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Article

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THE NEW SOCIOPOLITICAL AND ECONOMIC DYNAMICS OF DIGITALISATION AND AUTOMATION IN ROMANIA'S AUTOMOTIVE INDUSTRY

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Abstract

The Fourth Industrial Revolution, characterised by the convergence of digital, biological, and physical innovations, is fundamentally transforming industries, economies, and the very fabric of society. This study focusses on the Romanian automotive industry - a sector at the forefront of technological disruption, examining the impact of digitalisation and automation (D&A) on the labour market and the broader societal implications. First, this research examines the perceptions and experiences of employees and trade union representatives within this industry, addressing critical issues such as changes in working conditions, job security, workload, and workplace safety. Second, this study discusses how these firm-level changes in D&A inform the emerging political economy of digitalisation in Romania, with a special emphasis on the ongoing debate between liberalism and statism. The research is based on the analysis of secondary sources, as well as the analysis and interpretation of valuable primary data collected through the semi-structured interview method, explored in depth with the help of latent content analysis. The findings of this study indicate a predominantly positive perception of D&A implementation, but are accompanied by several challenges, especially changes in working conditions and the

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nature of managerial work. Findings offer insights into the intersection of technological progress and sociopolitical dynamics and highlight the need for innovative, well-targeted public policies to manage these transformations, such as industrial, labour market, and continuing education policies, also inviting us to imagine a new social economy of advanced technological progress in the context of the Fourth Industrial Revolution.

Keywords: digitalisation, automation, labour market, technology, sociopolitical economic systems, automotive industry

JEL Classification: O33, P16, J23, J24

Introduction

The dawn of the Fourth Industrial Revolution, characterised by the fusion of digital, biological, and physical innovations, has ushered in an era of unprecedented technological advancement, bringing society in the face of a much feared 'robotic brutality' (Prainsack, 2020, p. 439). This technological leap forward, in which digitalisation and automation (D&A) play a significant role, is reshaping industries and economies, also altering fundamentally the fabric of society, the welfare state, and, on the overall, socioeconomic and political systems. This conjecture has inspired, starting with the 2000s, a buoyant scientific literature on the relation between technology and socioeconomic and political transformations (Eichhorst et al., 2020; Bryan and Williams, 2021; Busemeyer et al., 2022; Collington, 2022; Acemoglu, 2023; Bucur and Rus, 2024). Based on theoretical ground, these advancements are also revitalising the age-old debate between liberalism and statism, a tension that has long been a central theme in political and economic discourse. This central dilemma has resurfaced with renewed vigour and complexity in the policy arena and in research (Azoulay et al., 2019; Ridley, 2020; Busemeyer et al., 2022; Acemoglu, 2023). This debate is particularly pertinent in Europe, where the tradition of social democracy often stands in contrast to more liberal market-oriented approaches and where there is an increased social investment, although to different degrees for the member states (Busemeyer et al., 2022). If until recently technology was not the main catalyst of welfare regimes, now a new political economy of digitalisation and a new economy of the welfare state are silently emerging (Eichhorst et al., 2020; Ridley, 2020; Collington, 2022). Still, despite the research 'enthusiasm' for these perspectives, the logic of the digital economy, its future zeitgeist, social contract, and policy instruments remain rather unclear (Collington, 2022; Busemeyer et al., 2022) in worldwide social sciences, including Romania, in which this type of scientific preoccupation is limited and fragmented. In this context, this study addresses these research gaps by providing an in-depth analysis of the impact of emerging technologies, specifically D&A, on sociopolitical and economic systems, with a focus on the labour market in the automotive industry, currently at the forefront of technological disruption.

This research addresses a significant gap in the academic literature on the impact of digitalisation and automation (D&A) on the workforce in the automotive industry by focussing on the employees and union leaders from a local context (Romania), a dimension not explored in existing research. Although several previous studies (Türkes et al., 2019; Cséfalvay, 2020) have analysed the general implications of D&A on the workforce, these do not provide a detailed understanding of individual-level dynamics, such as the specific collaborative attitudes of production line employees or contextual union strategies.

Furthermore, they do not address the implications of D&A on sociopolitical and economic systems, focusing mostly on the point effects of emerging technologies. This gap is concerning given the industry's important role in the national economy and labour market. The limited exploration of D&A's implications in Romania, coupled with the challenges of implementing European social protection policies, highlights the need for more comprehensive research. This study makes a valuable contribution by identifying unique aspects, such as the pressure of digitised work pace, the redefinition of supervision through advanced technologies, and the integration of reluctant employees. This level of granularity, in combination with local empirical data, expands theoretical and practical discussions about how D&A shapes working conditions and provides new directions for policies for the equitable deployment of technologies.

In this context, this study aims to examine how D&A changes can inform the new political economy of digitalisation in Romania, with a particular focus on revisiting the liberalism versus statism dilemma. The degree of novelty and originality of the article is particularly given by two essential dimensions of our research. First, we explored the effects of D&A as perceived by employees in the automotive industry, who are among the most affected stakeholders by technological change. This research direction focused on changes in working conditions, job losses, workload, and work safety. Second, the research proposes a scientific reflection on the intersection between D&A effects and sociopolitical and economic organisation, with an emphasis on re-discussing the classic liberalism-statism dilemma. The achievement of these research objectives is based, from a methodological point of view, on the collection of primary data through semi-structured interviews conducted with 21 employees, both in management and execution positions, some of them trade union representatives, from two large manufacturers ('Prod. 1', 'Prod. 2') and a component supplier company ('Supplier') from the automotive sector in Romania. The interviews were carried out in the context of the European funded project BARMETAL (Digitalisation, Automatisation, and Decarbonisation: Opportunity for Strengthening Collective Bargaining in the Metal Sector) implemented by the Bucharest University of Economic Studies in the period 2022-2024. Data analysis and interpretation were conducted within the framework of pluralistic economic thought, using a qualitative research methodology to explore participants' perceptions and reflect on the impact of D&A on socio-political and economic systems.

Next, the study presents the current state of knowledge and the research methodological framework, followed by the exposition and interpretation of the scientific results regarding the perceived effects of D&A, with an emphasis on exploring how these influence contemporary sociopolitical and economic systems, thus revitalising the dilemma classic liberalism – statism. The concluding section suggests both the need and some of the possibilities for a new social economy of advanced technological progress capable of meeting the current challenges posed by D&A.

1. Literature review

The relationship of sociopolitical and economic systems with technology began to be explored in the scientific literature starting in the 2000s, as researchers increasingly recognised the significant impact that technological advancements, particularly in digitalisation and automation (D&A), can have on economic structures, labour markets, and

governance. This body of work has expanded to examine how these technologies reshape power dynamics, influence policy decisions, and drive socioeconomic inequalities, highlighting the complex relationship between technological innovation and societal change (see, for example, Bussemeyer et al., 2022; Tinmaz and Fanea-Ivanovici, 2023).

Currently, production jobs are particularly at risk due to automation and the use of robots in factories. However, the services sector is also undergoing significant changes as new software products are introduced (Acemoglu and Restrepo, 2019). Additionally, D&A are driving an increased demand for high qualifications and digital skills (The Council of the European Union, 2023). At the same time, the demand for nonautomated jobs is increasing, with new employment opportunities emerging (Acemoglu and Restrepo, 2018, 2019). In this context, technological progress has come to exert a powerful influence on income distribution, monetary, and social inequality, and consequently, on redistribution policies and social intervention (Prettner and Strulik, 2020; Bryan and Williams, 2021; Acemoglu, 2023).

The social protection system and social dialogue are important instruments for reducing job polarisation, traditionally part of the architecture of many European welfare states. For example, recent European legislation (such as Directive (EU) 2019/1152 on Transparent and Predictable Working Conditions in the European Union) supports the revival of the tradition of labour relations and social dialogue, with the final goal of providing improved social protection (European Union, 2019). Several authors (Prainsack, 2020; Bussemeyer et al., 2022) have urged for novel and better articulated social and legal norms and institutions adapted to emerging technological changes, such as policies for the labour market, training, education, and welfare (Eichhorst et al., 2020).

However, these policies must be informed by empirical evidence. At the European level, several programmes are already in practice to address the challenges posed by Industry 4.0 and support workers' adaptation to technological change, including in the automotive sector. D&A effects are especially pronounced in the labour markets and at the firm level, affecting the employees. The effects on the labour market are mainly generated by the fact that D&A increase capital and labour productivity, also changing their allocation to production. At the company level, these effects could materialise in productivity gains and improved financial results (Acciarini et al., 2022). Still, many other complex changes are affecting both individual actors and holistically the entire market, such as a massive transformation in the nature of work. In this sense, changes in important business functions, such as management and control, were signalled in the direction of 'intensification' of managerial work, the use of linear control methods, and digitalised data (Bonekamp and Sure, 2015). In some cases, data on workers' productivity are provided directly by different gadgets worn by workers at work, which monitor in real time their actions and performances, suggesting the risks of operating a 'superpanopticon' (Poster, 1990) designed for permanent surveillance. Intensified supervision leads to a decrease in worker control and autonomy (Moore et al., 2017; Crouch, 2018). In general, some effects of D&A at the company level have been viewed positively, including increased interdepartmental and interdisciplinary teamwork, greater flexibility at work, improved employee well-being, enhanced teleworking options, better work-life balance, and more efficient communication (Bonekamp and Sure, 2015; Jasova and Kaderabkova, 2021).

However, other effects have also been perceived negatively, such as precarious employment, low social protection, alienation of workers, and unauthorised data usage (Acciarini et al., 2022). Other changes impacting employees, companies, and markets relate

to workers' competencies and job polarisation (Cetrulo et al., 2023). Job polarisation typically occurs between those in medium-skilled occupations and those in low-skilled jobs, which are more susceptible to automation (Balsmeier and Woerter, 2019; Eichhorst et al., 2020). For the automotive industry, various socioeconomic effects of digitalisation and automation (D&A) have been identified, including impacts on employment, particularly an increased demand for a skilled and educated labour force (Cetrulo et al., 2023). Advanced production technologies replace manual work in preparatory tasks, such as welding and mechanical activities. At the same time, new occupations, especially in ICT and engineering, orientated toward fostering innovation, are created in the sector.

The existing literature investigating the effects of D&A in the context of Romania is highly fragmented, dealing, for example, with the digitalisation of public services and administration (Panait and Rădoi, 2021; Popescu et al., 2023) or the effects of D&A at company level (Iliescu, 2020; Szentesi et al., 2021; Pînzaru et al., 2022; Stoica et al., 2022). Regarding the research on the adoption of new technologies in the automotive sector in Romania, the existing studies are still few (for example, Türkeş et al., 2019 or Cséfalvay, 2020), and these do not address the effects of D&A on sociopolitical and economic systems. Türkeş et al. (2019), for example, surveyed the opinions of managers of small and medium sized companies in Romania regarding technology in the automotive sector. They found that managers had a high level of knowledge of the requirements of advanced technologies and the willingness to use such technology. However, barriers such as limited resources, insufficient manpower, and the pressures derived from continuous employee education impeded the adoption of new technologies. Cséfalvay (2020) pointed out that in Central and Eastern European countries, including Romania, industrial robots are used in a less sophisticated manner. Especially used in production, robots are concentrated in the automotive sector, performing less innovative assembly operations. The relatively high use of robots in the mentioned region depends on the results of localisation strategies of Western companies, as is also the case of their business strategies (Guga, 2023).

The scarcity in the field contrasts with the social and economic importance of the Romanian automotive sector, which occupies a central role in the Romanian economy. Manufacturing and trade in the automotive industry are estimated to contribute 28% to the Romanian gross domestic product and 26% to Romanian exports (Ernst, 2022; Popescu and Ion, 2024). In 2023, the sector employed 5.8 % of the Romanian labour force, which is equivalent to 163,000 workers, according to Eurostat (2024).

An articulated academic reflection on the intersection between emerging technologies and sociopolitical and economic organisation has been missing from the academic debate in Romania. Similarly, consistent and dedicated public debate or programmes addressing the specific changes produced by technological advancement in the automotive sector are currently absent (Guga, 2023). The Romanian welfare state mainly shares the characteristics of the Central and Eastern European model of welfare, based on a reduced public financial capacity, lower social protection, and lower democratic participation (Alexopoulou et al., 2022). After the fall of the communist regime, the Romanian welfare state has undergone deep and abrupt transformations, mostly marked by a pronounced neoliberal orientation, complemented, however, by well-defined, still under-financed, social, and redistributive policies. From this ‘dualised welfare system’ (Raţ et al., 2019), mixed results have emerged, both in terms of economic achievement and social protection.

Furthermore, there are difficulties in reducing poverty and inequality and providing effective social protection to vulnerable categories (Ban, 2016; Raț et al., 2019). At the European level, European policies also reflect a hybrid approach that combines elements of both liberal market principles and state intervention, suggesting a general shift in the direction of increasing social investment, as discussed by the scholarly literature (Ridley, 2020; Eichhorst et al., 2020; Collington, 2022). Also, these measures illustrate a changing role of the state toward maximising employability and productivity, meanwhile, providing ex ante support to workers, rather than ex post (Eichhorst et al., 2020). In this context, this discussion emphasises the need for a more comprehensive understanding of how technological progress influences the broader sociopolitical and economic systems, particularly in crucial sectors like automotive manufacturing.

2. Research methodology

The main objective of the research is to analyse the impact of digitalisation and automation (D&A) on sociopolitical and economic systems, with a special focus on the labour market in the automotive industry in Romania. The research aims to provide a deep understanding of how these emerging technologies influence economic structures, working conditions, job security, and sociopolitical dynamics in the context of the automotive industry. The research also aims to explore the dilemma between liberalism and statism within the new political economy of automation.

This study uses an inductive reasoning and qualitative research methodology, since it allows for a detailed exploration of the perceptions and experiences of stakeholders in the automotive industry, in our case, automotive industry employees. Inductive reasoning is a method of evaluating qualitative data that is driven by a set of empirical observations to be analysed with the objective of identifying theoretical patterns. Research begins with a topic and lets data guide theory development. The main purpose of the inductive method is to allow research findings to emerge from primary data without being constrained by formal methodologies (Thomas, 2006). Using qualitative research allows us to explore in depth the complex nuances of personal perceptions and experiences regarding sensitive aspects of D&A in the automotive industry, as suggested by various authors (Grosso et al., 2021; Acciarini et al., 2022). Also, a qualitative approach allows us to contextualise the changes related to D&A according to the specifics of the Romanian automotive industry, in the context where the economic, political, and social conditions significantly influence the way in which D&A are implemented and perceived.

The method of semi-structured interviews is recognised as a flexible and adaptable technique to obtain in-depth information about respondents' perspectives and experiences of the respondents. It combines rigid structural elements (predefined questions) with the flexibility to explore emerging topics during the discussion (Patton, 2002; Kvale and Brinkmann, 2009; Bryman, 2016). In this study, the interview guide included predefined questions to cover key themes (e.g., employee perceptions of D&A, changes in working conditions), but also allowed flexibility to explore emerging topics, such as perceived pressure in the context of digitalised pace of work. This approach ensured the collection of rich and nuanced data, according to the methodological recommendations in the specialised literature. The interview guide was provided by the coordinator of the consortium of

institutions where the research was carried out and was based on the conceptual framework developed previously, within the BARMETAL research project.

The first stage of the research involved extensive documentation related to the sociopolitical and economic context of the Romanian automotive industry, as well as current trends in D&A, analysing automotive industry reports, academic studies, European and national legislation, and official statistics. In the second stage, primary data was collected through semi-structured interviews with 21 executive and managerial employees, some of whom were union representatives, from two car manufacturers (hereafter referred to as ‘Prod. 1’ and ‘Prod. 2’) and an automotive component supplier company (hereafter referred to as ‘Supplier’). Data were collected between February and October 2023. The demographic profile of the respondents can be found in Table no. 1.

Table no. 1. Respondents’ demographic data

Respondent code	Company	Function	Trade union member	Gender (M/F)	Age (years)	Education
R1	Supplier	General Director	No	M	55	Higher education
R2	Supplier	Technical Director	No	M	36	Higher education
R3	Supplier	Milling machine operator	No	M	37	Secondary education/post-secondary
R4	Supplier	Machine operator	No	M	30	Higher education
R5	Prod. 1	Production line operator	Yes	M	40	Secondary education/post-secondary
R6	Prod. 1	Quality controller	Yes	M	28	Secondary education/post-secondary
R7	Prod. 1	Responsible with technical and equipment check	Yes	M	42	Higher education
R8	Prod. 1	Basic logistic operator	Yes	F	36	Higher education
R9	Prod. 1	Senior analyst business applications and programme development	Yes	F	57	Higher education
R10	Prod. 1	Quality engineer	Yes	F	60	Higher education
R11	Prod. 1	Camera control operator	Yes	F	58	Secondary education/post-secondary
R12	Prod. 1	Logistics operator	Yes	F	30	Secondary education/post-secondary
R13	Prod. 1	Operator	Yes	M	42	Secondary education/post-secondary
R14	Prod. 1	Operator	Yes	M	46	Secondary education/post-secondary

Respondent code	Company	Function	Trade union member	Gender (M/F)	Age (years)	Education
R15	Prod. 1	Analyst of supply chain management	Yes	M	39	Higher education
R16	Prod. 2	President	Yes	M	52	Higher education
R17	Prod. 2	Operator electrician	Yes	M	40	Secondary education/post-secondary
R18	Prod. 2	Installation operator	Yes	M	38	Higher education
R19	Prod. 2	Cargo receptionist	Yes	M	49	Secondary education/post-secondary
R20	Prod. 2	Universal rectifier	Yes	M	52	Secondary education/post-secondary
R21	Prod. 2	Engineer, legal consultant	Yes	M	46	Higher education

Note: Prod. = Car manufacturer; M= masculine; F = feminine

Of the total of 21 interviews, 15 interviews were carried out in person in the company premises ('Prod. 1', 'Prod. 2' and 'Provider'), while 6 interviews were conducted online through Zoom. The average duration of the interview was 53 minutes. Sampling was carried out according to the principles of theoretic saturation (Flick, 2009), based on which research data collection ceases when the data stop bringing new information on the topic of interest. The interviews were recorded and transcribed in Romanian. After an initial discussion on the profile of participants and their job roles, participants were required to list the technologies they were using in their day-to-day work. Some examples of questions asked to respondents are: 'In general, what consequences has the introduction of digital technologies and automation had on the organisation of work so far?', 'How did the work process change, and which parts underwent major changes? Why?', 'What have been the changes in the tasks and activities of workers working with these technologies / in these processes? Of what kind?', 'Do you perform more or less tasks after technologisation?', 'Has there been professional enrichment or deskilling?', 'Have your working hours and work rhythms changed?', 'To what extent has your work been standardised?', 'Have there been, or will there be substitution of workers or shifts of workers from one unit to another, from one task to another?'

Latent content analysis was implemented to analyse the primary data collected in this research. Latent content analysis was chosen due to its ability to reveal deeper meanings and themes hidden within a text, which are not immediately obvious. Latent content analysis is a rigorous methodological approach used to systematically analyse textual data, including interview data, and its meanings, supposing the isolation of reduced pieces of the data that correspond to different concepts and the organisation and interpretation of these pieces with the purpose of explaining a phenomenon (Kleinheksel et al., 2020). The process corresponding to this analysis involves a detailed and interpretative examination of the text, requiring a comprehensive understanding of the context in which the communication takes place, as well as the sociocultural norms that may shape the implicit messages conveyed (Atlas.ti, 2024). Coding was carried out manually. Theoretical and emergent codes were

used. The coding was done independently by two researchers with an intercoder agreement, followed by a comparison of the emergent coding schemes, agreement, and adjustment to a final coding scheme.

3. Findings and discussion

3.1. Degree of D&A implementation in the automotive manufacturing process

At the time this investigation was carried out, the automotive production process exhibited varying degrees of implementation of D&A in all investigated companies. The degree of D&A also varied significantly between the two car manufacturers operating on the Romanian market. Both carmakers invested significantly in D&A technologies and integrated these technologies into their production processes, indicating a strong commitment to innovation and operational efficiency. Both companies also experienced challenges in fully automating certain production steps or procedures, indicating technological limitations or specific requirements of production processes. The most highly technologised company carried significant investments in D&A in the last 10 years, to automate several production divisions (such as divisions of Pressing & Bodywork, Paintwork, and Engines). Currently, more than 600 robots are being used in the production process. The other car manufacturer was using approximately 300 robots, most in divisions such as Assembly, Bodywork, and Pressing. Digitalisation at this company was also extensive, with 80% of quality control checks performed digitally using multifunctional smart tablets, tablets also used for training new employees. The component supplier, a foreign-owned small and medium sized enterprise, differed significantly from the two car manufacturers in terms of the level of D&A. Although the component supplier has continued to invest in modern technologies, its level of automation remained more limited than that of car manufacturers. The ‘Supplier’ focused on the digitalisation of mould design and manufacturing processes, but its manufacturing operations involved customised and even uniquely tailored manufacturing techniques, suggesting a batch rather than a mass production system. Furthermore, the component supplier has not yet adopted 3D printing, mainly due to the customer reluctance toward this production technique, which further differentiated it from the car manufacturers, who were more advanced in adopting innovative technologies.

3.2. The effects of D&A on labour in automotive production

The analysis of the perceptions and experiences of employees and union representatives in this industry, carried out using the method of latent content analysis, revealed four main themes regarding the automation and digitalisation of work: Collaborative mindset; Working conditions; Workforce high-tech specialisation; and Work supervision. These themes capture the varied perceptions and experiences of employees and union representatives regarding the impact of D&A in the industry. Figure no. 1 shows the taxonomy of D&A effects on labour in automotive production, describing the main themes and the associated categories and codes that emerged after the primary data analysis.

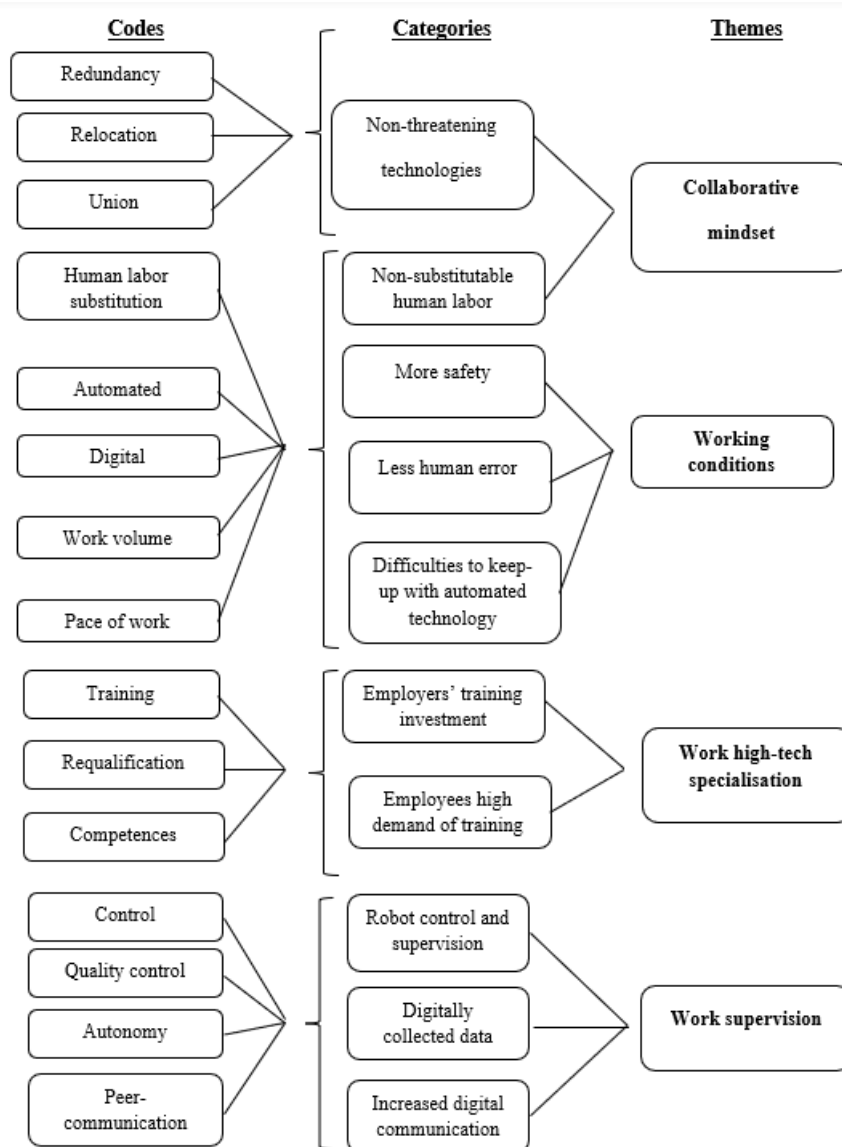


Figure no. 1. D&A effects on labour in automotive production

- **Collaborative mindset.** The analysis revealed that the employees, including production personnel, expressed a collaborative mindset in relation to D&A and their implementation processes. This research identified low resistance to change in relation to D&A transformations. Furthermore, the primary data suggested that most of the respondents did not perceive the new technologies used in production as a threat by most of the respondents. For example, R4 (machinery operator within the supplier company) said: 'the more advanced a machine is, the more it helps you as an operator.' This collaborative mindset was expressed in the context in which technological transformations were

perceived as significant, producing effects such as changes in the skills of workers and relocations of personnel to other divisions. This positive outlook was influenced by the fact that the implementation of new technologies has so far led to layoffs or salary reductions. The generalised labour shortage in the industry is massive, and manufacturing jobs are becoming less and less attractive for young generations. According to this research, it was observed that the introduction of D&A successfully compensated for the shortage of skilled workers in Romania's automotive production sector. Workers displaced by automation were instantly absorbed by other divisions within the same employer. Furthermore, D&A led to an increased dependence on teamwork, as the completion of tasks often depended on the work of other employees in the context of digitalised workflows.

- **Working conditions.** Improved working conditions have emerged as one of the main benefits of the implementation of new technologies in automotive production. For example, the full automation of the Painting Division allowed the removal of employees from a harsh working environment in which workers utilise toxic substances (e.g. paint). Before automation, workers had to perform painting tasks while wearing protective suits and often worked in physically challenging positions. In this sense, R10 (quality engineer, ‘Supplier’) said: ‘the main aim is to ease the workload of the workforce. If before (...), manual welding was done with pliers, now it is done by robots. (...) When putting pressure and stress on the employee, all kinds of demands on the body appeared. One was thinking: I have to go again, I am bending over, my back hurts. Now it is not like that anymore; it is much easier. (...) I prefer easy and modern work to hard work.’

Better working conditions were also derived from increased safety and less human error in the production process. Respondents identified lower human error and better quality of production processes and products as advantages of D&A. Despite the general positive perceptions, some respondents expressed concerns about the impact of automation on working conditions. They felt pressured to keep up with the pace of automated technologies, leading to shorter task durations and an increased number of tasks. In this sense, many respondents directly involved in the production process revealed that D&A impacted their individual targets, which became shorter in duration but more numerous. In this context, several employees found it difficult to keep up with the robots; the following extract from the transcript of the interview with R7 (technical manager in one of the producers) is illustrative in this respect: ‘[the pace of work] has increased because the duration of the interventions has decreased. Before, a diagnosis (...) could take several hours. Now, down to a few minutes, I have time to do more checks. (...) I do not have more free time, unfortunately (...) technology has helped me to do it faster, but my workload has increased.’ Respondents also shared that they also set their breaks according to the pace of the robots or technologies that are being used.

The labour unions were instrumental in ensuring that the transition to new technologies was made without layoffs. They have protected workers from the potential pitfalls of automation, such as increased workloads and pressure to keep up with faster production processes. By negotiating reasonable work targets and ensuring that automation does not compromise safety and health standards, unions have been helping to maintain a balanced and humane working environment. They ensured that vulnerable workers, such as older employees, women, or those with less technical experience, were not disproportionately

affected by automation. Elder employees (over 50 years of age) were more reluctant to use the new technologies, having more technical difficulties and less adaptive behaviours.

- **High-tech specialisation of the workforce.** The degree to which human labour was substituted by robots and digital automated technologies varied considerably depending on the type of task and production stage. However, almost unanimously, the labour force was perceived as important and necessary in the production processes. The majority of the respondents identified a multitude of examples of tasks that could not be performed by robots, artificial intelligence technologies, or advanced production technologies. Participants in this study did not ignore or contest the fact that some jobs have been lost or will be lost in the near future. To comply with the D&A requirements of D&A in the automotive industry, the workforce received extensive training to improve their skills. The employees were retained and provided extensive professional training, requalification, or reconversion courses. These training programmes were essential to align the workforce with D&A requirements. Equally important, the collected data also suggested that employees showed a high demand for training, expressing interest in using even more sophisticated technologies. However, on several occasions, there have been limitations in the acquisition of such courses due to high acquisition costs. In general, D&A training led to an increased specialisation of the workforce, enhancing its ability to operate and integrate advanced technologies effectively within production processes.

- **Work supervision.** Supervisory roles became more complex and digitalised due to the integration of D&A technologies. Managers found their work increasingly challenging, as they had to supervise both robots and human workers, or in some cases, only robots. Respondents with highly skilled managerial positions perceived that their work was becoming more sophisticated and challenging. The intervention of the quality control engineer working at 'Prod. 1' is eloquent in this regard: 'So basically [the work done with the help of technology] has lengthened my verification process, because now I have to verify both the employee and the robot from scratch every time, on the premise that the technology does not do anything good and to arrive at an answer that makes everything good. That is, the verification is much more extensive. Before, when it was only the employee to check, it was simpler because I was doing a recap of the steps. Now, while making the robot, I have to make sure that the movements are also good, that the operating devices (...) are also good (...). The process is more complex now' (R10). Additionally, in a more succinct form, R7 stated that: '... And the robot is also checked by a human!'

The main reason for such a transformation was that supervisory work involved either a mixed control of robots and humans, or only robots / technology supervision. In addition, the control function was based on more complex and detailed digital data collected by different IT systems. As a result, some of the respondents identified possible sources of concern, such as the need to protect the privacy of employees and the right to disconnect from the workplace communication flow (for example, from WhatsApp messages, emails). R16 (President of a trade union in 'Prod. 2'), for example, states about the new challenges related to data privacy: 'basically the problem is to accept permanent surveillance of biometric data, etc. ... Big problems. No one is teaching people to protect their rights in the context of digitalisation, including at work.' (R16). As management control became more digitalised, human interaction decreased, both between employees and between managers and employees.

3.3. Discussion: D&A and sociopolitical and economic systems

The results of the empirical study indicate a collaborative attitude of employees in the automotive industry towards D&A, in line with the conclusions of the Eurofound report (2021a), which emphasises the reduction of resistance to change due to the perception of technologies as a work support. Regarding work conditions, the study reveals significant improvements, also confirmed by the INACO study (2018), which mentions the elimination of heavy tasks and the reduction of stress. However, the intensified pace of work observed in the empirical study is less addressed in the identified literature. High-tech specialisation was another major theme, and the present data coincide with the Eurofound report (2021a), which emphasises the need for professional reskilling to adapt to technological demands. In contrast, the challenges of digital surveillance and privacy and human interaction detailed in the empirical study were only partially explored in the Eurofound report (2021b), which mentions digitisation of managerial control and the associated risks. In general, the study adds important empirical details to the dynamics between technology and labour in automotive.

The results of this study reveal a predominantly positive perception of D&A implementation in the automotive industry sector, although several challenges have also emerged. These findings correspond to the conclusions of other scientific works carried out in Romania, signalling the existence of similar positive opinions regarding the effects of D&A, including in the automotive industry (Türkeş et al., 2019; Iliescu, 2020; Pînzaru et al., 2022).

The role of trade unions in shaping positive attitudes towards D&A is crucial. They helped maintain fair working conditions in the context of increasingly automated jobs and monitored the pace and schedule of work, reducing some of the potential disadvantages of D&A. The opinions that high D&A costs are a barrier to technology and modernisation are consistent with previous research results (Türkeş et al., 2019), aligned with the predominantly positive perceptions of D&A effects expressed. As the primary data suggest, after D&A adaptation training processes, the workforce became more adaptable and competent in managing the complexity of digital and automated systems, which not only improved individual performance, but also contributed to the efficiency and overall competitiveness of the company. Equally, employee perceptions highlighting the increasing importance of teamwork between employees at an inter- and intra-departmental level in the industry resonate with the results of other research, such as Bonekamp and Sure (2015).

However, certain perceived changes in working conditions were not perceived as positive, particularly the need to keep up with robots, which work faster by nature, and the feeling that workplace activities and work pace, including breaks, are dictated by technology. Furthermore, certain transformations identified at the level of work supervision processes were perceived as a less desirable effect of D&A. These transformations specifically refer to the work of managers, which has become more complex and challenging, considering that it also involves the supervision of robots or the operation of technology, based on an increased volume of digital data, which is more difficult to manage. Also, the reduction of human interactions and the intensification of digital communication implies that for employees less attention is paid to emotional relationships at work and less effectiveness in solving problems or conflicts. Similarly, the need to protect confidential data, another

challenge perceived by employees, related to labour supervision processes, is in agreement with the conclusions of some of the existing studies (Acciarini et al., 2022).

The results derived from this research suggest that workers' perceptions of well-being and their expectations for the future in the context of technological progress require 'refreshed' sociopolitical and economic systems. The research findings provide nuanced insights for public policy decision-making to respond to new societal and economic challenges through several main policy categories, as discussed next.

From the point of view of industrial interventions, this study illuminates aspects that have remained generally obfuscated in current policies and programmes. First, the positive attitudes in relation to D&A contrast the discourse dominated by fear of public policies and programmes that focus primarily on the 'negative' effects of technological progress. Second, these attitudes also suggest adaptations to industrial policy. These adaptations suppose capitalising on positive worker perspectives on technology and employing these as new competitive advantages. This would also mean a successful alignment of the policy with the needs and an improved mechanism to increase productivity. The positive perceptions on D&A do not invalidate by any means that technological progress changes the nature of work and might lead to unemployment, as respondents also lucidly understood. Still, these perceptions also signal potential competitive advantages embedded in the labour force, which have remained until known rather unrecognised in current policy making, that might be used strategically, for increasing productivity gains, in line with extant research suggesting productivity maximisation as a key objective of new welfare regimes, together with maximising employability (Eichhorst et al., 2020). At the same time, the collaborative mindset that this study revealed might serve as a counterponder to the well-established, but unilateral discourse of job losses related to technology. This type of discourse distorts economic policy and jeopardises state interventions from more targeted and flexible aims. This perspective is especially useful for the case of Romania, in which the automotive industry is struggling to improve its strategic position on the European map of car manufacturing and to increase its degree of D&A.

In what concerns labour market regulations, this study invites us to imagine not only a new political economy of D&A, but also a social economy of D&A, robust enough to ensure an equitable distribution of the benefits of Industry 4.0. This research validates the importance of effective workers' trade union action; an efficacy that is already the target of current European legislation, as mentioned. At the firm level, this primary research illustrated that providing workers protection, specifically in terms of not using dismissals or salary cuts due to technology changes, leads to the satisfaction of the most basic human motivators, such as job safety, thus paving the road toward business conditions of mutual gains. In this context, social dialogue can play an important role in the emerging socioeconomic and political system, as already signalled by research such as Eichhorst et al. (2020) and Busemeyer et al. (2022), with the condition of not being understood in an oppositional relation with business objectives. Therefore, the legitimisation of union participation to strategic decisions regarding D&A can constitute a novel objective of social dialogue, a measure that must be back up not only legalistically but also by the (re)creation of a culture of social dialogue. The findings also illustrate the importance of providing additional support to vulnerable groups of the labour market, such as older employees, who face more difficulties in adapting to D&A. Social protection policies must be adapted to support

workers affected by job loss or transition to new fields, thus reducing job polarisation and its associated social risks.

Next, labour market legislation must respond to novel challenges and risks associated with the type of work in which human employees interact with robots, such as those observed in our research, for example, an increased pace of robot work, compared to that of humans, new difficulties in robot supervision or both robots and humans' supervision. Automation and the intensive use of digital technologies on the job require a review of workplace safety and health policies, including the rights of employees regarding electronic surveillance, the 'right to disconnect', and the use of personal data. These should include updated regulations to protect workers from risks associated with new technologies, such as technological stress, constant monitoring, and digital ergonomics issues. In general, these two possible interventions for the labour market are in line with existing research that observes an already increasing importance of social investment and intervention (Prettner and Strulik, 2020; Bryan and Williams, 2021; Agemoglu, 2023).

In what regards, continuing education policy, the results of this study confirm the need for training or requalification in the context of D&A, as these have proven to be essential tools used by companies to align to D&A and ensure worker protection in the context of technological change. From a public policy perspective, training or requalification courses were instruments that allowed employment maximisation, in line with Eichhorst et al. (2020). Furthermore, insufficient training and requalification was perceived as a harsh barrier to competitiveness. By prioritising continuous education and professional development, societies can better harness the potential of D&A, ultimately driving economic growth and ensuring that the workforce remains relevant and empowered in the knowledge economy (Popescu, 2012). In general, this research reconfirms the importance for human capital policies of skills development and professional requalification in the context of current socioeconomic and political transformations, especially for vulnerable categories of workers, but also, generally, for supporting employment. The study advocates for the need to invest in professional training and retraining of the workforce to adapt to the demands of new technologies. Continuing education policies should include training programmes in digital and technical skills, accessible to all types of workers, to ensure that they can meet the challenges posed by D&A.

The findings of this study provide a complex framework for analysing the impact of D&A on the automotive workforce from the perspective of the dilemma liberalism versus statism. On the one hand, the positive perceptions expressed by employees and union representatives could be interpreted as an argument in favour of economic liberalism. It suggests that free markets, supported by technological innovation and firm-level strategic decisions, are able to generate beneficial outcomes for employees and companies without massive government intervention. The fact that employees do not perceive D&A as a threat and that firms invest in training and retraining staff, without resorting to layoffs or wage cuts, supports the idea that market mechanisms can contribute to the adaptation of the workforce to new technological realities through economic incentives.

On the other hand, the important role unions play in the adoption of D&A strongly advocates efficient social dialogue. Moreover, the negative aspects highlighted by the study also suggest several limits of a purely liberal approach. The difficulties experienced by employees in maintaining the pace of work imposed by automated technologies, the

difficult adaptation of older workers to technological progress, the increased dependence on colleagues, and the complexity of digital surveillance underscore the challenges that D&A can bring in the absence of appropriate regulations. For example, concerns about protecting employees' privacy and the 'right to disconnect' point to the need for public policies that protect workers' rights in the face of excessive digitalisation of work. The reduction of human interactions and the increased reliance on digital communication also highlight the potential negative effects of D&A on the cohesion and effectiveness of work teams, suggesting the need for regulatory measures to ensure a balance between technology and human interaction. Overall, the results of our research suggest that there is a sociopolitical and economic dynamic specific to D&A, which generates new needs and social claims in terms of welfare, addressed to a new emerging political economy, as shown by other similar studies (Ridley, 2020; Eichhorst et al., 2020; Collington, 2022).

Conclusions

This paper provides the results of a detailed research on the impact of new technologies, especially D&A, both at the company level and on the sociopolitical-economic system, starting from the analysis carried out in the Romanian car industry. Analysis of firm-level D&A effects suggested a complex and heterogeneous picture of D&A effects and a set of implications for public policy making.

This research provides valuable information on the complex and multifaceted effects of D&A in the automotive industry by identifying four key themes: collaborative attitude, working conditions, high-tech specialisation of the workforce, and labour supervision. The added value of this study lies in the comprehensive assessment made of how these themes, identified through the latent content analysis method, are developed and complemented. Thus, this study also provides practical information for companies, unions, and policy makers on how to 'navigate' the opportunities and challenges of technological progress, ensuring that the benefits of D&A are maximised while minimising potential risks to the labour force. The findings of the study reflect the new tensions between liberalism and statism in the context of D&A in the automotive industry. Although market mechanisms and firm initiatives have generated significant positive results, there are clear limits to them that suggest that state intervention is also necessary to protect employee welfare and maintain equity in the context of rapid technological transformations. This argument emphasises the importance of a balanced approach, where both market mechanisms and public policies play a crucial role in managing the impact of D&A on the workforce. Overall, this research shows that a new political economy of digitalisation and a new economy of the welfare state are quietly emerging, while also providing arguments for imagining a new social economy of advanced technological progress capable of responding to today's challenges brought by D&A. Implications for industrial policy, labour market policies, and continuing education policy were also discussed in the research.

The present study contributes significantly to the literature on the impact of D&A on the workforce, bringing valuable insights into several relevant theoretical directions. First, the study provides empirical evidence in favour of technological adaptation theory. The results of the study offer empirical evidence on the collaborative attitude of employees toward the implementation of new technologies, complementing the theories of resistance to change and the adoption of innovations. According to Rogers (2003), the acceptance of

technologies is facilitated by their perception as beneficial. This study supports this perspective, demonstrating that employees perceive technologies as work support, which reduces resistance to change, as suggested by Kotter and Schlesinger (1989). Second, the high-tech specialisation of the workforce, evidenced by reskilling programmes, extends the applicability of human capital theory (Becker, 2009) in the digital age. The study reveals that investments in training increase employee value, which is essential for the integration of advanced technologies. Last but not least, the collaboration between employees and technology highlighted in this study supports the technology-organisation-environment framework (Baker, 2011) that explores the complex relationships between technology, organisational structures, and human interactions. Our study extends these frameworks by empirically detailing the integration of D&A technologies in the automotive industry and the resulting social dynamics. The improved working conditions through automation observed in this study confirm the findings of the work of Karasek and Theorell (1990), who point out that automation can reduce heavy physical tasks and improve safety. However, the intensification of work pace reported by respondents adds an underexplored dimension to the literature, suggesting a reassessment of work-life balance theories in the context of digitalisation.

The study on the impact of D&A in the automotive industry in Romania highlights significant managerial implications, focussing on the need for an integrated strategic approach to the management of human resources and operational processes. Managers must develop advanced coordination and supervision skills, given the increasing complexity of automated processes and the extensive use of digital data for decision-making. In addition, continuous training of employees becomes essential to adapt to new technologies, which requires additional investments in professional development programmes. At the same time, managers must navigate the challenges associated with digitised surveillance, maintaining a balance between controlling productivity and respecting employee privacy. In this context, an effective social dialogue, including the participation of trade unions in strategic decisions, becomes vital to ensure a positive organisational climate and a sustainable technological transition.

Although this research makes valuable contributions, the conducted study also has several limitations. First, specific to qualitative research, the results cannot be generalised to larger statistical populations. Second, the research is based solely on the opinions of the respondents, which can be distorted by a number of elements, such as lack of information or social desirability. In this context, extending such research, based on quantitative or mixed methods, together with the multiplication of research methods and tools in order to triangulate the results, for example, by analysing financial data of companies or formal policies, could render a richer and more complete picture of the transformations brought about by D&A.

This research opens several avenues for future exploration. First, expanding the research through quantitative methods could provide a generalisable picture of the phenomenon, complementing the current qualitative data. Second, a comparative analysis between various industries could highlight sectoral specificities regarding the effects of automation on the labour market. Another direction is the detailed exploration of the public policies needed to support technological transition, with a focus on social protection, continuing education, and regulations on digital work surveillance. It would also be valuable to

investigate the relationship between the perception of new technologies and the economic results, which could contribute to the foundation of more effective management strategies. Equally, the analysis of the ethical and legal implications of the use of advanced technologies in industry could complete the picture of the emerging new political economy at the intersection of liberalism and statism.

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