industrial automotive systems.

Marta Candeias is a PhD researcher of the CICS.NOVA. Her research interests involve innovation in the automotive sector, technology innovation and organisation of work.

Nuno Boavida is a researcher of the CICS.NOVA and Deputy Director of Observatory of Technology Assessment. His recent research interests involve artificial intelligence, technology assessment, labour and employment.

This paper is a revised and expanded version of a paper entitled 'Changes in productivity and labour relations: artificial intelligence in the automotive sector in Portugal' presented at 29th GERPISA International Colloquium, Online, 14–18 June 2021.

1 Introduction

The effects of automation in labour have rarely been studied approaching an emergent technology with the potential to swiftly change employment patterns. The emergence of artificial intelligence (AI) has the potential to create disruptive effects in the employment systems across the world. The future deployment of broad-spectrum algorithms capable of being used in wide areas of application (e.g., industrial robotics, software, cyber-physical systems and data communication) can lead to considerable changes in current work patterns and provoke technology unemployment across the globe. These changes will profoundly destabilise labour relations.

However, it is not only the technology that will produce such changes. A combination of technological breakthroughs in AI, together with telecommunication and social media (Degryse, 2019; Eurofound, 2019) imply changes at the level of interaction between humans and machine and not only on the labour market structure.

In this regard, there are authors that named this present phase the 'second machine age', and they argued that it involves the substitution of the human cognitive features by AI (Brynjolfsson and McAfee, 2014). Furthermore, several authors consider AI as the most relevant emergent technology to understand the development of automation in the manufacturing sector (Geels et al., 2016; Moniz, 2018). The demonstration of these effects and the path of changes must be taken from micro-level empirical analysis.

The study of Frey and Osborne (2017) indicated that the automatable tasks are the ones that will endanger most of manufacturing jobs, but other authors argued in a different way (Autor, 2015; Bisello et al., 2019; McGuinness et al., 2019; Acemoglu and Restrepo, 2018). Such impacts could be witnessed especially in the automotive sector. However, many non-automatable tasks make jobs less vulnerable than suggested by the pessimistic studies. It seems that within the same occupation the automation potential can vary greatly from job to job, and the threats in occupations vary significantly by qualifications, sectors and by countries (Arnold et al., 2018). As Autor (2014) verifies, the complementarity role of technology (instead of substitution) might prevail in many workplaces. Most of these studies have been done using secondary economic data.

Therefore, despite the resurgence of the old debate and social angst about the future of work, there is not a clear consensus on whether we are on the verge of a quantum leap in human-machine interaction or seeing a continuation of previous trends.

The paper will contribute to answer the questions: has employment in the automotive sector changed with the recent automation trends in Portugal? Do these trends have implications on industrial productivity and employment in the automotive sector? Do they have impacts in traditional labour relations in the sector? Are there signs of improvement in qualifications with increases in automation? Or can we observe an increase in job precarity in the automotive labour market with increased application of AI in this sector?

The relevance of intelligent manufacturing in the automotive sector has also been vastly documented in terms of working conditions, qualifications, and skill requirements (Moniz, 2018; Moniz et al., 2002; Arnold et al., 2018). Furthermore, Portugal is an interesting case to be studied as it is a peripheral country like many others that do not own but participate in the supply chain of the original equipment manufacturer (OEM).

The paper will focus on AI, as an umbrella of technologies such as cyber-physical systems, intelligent automation, robotics and internet of things (IoT) (European Commission, 2020). Research and development (R&D) investments in industrial processes in general may reflect productivity improvements derived from the increased automation process, but that may not be the general trend. Our empirical data was based until now on initial case studies from the automotive and components industries combined with database search by keywords that signal intelligent automation developments and AI applications selected from national R&D projects on robotics, machine learning (ML), collaborative tools, human-machine interaction, and autonomous systems, supported by European Regional Development Fund (ERDF).

The article first contextualises the automotive sector in the world and in Portugal (Mordue, 2020; Mordue and Sweeney, 2017). Evidence from databases and interviews around cases will be presented approaching the implications of R&D projects in productivity and employment in the Portuguese automotive sector. Last, the implication of these cases in the automation debate will be discussed.

2 AI and jobs

Automation is a process that encompasses different technologies, and each one will impact labour in different ways (Eurofound, 2019; Pfeiffer, 2017; Moniz and Krings, 2016; Brynjolfsson and McAfee, 2014). One can consider a robot or a computerised numerical control (CNC) machine tool in manufacturing. They may be complex and programmable machines and they are expensive to implement. Eventually, they can replace a few workplaces, whereas a software algorithm is relatively simple and inexpensive to implement. Both cases can generate unemployment.

But, as Frey (2021, p.63) presents the issue, the "adoption of automation technologies is dependent on several additional variables, the relative costs of automation being a central one. If the cost of automation technologies vastly exceeds the amount of wages that can be saved by introducing them, adoption across the economy will likely be slow." Furthermore, the effects of technological change can be differently distributed, depending on the institutional framework that each society sets for itself (Eurofound, 2018). The impacts in work and employment of each technology will vary depending industrial relations system (Freeman, 1995), on the national innovation institutions (Geels et al., 2016), and even on the type of capitalism (Hall and Soskice, 2001), from liberal to the coordinated market economy.

A much-debated form of automation is related fundamentally to AI. However, findings of concrete effects of AI in industrial relations are scarce, mostly probably because it is an emergent technology. At the same time, some developments are also leading to a wave of innovation in organisational design and changes to institutionalised norms of the workplace (Schildt, 2017). The knowledge about these experiments is as well still scarce. What we know, for sure, is that the advanced algorithms can have a broad range of applications and be applied to many situations. And, in most cases, they can generate more concern as they may produce significant technical, economic, and social effects in firms. But, to avoid speculations, these systems must be at least in a development phase seven of the technology readiness levels (or TRLs) that would imply to have a system prototype demonstration in an operational environment (SPARC, 2016). The TRL are a type of measurement system used to assess the maturity level of a particular technology. It was firstly applied by NASA[1], and then used by many technology institutions around the world, namely the EU's research framework programs. Each technology project is evaluated against the parameters for each technology level and is then assigned a TRL rating based on the projects progress. There are nine TRLs. TRL 1 is the lowest and corresponds to the basic principles observed and TRL 9 is the highest referring to the system ready for commercialisation.

The estimation of the impact of AI is usually based on quantitative modelling of employment by professions or tasks (Acemoglu and Restrepo, 2018, 2019; Autor, 2015; Autor et al., 2003; Bisello et al., 2019; Malone et al., 2020). In Europe, the impacts of AI were estimated to lead to a reduction of millions of workplaces by 2030. Some data reveal that, in Finland, AI could destroy around 15% of jobs by 2030, and the retraining of one million Finnish workers will be needed (Koski and Husso, 2018). In Portugal, similarly, a study from the employers confederation reported that AI can reduce 1.1 million workplaces and suppress 50% of the work hours by 2030 (Nova SBE and CIP, 2019). Finally, Hungary may have 49% of work hours be automated, which is equivalent to the work of about 2.2 million people (Fine et al., 2018). Other reports, based on qualitative data analysis on virtual work and digital platforms, have identified significant difficulties of social partners to deal with the broad effects of automation phenomena[2] (Boavida and Moniz, 2019, 2020).

The automotive sector has a significative weight in the Portuguese economy. In 2017 (last date with statistical information), the automotive industry turnover was 4.41% of gross domestic product (GDP) (INE, 2021) with an average annual growth rate (AAGR) of 3.65% since 2010. It should also be noted that this is significantly higher than that of the manufacturing industry, which did not go beyond 1.30% on average per year in the same period (2010–2017), according to the national statistical office (INE, 2021).

Since 2013 to 2017, the employment in the automotive sector grew from 32,400 to 41,300 workers in Portugal. This growth was significant because the automotive sector had an annual growth average rate of 6.19% compared to an increase of only 1.92% in the total employment, in this period. In 2017, the automotive sector represented 1% of the total employment, which represents a significant volume of the total employment within Portugal, but it is lower than comparable countries (Spain, Italy, France, Belgium, the Netherlands, the UK and the USA) even though a positive trend of growth since 2013 is observed (OECD Statistics – STAN).

At the same time, improvements to raise productivity in a production system can be made in many areas of a factory. There are many ways to measure productivity. We have used labour productivity and capital productivity as the main indicators. The series of gross fixed capital formation (GFCF) by asset type was used to estimate productive capital stocks and to compute an aggregate measure of total capital services. To take account of the role of the capital input in the production process, the preferred measure is the flow of productive services that can be drawn from the cumulative stock of past investments, such as machinery and equipment (OECD, 2019).[3] This can provide an approach to the number of investments made for the industry infrastructure in this sector, and for the equipment and machinery, that we assume has a higher component of AI elements.

To sum up, being AI a recent technology to become widely applied in the manufacturing industry, the consequences must be studied in greater detail. Most research done on the AI impact on industrial labour force has been performed by labour economists, and usually based on statistical modelling (Cetrulo and Nuvolari, 2019; Moniz, 2014; Moniz and Krings, 2016). Sociological approaches based on case studies (with interviewing, indirect observation procedures at shop floor and detailed document analysis) provide further detail on the changing processes that are occurring in Portugal and other countries. That would not be possible if only secondary data analysis was done.

3 Methodological approach

We have used mixed methods to bring quantitative analysis together with qualitative evidence to support findings in the automotive sector in Portugal. This approach allows for a closer examination at the company level of ways in which work is being redefined and what the future expectations are. Although AI is an emergent technology that appears not to have yet be fully adopted, and in many cases, is in pilot projects, some insights of what is happening can be collected by conducting interviews on cases from the automotive and components industries. A study just based on official statistical data can present limitations once is not possible to collect micro-data, for example, on implications at the shop floor, or with specific qualification groups. These cases were selected by using keywords that signal intelligence automation developments and AI applications in Portuguese R&D projects, based on the methodology of Boavida and Candeias (2021).

The expected technology effects of each AI project can be assessed by innovation experts and technology managers with details about productivity improvements and implications to operators. Experts on organisational change and labour processes can also provide details about the effects on work organisation, skills and qualifications required. Industrial relations partners can provide wider expertise about the implications to the existing system.

The methodology consisted in systematic literature and grey literature review (reports, official documents, newspapers), international database analysis, Portuguese databases of R&D projects and fieldwork with experts in R&D related to AI projects in the automotive sector to investigate the implications of AI in productivity and employment. Due to COVID-19 pandemics, the fieldwork included online exploratory, in-depth interviews (3) and non-structured interviews with experts a technology provider of the automotive sector (1), an automotive components company (1) and work organisation and labour experts (2). These online interviews were conducted for one hour on average and with all three authors to improve their quality, accuracy and value to the research. Most relevant quotes and new knowledge are presented in the results and discussion section. This research work was carried out from September 2020 to October 2021. Some initial data were also published at Boavida and Candeias (2021). In this paper, we went further on with more interviews and case studies.

3.1 Data analyses

The productivity used in the analysis was based on OECD's variable production gross output at current prices (PROD), as inflation between 2010 and 2017 was very low in most OECD countries. Furthermore, we used the OECD's variable GFCF at current price because it reflects investment for improvements to existing fixed assets, such as buildings or computer software and the inflation between 2010 and 2017 was low in most OECD countries. We assume that this later variable is a proxy of the investment in automation, related to information and communication technologies (ICT), machinery, electronics, and electricity, even though it also includes construction. We consider the construction investment to be minor in the Portuguese context of the same period. In addition, we were able to use the OECD's variable GFCF in ICT equipment, software, and databases (GFCF_ICT) at current prices because it is a good proxy of AI development in the sector and the inflation between 2010 and 2017 was low in most OECD countries. All these variables were extracted directly from the dataset STAN Industrial Analysis (2020 ed.) on 27 Apr. 2021 13:06 UTC (GMT) of OECD.Stat.[4] The automobile sector was defined as ISIC 29 (OECD, 2007).

The data analysis on empirical data from R&D projects related with AI funded by European Regional Development Fund (ERDF), between 2008 and 2020, in Portugal was performed, following the methodology of Boavida and Candeias (2021). Through this analysis, we gained a perception on AI technologies that are being applied and an indication on the investment done in AI in Portugal at the pilot level. It also enabled us to identify experts with specific AI cases in the automotive industry. This analysis was conducted through the application of search strings constructed based on core concepts associated with AI technologies used in manufacturing activities (algorithm, AI, augmented reality, automated decision-making, computational vision, ML, predictive analysis, robot) (Peres et al., 2020).

The most interesting findings resulted from the discussion around one R&D project and several other cases from current activities of the interviewees. The OEM is a foreign owned company, and in 2020, it had 5,282 workers, a turnover of €2,832 M and exported 99.4% of its production. Furthermore, the Tier 1 supplier is a Portuguese company, with subsidiaries in Germany, Mexico, and China, and in 2020, it had 143 workers (260 in 2021), a turnover of €13 M and exported 61% of its production. Finally, the Tier 2 supplier is a Portuguese company with logistic support centres in Germany, France and Spain, a plant in Mexico, and in 2020, it had 367 workers, a turnover of €25 M and exported 87% of its production. It was possible to identify several implications on productivity and employment from the demonstration of AI application cases in an automotive industry factory floor and in a components supplier. The cases considered for this study are shown in Table 1.

Some limitations are inherent to the approach used that should be taken in consideration when interpreting the research results. Interviews were planned to be done along with visits to the plants but due to COVID restrictions they were done only online. However, a communication platform was used (e.g., Zoom) allowing to also assess body language associated with the speech. Moreover, we also had access to some videos of the technologies working at the shopfloor.

Table 1 Automation application cases studied

Case number		*Description*
		System developer company to the automotive industry with several automation systems:
1A	a	Cobots for assembly and production line of an OEM.
1B	b	Automated glue bead inspection systems (computational vision and predictive analysis) on the glue bead dispensing and after the process, for all produced parts, automatically, at tailgates in an OEM.
1C	c	Computational vision system for quality inspection of zippers for the automotive industry, in a textile company.
		Components and accessories company to the automotive sector with several automation systems:
2A	a	Welding robotic cell
2B	b	Automated inspection system
2C	c	Cobots for production line

In our empirical research, it would be needed to reflect the view of labour organisations (unions and workers committees) on the same arguments. The debate on technology adoption, changing skills and labour productivity would have been richer. At present, we could only achieve interviews that mostly report the perspective of the technology or innovation managers, which have limitations that we want to overcome with further interviews. The unions acting in the automotive sector are not sufficiently engaged with the introduction of AI at the work processes and with the related policy debate. This has been clear with the documentation analysis.

Finally, evidence collected on productivity and employment from the interviews are based on the assessments of those individuals interviewed, rather than quantified statistics. These are qualitative assessments of very experience and knowledgeable leaders of the Portuguese automotive sector.

In the following pages, we present results based on the interviews done during 2021.

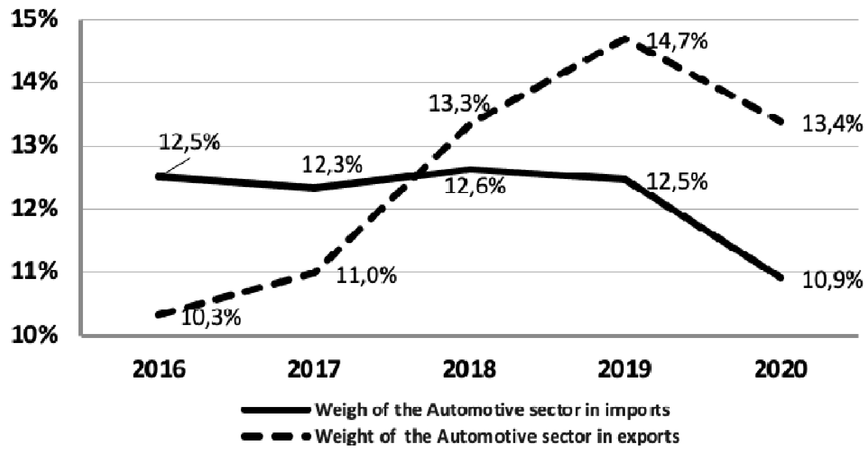
4 Results and discussion

4.1 Automotive sector in Portugal

In 2017, in Portugal, the automotive sector was composed by 70% of component and accessories manufacturers, 25% of manufacturing of bodywork, trailers, and semi-trailers companies and 5% of automotive manufacturing companies (INE – Sistema de contas integradas 2017). According to automotive business association ACEA, in Portugal in 2021, there are five big production units of OEM: Volkswagen AG (Volkswagen, Seat), Toyota Motor Europe (Hyace), Stellantis (Peugeot, Citroën), Daimler Group (Fuso) and Caetanobus (Caetano, Cobus).

In Figure 1, it can be observed that, between 2016 and 2019, the share of the automotive sector in exports as been increasing, and from 2018 onwards, it is higher than the share of this sector in imports. From 2019 onwards, because of the pandemic crisis, the automotive share, both in exports and imports, have decreased, though the share of this sector in exports remains higher than its share of imports contributing for a positive commercial balance.

Figure 1 Share of the automotive sector in commercial balance, between 2016 and 2020



Source: Author’s calculations based on Marques (2021)

Often, investment in automation, which can be both automation hardware (e.g., mechanical parts, and/or the electrical and electronic parts) and software (Vogel-Heuser et al., 2015) are made to perform upgrades in the manufacturing sector.

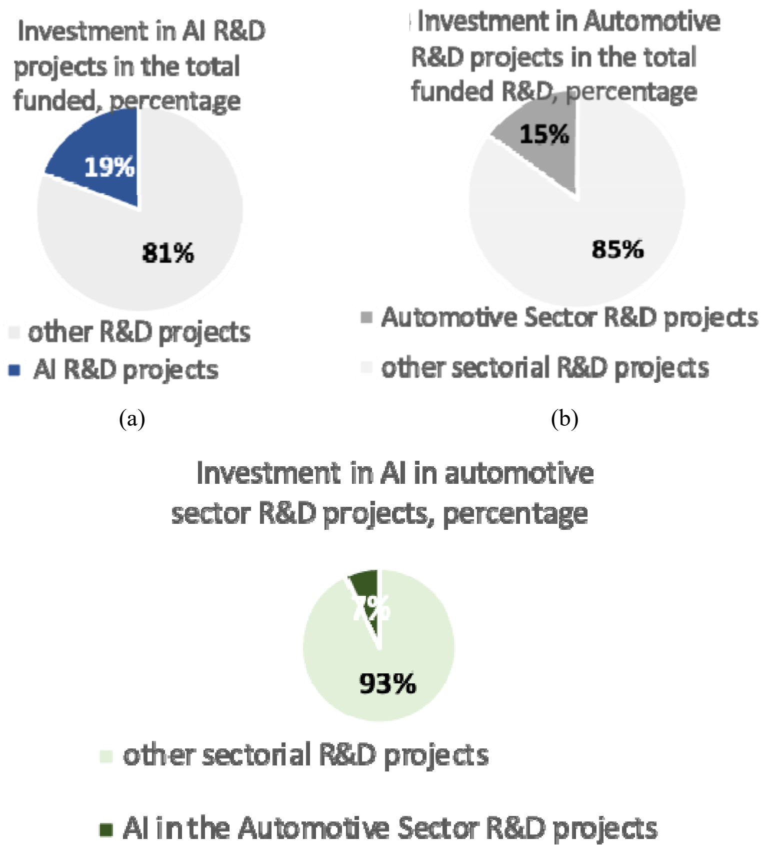
According to our calculations based on data from OECD STAN Industrial Analysis (2020), the GFCF in the Portuguese automotive industry increased significantly from 2010 to 2017, with an AAGR of 7.9% in this period. An observation in more detail shows two different tendencies in GFCF. From 2010 (€455 M) to 2013 (€256 M), there is a decrease in GFCF at an AAGR of –17%. In 2013, there is a shift in the investment on automation as, since then, the GFCF has been steadily increasing at an AAGR of 32% between 2013 and 2017 (OECD Statistic, 2020).

The share of GFCF invested in ICT equipment, software, and databases in the total GFCF is an indicator of AI investment, as mentioned above. This investment represents the efforts conducted to improve computational power applied in companies. Some of these investments are not necessary entailing AI, but once the available data provides that distinction (ICT and total GFCF), we can assume the ICT investment as a proxy for AI because it contains AI technologies present on the automation strategies in these companies.

In Portugal, the investment in ICT of the GFCF maintained steady from 2010 until 2015 on average €22 M. Afterwards, the investment grew significantly up to €36 M in 2017, which represents an annual average growth rate of 30.3% between 2015 and 2017. In 2017, investment in ICT accounted for 4.6% of the total investment made in the Portuguese automotive sector (OECD Statistic, 2020).

The increase investment observed in OECD statistics can also be seen in the empirical data from the Portuguese R&D projects’ database, funded by European Research and Development Funds (ERDF)[5], in the period of 2008 to 2020. This database includes several types of projects: research-oriented, industrial research-oriented pilots, and projects to mobilise R&D activities between companies and universities. From a total of 3,151 research and innovation projects, 543 are AI related projects, 275 are automotive sector projects and 50 are AI in the automotive sector projects. Figure 2 shows the share of investment on R&D projects.

Figure 2 Investments on Portuguese R&D projects funded by ERDF[1], in percentage, (a) investment in automotive R&D projects in the total funded R&D (b) investment in AI R&D projects in the total funded (c) investment in AI in automotive sector R&D projects (see online version for colours)



(c)

Note: [1]The ERDF is a European Union Public Fund, managed at national level, which aims to strengthen economic and social cohesion in the European Union by correcting imbalances between its regions: European Regional Development Fund 2014–2020 – Regional Policy – European Commission (europa.eu).

Source: Authors calculations on Portuguese R&D database funded by ERDF

As we can observe in Figure 2, only 19% of the investment in R&D projects was dedicated to AI R&D projects, and only 15% of investments in R&D projects funded were from the automotive sector. The value of the absolute expenditures on investment on AI related R&D projects in the automotive sector represented only 7% of all R&D investments in all sectors.

According to our calculations, 70% of AI in the automotive sector projects is industrial research-oriented ones. Nevertheless, the ability to extend those experiments to further standardised AI investment is not yet foreseeable. The investments in R&D in the Portuguese automotive sector, in the period from 2008 to 2020, was €518 M and around 43% of this investment (€225 M) was in AI related projects, by our calculations. We can conclude that, within the automotive sector, there is a large amount of R&D investment related to AI (43%). But, considering the whole amount of Portuguese R&D projects, the amount of AI projects applied to the automotive sector (50) and the amount of investment (7%) are rather low.

From 2008 to 2020, investment in AI projects in the Portuguese automotive sector has been growing with an annual average growth rate of 17%, by our calculations. This impressive growth still lacks an accurate explanation, but interviewees seem to be convinced that companies in Portugal understand the inevitability of adopting Industry 4.0 technologies if they want to be competitive and increase productivity.

In fact, in 2017, an initiative (Portuguese Industry 4.0, or I4.0), integrated in the National Strategy for the Digitisation of the Economy, with the aim to generate favourable conditions for the development and deployment of the new paradigm of the Digital Economy was launched. It was organised in two stages. Between 2017 and 2019, it focused on demonstration and mobilising human resources training, technological cooperation, creation of the 'Start-up I4.0', financing, investment support, internationalisation and legal and regulatory adaptation. While from 2019 to 2021, it intended to be transformative estimating that public and private investments would leverage the amount of 600 million euros over the two years, involve 20,000 companies in the various initiatives, train more than 200 thousand workers and finance more than 350 transforming projects. However, impact assessment of this policy has not yet been performed. Besides its awareness effect, it is not clear the relation between investment and training, and if there is any potential for new organisational concepts.

This information seems to be aligned with interviewees' statements about the awareness of companies on the importance of industrial transformation through digital technologies, which might explain the growth of investment in AI R&D projects. According to the executive manager of Case 1 which jointly develop projects in automation and AI, these technologies are a trend. His company has created a new business area around a solution developed in an industrial research project (Case 1B) that included computational vision and predictive analysis, as they perceived a strong expected demand from the market for these technologies.

Although a new business area was created to respond to the needs of the automotive sector, due to the COVID-19 pandemic, the company was faced with the need to diversify its markets. In this sense, the company is developing several contracted projects with other firms within the automotive sector value chain (exhaust pipes and zippers suppliers and OEM) and with the food industry. According to its CEO, the technological challenge associated with companies that are based on low intensive technology is in the information processing, in the decision making (AI) and in the integration with other systems.

In Case 2 (components and parts company), the head of technology department interviewed said that the investment in automation is mainly depending on the production volume and high-quality products, which is the case of the automotive sector.

We can conclude that the investment in automation, including AI technologies, is increasing and there is the general perception that Industry 4.0 technologies contribute to annual growth in productivity and competitiveness. Effects from these technologies can only be reflected in the economy if they advance from the pilot project to a broader adoption of the technology. However, adoption of technologies may be hindered by several factors such as, technical challenges, which means, problems on information processing, decision making, flexibility and systems integration. Moreover, the wide dissemination of these technologies might also be a challenge because of the different levels of modernisation at company level.

4.2 Productivity

We have already discussed GFCF investments and concluded that there has been an increase in automation, including AI, investments, and consequently, of capital productivity (AAGR 2010–2016: 7.9%). Those investments were not done on new factories or premises, but on new production lines, new automation equipment and ICT-based machinery [based on definitions of Galindo-Rueda and Verger (2016)]. Evidence from the interviews substantiates productivity increases due to investment in automation and AI technologies. As mentioned previously, GFCF investments can be understood as a proxy for automation. This understanding goes in parallel with the figures on growing employment, and growing productivity, which are consistent with the investment on new plants and facilities. From interviews and document analysis, we know that such investment includes the investment on new equipment, which for the sector, implies a significative share of automated systems and AI elements. So, the overall balance of the data makes clear the relation of GFCF with automation, which is true for the automotive sector, but not necessary to the whole manufacturing industry, as was concluded above.[6]

In Case 1B, the integration of an automated system, including an AI solution (applied to the quality inspection process at the automotive parts of the assembly line in an OEM), had resulted in an increase of process efficiency, improvement of product quality and reduced waste. This resulted in savings and contributed to an increase in productivity of the car manufacturer, as informed by the innovation manager.

In the Case 2B (components and parts company), only in high quality products, automation systems were implemented. For example, the quality inspection of parts is done by an automated system, which does the automatic rejection of the part, registers it in a database allowing efficiency, traceability and parts' remanufacturing leading to an increase in productivity and reduction of costs. Overall, this company has been experiencing productivity and reliability increases with the adoption of automation technologies which is important for competitiveness and winning future projects On the other hand, in Case 2A (welding robot cell) automation systems lack flexibility where a worker can fix an occurrence of the moment, stated the responsible for the technology department. In Case 2C, in response to an increase of production volume, the production line capacity and productivity had to be increased. The new process design and robots programming was done internally, and a new machine was acquired. This case was a success, as the company' head of maintenance department evaluated.

Labour productivity is measured as GDP per hour worked. It is one of the most widely used measures of productivity at country level. Productivity based on hours works better captures the use of the labour input than productivity based on numbers of persons employed (head counts) (OECD, 2019).

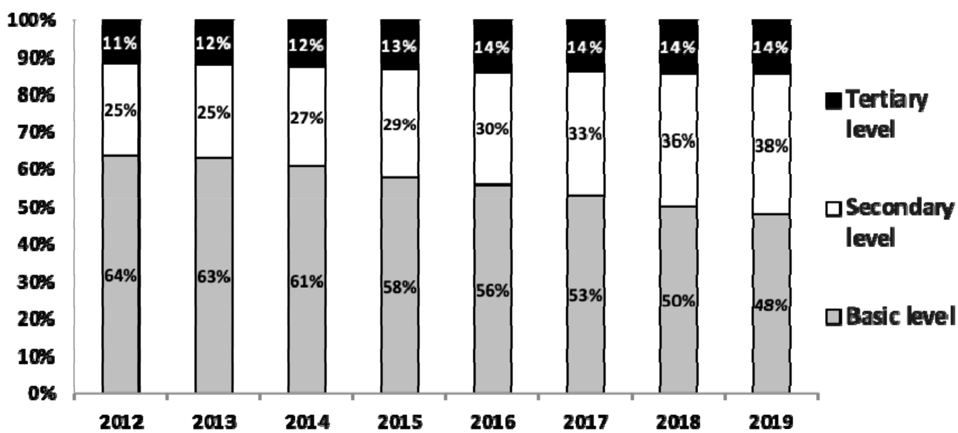
According to author's calculations based on data from OECD Statistics, Labour productivity in the Portuguese automotive industry increased from 2010 to 2016, at an AAGR of 4.3%. In 2016, labour productivity was significantly higher in Portugal than in Spain and close to the Slovak republic, France, and Belgium, to name a few countries comparable, referenceable and with available data.

In short, our hypothesis is that for the Portuguese automotive sector, improvements of productive capacity by automation efforts are the main reason for productivity increases in the sector since labour productivity grew annually on average lower than capital productivity (4.3% and 7.9%, respectively). The capital productivity can be represented with the above-mentioned investment of GFCF component on automation (a reflection on a recent modernisation process of industrial infrastructure), which allows such high rate of labour productivity.

4.3 Employment

A detailed analysis shows two different periods of development in the levels of employment. From 2008 until 2013, the employment levels in the automotive sector decreased at an annual average growth rate of –3%. From this year onwards, the employment levels started to rise in the automotive sector at an annual average growth rate of around 6%.

Figure 3 Variation of the weight of the schooling level of workers in the Portuguese automotive sector between 2012 and 2019

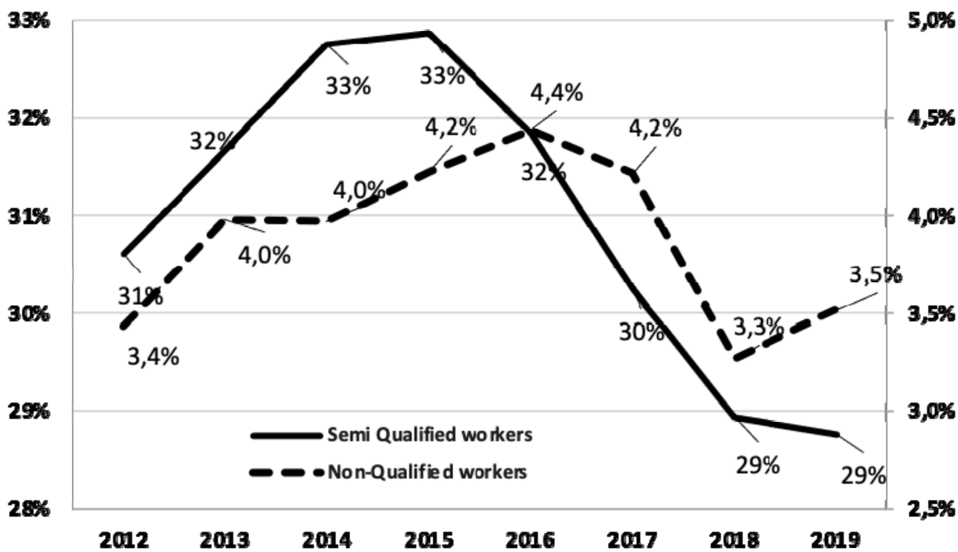


Source: Quadros de Pessoal (Quadro 36) 2012, 2013, 2014, 2015, 2016, 2017, 2018 and 2019, Ministry of Labour (MTSSS)

According to Figure 3, the schooling level in the automotive structure is gradually changing with time. It has moved from a workforce mainly with basic, compulsory school (elementary and primary school) to a workforce concentrated in the secondary school level (37%) with a slightly increase in the workforce that obtained a tertiary level degree (graduation – 10%, MSc – 2%) in 2019. The technology manager (Case 2) confirmed that this was the case in the company he works for. In this case, young workers usually have a good schooling level (secondary schooling level) due to the company's concern in hiring workers that have at least the secondary schooling level or vocational training, because they learn very fast. In Case 2C, when a productivity increase was needed, the design of the new process for the production line and robots' programming was done internally, with only one machine acquisition externally for which the operators received training. However, he also reported some difficulties in maintaining qualified personnel or hiring new employees.

At the same time, we can observe a decrease in the share of low-skilled employees in the employment structure of the Portuguese automotive sector, between 2012 and 2019. We have used only this indicator because the statistical definition for the classification of 'qualified and highly qualified' workers in the statistical database of the Ministry of Labour is not precise. Most workers classified as 'semi-skilled', become 'skilled' after few years of professional activity in a company. Even the training access to the level of qualification is vague. In all, they do not correspond to the levels used in EU used, for example, by CEDEFOP. Therefore, due to the classification of non-skilled and semi-skilled to be more precise, we can presume the variations based on the total volume of these groups. Results are presented in Figure 4 which clearly shows that the share of low skilled workers in the automotive sector tends to decrease in the last five years. That happens even when the semi-skilled workers represented almost 1/3 of the total number of employees.

Figure 4 Variation of the weight of low qualified workers in the employment structure of the Portuguese automotive sector, between 2012 and 2019



Source: Quadros de Pessoal 2012, 2013, 2014, 2015, 2016, 207, 2018 and 2019, Ministry of Labour (MTSSS)

As we have mentioned, the volume of employment in the sector is increasing. But considering the recent trend shown here, the job entry is done mostly at higher levels of qualification. In this group, and for 2019, we count 43% classified as 'skilled workers', 8% as 'highly skilled', 'team leaders' 5%, managers 6%, for a total employment in the sector of more than 47 thousand employees. Although a decrease can be observed (Figure 4) in absolute figures is still a large number of low skilled workers at companies.

This situation seems to be preventing the adoption of AI systems in some companies as shared by the general manager of Case 1 (ICT technology supplier and Tier 1) “Companies want to invest in new solutions, but they do not have people with knowledge/skills to work with the new systems (in their workforce or in the market). Or even if they have one or two people and they get training, there is always a set of unforeseen events (illness, change of job, retirement, etc.) that can affect availability and access to knowledge/skills” (Boavida and Candeias, 2021).

Employment in the Portuguese automotive sector has grown significantly in the period 2013–2017, suggesting that although automation technologies were adopted, they did not affect employment. According to the technology manager (Case 2), although automation investments have reduced the number of workers by individual cells, due to productivity and competitiveness increases, the company was generating more business which increased the number of cells, and thus, overall, the number of workers needed. In fact, before the health pandemic crisis, the company was increasing its workforce due to the high number of contracts. In Case 1A, the final assembly is one of the four large areas in a car manufacturing factory (OEM) which allocates around 80% of the human resources, according to the general manager, thus being the area where is more attractive to invest in automation and AI technologies. Furthermore, he added that “contrary to what one might think, it is not a question of people going out of work, but rather the difficulty to attract and retain people to do the final assembly tasks. (…) Tasks performed by workers in the final assembly lines of car manufacturing are boring, repetitive, and physically demanding.” In this sense, the motivation for investments in automation for car assembly lines is linked to the lack of workers to perform physically intensive work and repetitive tasks (Pettersen, 2019).

According to Case 1A, human-machine collaboration is currently used in the final assembly of the OEM. In this case, the innovation manager stated that “the quality inspection has to be done by a human-machine system in the final assembly, where all the characteristics are inspected before the car is released. Currently, technological limitations related with robot’s limited time cycle prevent this task to be done by the robot alone and so human-machine collaboration is used to perform this task.”

In the Case 1C (zippers supplier of the automotive sector), due to the complexity of the requirements to be inspected, automated artificial vision systems are an added value because they can perform a quality assessment more efficiently than humans. Still, human presence continues to be necessary though in other tasks of the process (as indicated by the innovation manager). When large quantities of data need to be processed, AI and specifically ML, can be a solution. It allows to identify defects that are not visible to the naked eye and are presented too fast to operator’s perception, to be consistent in the decision about non-conformity and increase product quality. Evidence from the interviews seem to indicate that these systems, in essence, assist operators as they manage to make a detailed analysis, more adequate to the objectives of the task, increasing the efficiency of the process.

According to Case 1B, the solution developed there is completely automated. It is characterised to detect the most typical defects in glue beads and to do automatic diagnosis of the equipment status through historic data processing and automated correction of the correctable bead defects. However, although the system can complete its tasks by itself it still needs human intervention to add any additional features or to solve any obstruction that may arise in the production line (as indicated by the innovation manager). In Case 1A (collaborative robots), where there is human-machine interaction to pick-and-place parts, the human presence is essential. “In case the parts are inaccessible because, for example, they came from logistics in a wrong position and the robot cannot perform its function, the operator must stop the line, put the part in the correct position, and start the line again”, as is referred by the innovation manager of the Case 1.

Thus, it seems that the sector is experiencing changes in work organisation. Potentially, it is possible to verify a major displacement of the more qualified operators to conduct control and to perform machine supervision tasks.

In conclusion, according to interviewees, computer vision, human-machine interaction, and predictive analysis are changing the operator’s tasks but are not resulting in dismissal of workers from the companies. In some tasks, efficiency is higher with technology than with humans, but there are still perceived technological, work organisation and skills limitations that restraint this transition to happen. Companies are aware of the need for digital transformation of their processes but, despite being more open to adopting these technologies, they are faced with the lack of available of human resources, skills and/or access to knowledge.

Interviewees’ expectations about the implications on productivity and employment of AI adoption in the automotive industry revealed that it will take still some time due to technical, management and workforce skills challenges. As El-Haouzi et al. (2021) mention, “the development and use of social interaction between objects and humans could today be envisioned as a key enabler of the extension of the paradigms of CPS and IoT to human beings in industry.” And Moniz and Krings (2016) mention that the application of new automated systems in the manufacturing shop-floor level is widely undertaken without the reference of ‘real’ social implications (or ‘skill challenge’, in the words of our interviewee).

In fact, these ‘skill challenges’ are verified due to the cognitive and perceptual workload for the automated systems operators, especially at the complex and automated working systems. There, the social dimension is currently defined by system developers with the focus on the issues of security, and eventually, qualification. However, the social dimension remains in a limbo regarding the technical debate about interaction systems (Moniz and Krings, 2016).

Therefore, the expectation is not for automation to replace workers but augment their capacity to perform their tasks and/or alleviate burden, in the short time. Robotics, automation, and computational vision will have widespread adoption in one to two years. However, cloud, plug and produce, blockchain and AI will take longer to be implemented as they involve connectivity, monitoring, data collection and automated decision making with implications at management level, as was indicated by the Case 1 innovation manager during the interview.

The transfer of automation technologies to other less technology intensive sectors faces additional challenges related to labour costs. The decision to adopt a technology has two main drivers: savings in terms of labour costs (reduction of workers health problems, labour relocation, or dismissal) and gains in productivity and efficiency. But these should have a return of investment (ROI) high enough in a short-term to be worth to be applied. However, decisions are mostly made to follow technical requisites, mainly imposed by the OEM to the suppliers. That would have a consequence of lower ROI, and even problems to manage the human resources in a balanced way.

5 Labour relations in the Portuguese automotive sector

At the national level, trade union's density is down from 21.7% in 2004 to 16.3% in 2016, according to ILO (2018a). Portugal has a significantly low level of employees reporting the existence of a trade union, works council or similar body (Eurofound, 2018, 2019). Collective bargaining coverage is low and declining from 80.2% in 2004 to 72.3% in 2015. Trade unions are not particularly strong in the automobile sectors. This may lead to non-negotiated modernisation processes. This information and the following are collected from secondary data, and interviews from previous research done by the authors.

The current generational change within these organisations is opening new horizons for cooperation, according to Naumann (2017). For example, some important negotiations on working hours were successfully achieved. But the financial crisis and the Memorandum of Understanding with the Troika (2011–2014) resulted in a deep and still existing crisis in collective bargaining (Naumann, 2017).

The main social dialogue institution is the Economic and Social Council (Conselho Económico e Social – CES).[7] The council includes the only organisation with a tripartite composition, named the Standing Committee on Social Concertation (CPCS). The main purpose of CPCS is to promote social dialogue and consultation with a view to concluding agreements with these partners. The list of matters discussed includes public policies for employment, vocational training, social security, taxation, and public administration, among others.

The CPCS is not very prolific in reaching agreements. In fact, since 2012, the committee produced only five agreements, with a relatively small impact in labour relations. The tripartite social dialogue in Portugal was challenged during the crisis, but the tripartite institutions played an important role in revitalising it afterwards (ILO, 2018b).

According to the Portuguese Ministry of Labour, there are 11 collective bargaining agreements (CCT) and one company agreement (AE) established for the automobile sector.[8] This AE was established between the company Fico Cables and the trade union National Union of Industry and Energy (SINDEL). The other CCT were established mostly with the Industrial Association of Metal Sector (AIMMAP) and National Association of Electric and Electronic Industries (ANIMEE), among others, with the Union Federation of Metal (FENAME), the mentioned SINDEL, the Metal Union, and the Union Federation of Industry and Services (FETESE). Most of those agreements were established to focus on salaries and working conditions.

In terms of labour relations at company level, we have detected two emergent major models: one, a near 'German model', and the other, a near 'Japanese model'. The case of company Volkswagen AutoEuropa is single in Portugal, once the workers council is involved in the decision processes, following the German model of labour relations. In the electronics sector, the Bosch case in Portugal approaches this model as well. The other case is the one of CaetanoBus and Mitsubishi Fuso which still has partial influence of the Japanese labour relations model, where the workers involvement is done in the quality management processes (Machado and Moniz, 2003, 2005). Some results of the interviews made some years ago can be still confirmed by further document analysis on these case studies.[9]

It is in this context that recently the government issued a new document that would focus on the digitalisation process and its effects on the manufacturing sectors. Main goal of the Portuguese *Green Book on the Future of Work* (issued by the Ministry of Labour in 2021) is to be a tool that can be helpful to transform the uncertainties related to the future of work into new opportunities on the labour market, regarding skills and productivity, working conditions and salaries, remote work, the stability of jobs, equality, and social protection. However, the discussions on the new employment forms are only associated with remote work, telework and digital labour platforms.

In this *Green Book*, almost nothing is proposed about the digitalisation of work in the manufacturing industries. In fact, many robots have been recently introduced, especially in the automotive industry, but its implications are not tackled after a strong digitalisation process has been recently introduced in the shopfloor in these companies.

On the recommendations, the book mentioned that algorithms should be regulated, especially in terms of their impact in the labour relations system. It is also mentioned the need for further legislation on 'autonomous behaviour of AI'. But until now, no further legislation has been proposed or even approved on this. Besides this, social partners have no concrete proposals on the process of digitalisation impact on employment, except the need for further training.

On the other hand, recently, the ILO (2021) Technical Meeting on the Future of Work in the Automotive Industry approved a very significant number of conclusions. It was recognised that "technological advances, climate change, demographic shifts, new consumer preferences and mobility concepts, and a transformative era of globalization are rapidly changing the organization of production and work in the industry" (Conclusion no. 3).

The main challenges were identified. It was underlined as well that the:

> "Demand for workers with both technical and core work skills to drive innovation, productivity and sustainability in the industry is increasing. Investments in education, training, quality apprenticeship schemes, up- and reskilling and lifelong learning are urgently needed to retain skills, safeguard existing jobs, respond to the need of the industry and ensure that all workers, inter alia young women and men as well as older workers, can take advantage of future opportunities in the industry or elsewhere." (Conclusion no. 7)

There were also considerations about labour relations. A conclusion from this technical meeting (the No. 19) was "social dialogue, based on respect for freedom of association and the effective recognition of the right to collective bargaining, has a crucial role in designing policies to promote social justice. It is a means to achieve social and economic progress. Social dialogue and tripartism are essential for democracy and good governance." Thus, some of the main premises to understand the limits and challenges of the automotive industry in the next years were identified. The role of labour relations was clearly defined.

The approved text by all social partners and government representatives also formulate the following: the governments, employers' and workers' organisations should:

> "Jointly engage in formulating and implementing coherent and comprehensive economic, trade, fiscal, education and sustainable industrial policies, incentives and actions, in accordance with national law and practice, to:
>
> 1 create an enabling environment for entrepreneurship, increased productivity and for sustainable enterprises of all sizes to grow and generate decent and productive work;

2 improve working conditions and safety and health at work and extend social protection to all workers to promote decent work; and

3 facilitate a just transition to a future of work that contributes to sustainable development in its economic, social and environmental dimensions." (Conclusion 20)

This new agreement at the ILO level for the automobile sector will have an impact on the industrial relations in Portugal. But the available policy tools still did not reflect such achievements. Employer associations, union federations and government are still far from the elements of such international agreement topics. Usually, the collective agreements are directed towards salaries, working time regulation and occupational definitions.

The Portuguese social partners have no concrete proposals on the process of digitalisation and its impact on employment, except the need for further training. New legislation on digitalisation of work is not expected to be negotiated. In the public debate, there is a wide consensus that algorithms should be regulated. This eventually may happen as translation from the European legislation.

Finally, as nothing was proposed by the government about the digitalisation of manufacturing, even after many robots have been introduced, new legislation is not expected to be introduced soon. The public pressure is not high once there are no statistics on the number of operating robots, and social partners are focused on the classic themes for negotiation, as mentioned above. In the same direction, we can conclude that further legislation on autonomous behaviour of AI, although necessary, is not expected.

6 Preliminary outcomes

This paper gives a closer overview at the company level of ways in which work is being redefined and what the future expectations are around the implications of automation and AI in the Portuguese automotive sector. Findings suggest that employment has not been affected with recent automation trends in Portugal. In fact, before the COVID-19 crisis, the automotive sector was growing, and tendency was to increase its workforce.

Our results also indicate that productivity increases are mainly due to capital investments (proxy for automation, including AI). Although automation affects productivity in a positive way, it requires an adequate infrastructure to integrate automation technologies and skilled workers to operate it. The impact of these increases should be assessed by workers representatives, but until now there are no clear statements and positions on this topic. As mentioned, further interviews will be done.

AI has further challenges such as technological limitations and need for specific knowledge associated with the development, understanding and recompute new algorithms, control of the AI system and production, immateriality of software and increase complexity at management level, among others. However, schooling level of the employment structure in the Portuguese automotive sector is gradually changing. Thus, more adapted to the requirements of automation technologies, including AI. A reduction of the weight of low qualified workers in the employment structure in the Portuguese automotive sector is also indicating that skilled workers are better prepared to deal with these technologies. If this impacts on the action of social partners, is not yet clear.

The motivation for investments in automation and AI seem to be linked to the lack of workers to perform physically intensive and/or repetitive tasks. Technological challenges remain to be solved though some research and innovation projects are advancing in finding solutions. Therefore, in a short to medium term, automation will not replace workers but augment their capacity to perform their tasks and alleviate their burden. Further studies on the needs for organisational developments and qualification processes have not been done recently for the sector. This lower level of intensification of automation has implications mainly in the organisation of work and may imply job displacement. However, unions are not aware of such trend. In a semi-peripheral country of the OEM, where salaries are low, the technology costs may not be able to compete with labour costs resulting in a delay of industrial transformation unless large production volumes or high-quality products are needed.

We also verified that social partners have no concrete proposals on the process of digitalisation and its impact on employment, except the need for further training. New legislation on digitalisation of work is not expected to be negotiated. In the public debate, there is a wide consensus that algorithms should be regulated. This eventually may happen as translation from the European legislation.

In conclusion, the expectation of recent automation trend, including AI, in Portugal is an increase in productivity and an increase in complexity of the technological apparatus and in management by companies. The intensification of the dependency on new automation and AI artefacts, calls for preparation of the company to deal with technical problems, maintenance, health and safety, and security regarding its investment. Evidence suggests that automation can have widespread adoption in the short-term, but AI technologies are still in their initial phase of implementation and will take more time to be adopted. In an automation or AI project designed to improve productivity, it should be taken into consideration the developments in work organisation, otherwise the projects can have limited implementation and be postponed (or forgotten).

During this research work, some limitations were found regarding interviewees' perception of differences between automation and AI in the production process. Further research can compare the results that were found for this sector with more empirical evidence of other sectors where algorithms can play a stronger role on the design of workplaces or even on the employment structure.

Acknowledgements

This research was partially funded by Santander-Nova 2020 Collaborative Research Award and Portuguese national funds through Foundation for Science and Technology (FCT), I.P., within the scope of the project 'UIDB/04647/2020' of Interdisciplinary Centre of Social Sciences of Nova University of Lisbon – CICS.NOVA.

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Notes

1 https://www.nasa.gov/pdf/458490main_TRL_Definitions.pdf.

2 *Project Deep View* (https://www.deepview-eu.org/).

3 *Project CrowdWork21* (https://crowd-work.eu/).

4 Available on https://stats.oecd.org/Index.aspx?DataSetCode=STANI4_2020.

5 The ERDF is a European Union Public Fund, managed at national level, which aims to strengthen economic and social cohesion in the European Union by correcting imbalances between its regions: European Regional Development Fund 2014–2020 – Regional Policy – European Commission (europa.eu).

6 See also the information produced by the National Agency for Innovation at https://www.ani.pt/media/4902/industria_40_mini_report_26-11-2019.pdf.

7 The Economic and Social Council is a constitutional body for consultation and social agreement between the government, the social partners and other representatives of organised civil society. It aims to promote the participation of economic and social agents in the decision-making processes of sovereign bodies in socio-economic matters.

8 https://www.dgert.gov.pt/ferramenta-para-pesquisa-de-convencoes-coletivas#irct_form (5 September 2021).

9 https://expresso.pt/economia/2021-12-17-Mitsubishi-Fuso-do-Tramagal-vai-buscar-novo-presidente-ao-Japao-d74adf99.

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