Automation in the automotive sector: Romania, Spain and Germany

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Abstract

This study investigates the impact of technological upgrades and automation, on employment and working conditions in the automotive, sector in Romania, Spain and Germany. Utilising qualitative research methods, the study examines work organisation, job quality, and occupational composition from a gender perspective.

The findings of the study exploring the impact of technology, identified main drivers for automation implementation as increased productivity, quality, and reduced manual labour availability. Automation and robotisation have also increased flexibility to cope with the variable composition of final products and the traceability of production processes. Barriers include high costs, technical difficulties, and the need for worker training. It observed that automation can simplify tasks, create new jobs, and increase responsibilities in middle management and team/shift leaders, while potentially reducing worker autonomy and increasing work pace. Positive job quality implications include ergonomics and improved operators' safety. Automation has reduced the number of line operators, while increased maintenance workers, quality control, logistics and indirect labour. The study observed vertical and horizontal gender segregation in hybrid production processes, with advancements towards horizontal gender equality in technologically advanced establishments. Addressing cultural attitudes and technical challenges is crucial for equitable benefits, as both industries currently undergo a transitional phase.

Cette étude examine l'impact des mises à niveau technologiques et de l'automatisation sur l'emploi et les conditions de travail dans les secteurs de l'automobile en Espagne, en Allemagne et en Roumanie. Utilisant des méthodes de recherche qualitatives, l'étude examine l'organisation du travail, la qualité de l'emploi et la composition professionnelle dans une perspective de genre.

Les conclusions de l'étude explorant l'impact de la technologie ont identifié les principaux moteurs de la mise en œuvre de l'automatisation comme l'augmentation de la productivité, de la qualité et la réduction de la disponibilité de la main-d'œuvre. Dans le secteur automobile, l'automatisation et la robotisation ont également augmenté la flexibilité requise pour faire face à la composition variable des produits finis et la traçabilité du processus de production. Les obstacles comprennent les coûts élevés, les difficultés techniques et le besoin de formation des travailleurs. L'automatisation peut simplifier les tâches, créer de nouveaux emplois et augmenter les responsabilités des cadres intermédiaires et des chefs d'équipe tout en réduisant potentiellement l'autonomie des travailleurs et en augmentant le rythme de travail. Les implications positives sur la qualité de l'emploi incluent l'ergonomie l'amélioration de la sécurité des opérateurs. Dans le secteur automobile elle a réduit le nombre d'opérateurs de ligne tout en augmentant les travailleurs dans la maintenance, le contrôle de qualité, la logistique et la main d'œuvre indirecte. L'étude a observé une ségrégation verticale et horizontale entre les sexes dans les processus de production hybrides, avec des progrès vers l'égalité horizontale entre les sexes dans les établissements technologiquement avancés. Aborder les attitudes culturelles et les défis techniques est crucial pour des avantages équitables, car ces deux industries traversent actuellement une phase de transition.

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Executive summary

Introduction

Technological progress has improved our living standards and raised concerns about job displacement and changes to working conditions. The EU has made understanding the impact of technology on employment a policy priority and has established initiatives, such as the Digital Jobs and Skills Coalition, to equip workers with necessary digital skills. In this regard, this study aimed to conduct comprehensive research on the impact of technological progress on the labour market, specifically examining three vectors of change: the digitisation of processes, digital labour platforms, and automation in the industrial sector. The main aim is to investigate how these technological changes affect employment and working conditions to support the Commission's political needs.

The current study investigates the socio-economic impact of new technologies, such as robotisation and automation, in the automotive sector in three European countries, Romania, Spain and Germany, focusing on the labour market and gender implications. The study explores various topics related to automation, such as its impact on work organisation, job quality, and occupational composition.

The study's methodology involves qualitative research methods, specifically in-depth desk research, semi-structured interviews, and field visits. In this sense, the study involved visiting two different establishments in each location. No company visits were possible in Germany. The interviews were conducted with management, union/worker representation, and workers, with at least nine persons interviewed in each establishment.

Main findings

Despite important advancements in the adoption of new technologies in **Romania**, the country shows several structural weaknesses hampering the implementation of more advanced levels of automation. The automotive industry, geographically concentrated around the two OEMs present in the country, represents the first adopter of automation technologies, especially for what concerns the use of robots. The relatively lower level of wages and flexible labour regulation have favoured the adoption of more labour intensive production. For what concerns line operators, there is evidence of job displacement, increasing work intensity and growing standardization of the production processes. On the other hand, important improvements have been recorded in terms of ergonomics and health and safety work condition, allowing the entrance of female workers in occupations usually occupied by male workers. The new job profiles demanded (from maintenance workers to IT specialists) are in short supply and companies are responding by investing in training and professional development of the workforce employed in the automotive sector.

The research team could not interview line workers. The empirical evidence, collected through interviews with managers, technical staff and trade unions, has shed light on:

- Efficiency and cost reduction as main drivers of automation, complemented with the need of improving working conditions and ergonomics.
- Presence of several barriers and constraints that slow down the process of technological modernization, from the need to reorganize and enlarge physical facilities across the various departments to the relation with technology providers and the interconnection across different departments and suppliers. This wide set of bottlenecks pushes firms to develop their own specific strategies to tackle them.
- Multiple impacts on work organization and employment, ranging from displacements of specific job profiles, increasing workload and process standardization with a reduction of workers' autonomy and discretion, still uncertain adoption of job rotation and teamwork schemes related to the lean work organization model.
- Increasing participation of female workers in the automotive sector and potential positive impact in terms of employment opportunities given the improvements of ergonomic conditions of specific occupations with a traditionally strong male segregation.
- The complexity of the process of automation and the crucial role played by companies' specific characteristics suggest that an important role could be played by social actors. In both companies

workers are unionized and trade union organizations are present in the plants, However, trade unions' direct participation in the process of technological implementation seems to be quite limited, despite their more active role in collective bargaining.

The automotive sector in **Spain** produces more than 2 million vehicles, being the second producer after Germany in the EU and the eighth in the world. Its production is specialised in passenger cars, followed by commercial vehicles and, at a smaller extent, industrial vehicles. Spain launched in 2016 a specific program – Connected Industry 4.0 – to enhance the introduction and diffusion of Industry 4.0 technologies. The program, that is still on-going, devotes particular attention to small and medium enterprises where digital technologies are scarcely diffused. Important networks of collaborations are developed among industries, universities, and technology centres.

Given its position in the global value chain, lowering costs and in particular labour costs is one of the most common strategies adopted by Spanish automotive plants to attract investment from the parent company. In this sense, high workers' turnover and massive use of temporary and part-time contracts can be interpreted as a strategy to cut on labour costs and better fit with requirements on plants' modernization within the digital transformation network.

Interviews in Spain refer a tier-1 producing car seat padding and a tier-2 company specialised in bending and stamping that realizes welding of subassemblies of car. Both companies belong to multinational companies, and play a dynamic role in the overall reconfiguration of the parent company in automotive value chain. Further material was collected through a focused meeting at the Cluster de Automoción in Aragóna. The most relevant issues emerged during the field-study are:

- Implementation of automation and digitalization mainly driven by the need to increase the competitiveness of Spanish companies, through an improvement of the entire production process, particularly stringent in the case of suppliers that must deal with high variability of models.
- Pivotal role of data analytics, supported by MES, largely deployed in logistics, quality, and maintenance departments to increase efficiency, facing the subordinated position of suppliers within the value chain and a strict just-in time production model.
- No evidence of significant job displacement, but contrasting trends in terms of working conditions improvement and job quality.
- Crucial role of training courses on digital skills and data analysis, done both internally and through training centres in the automotive clusters that propose tailored courses on the needs of SME located in the area.
- Positive impact on gender participation, since the introduction of automation technologies has reduced the incidence of the heaviest and less ergonomic tasks, despite the sector remains highly segregated in terms of gender and type of occupations.
- No direct decision role of trade unions on the introduction of automation and digitalisation, but strong commitment to improving working conditions and ensure an adequate supply of training opportunities for workers particularly affected by the adoption of new technologies.

The **German** automotive sector plays a crucial role in the national economy both in terms of employment, value added, export, R&D expenditure and exhibit a high degree of automation.

OEMs are massively investing to advance on digitalization, autonomous driving, electromobility and decarbonization. Particular attention is also devoted to the integration of battery assembly/power electronics and battery cell production within the OEMs' production networks. In this context, a tendency towards in-sourcing seems to take place in Germany, as OEMs have announced their intention to manufacture as many components as possible in-house, also to face and manage potential job losses due to the shift from powertrain to electric mobility.

In terms of skills and occupations, the German automotive sector does not seem to be experiencing any significant shortage in the labour market. At the same time, big OEMs are developing new strategies to become more attractive and face competition from other highly dynamic sectors.

German trade unions, endowed with participatory and information rights granted by the codetermination model, are also facing new challenges especially related to the process of sectoral restructuring and the low unionization rate in smaller suppliers.

Information and data are mainly obtained through desk research and interviews to four scholars in the field of automation technologies and labour, four trade union staff members with policy analysis responsibility, a multinational company HR manager. It was not possible to get direct access to the OEMs plants located in Germany, a consequence of the specific and serious challenges that the sector is facing. The main findings can be synthesized as follows:

— High but heterogenous degree of automation within and across car makers and suppliers, emergence of new obstacles and challenges with respect to robot flexibility and adaptability to complex production environment.

— Increasing digitalization of the entire production process, allowing workers to have a comprehensive and up-to-date perspective on the tasks executed or to be performed. On the other hand, still limited degree of coordination across different departments on the collection and use of data, mainly because of organizational constraints.

— Significant unbalance in the expected distribution of job losses - spurred by the move towards e-mobility and fostered by increasing degrees of digitalization - along the value chains, with well protected jobs within OEMs and more precarious and uncertain jobs in the supplier sector.

— Crucial role of vocational training and dual education system in ensuring an update of workforce skills, competences and job profiles needed in the sector.

— Active and participatory role of work councils in ensuring job security and favouring the transition towards emerging industries. Exclusive focus on German workers and national competitiveness, but lack of any well-structured coordination with other European trade unions.

Résumé

Introduction

Le progrès technologique a amélioré notre niveau de vie et soulevé des inquiétudes concernant le déplacement d'emplois et les changements dans les conditions de travail. L'UE a fait de la compréhension de l'impact de la technologie sur l'emploi une priorité politique et a mis en place des initiatives, telles que la Coalition pour l'emploi et les compétences numériques, afin de doter les travailleurs des compétences numériques nécessaires. À cet égard, cette étude visait à mener une recherche approfondie sur l'impact du progrès technologique sur le marché du travail, en examinant spécifiquement trois vecteurs de changement : la numérisation des processus, les plateformes numériques de travail et l'automatisation dans le secteur industriel. L'objectif principal est d'étudier comment ces évolutions technologiques affectent l'emploi et les conditions de travail afin de répondre aux besoins politiques de la Commission.

La présente étude examine l'impact socio-économique des nouvelles technologies, telles que la robotisation et l'automatisation, dans les secteurs de l'automobile, de l'habillement et de la chaussures dans trois pays européens, la Roumanie, l'Espagne et l'Allemagne, en se concentrant sur le marché du travail et les implications de genre. Le niveau de mise en œuvre de l'automatisation diffère considérablement entre les deux secteurs, et l'étude explore divers sujets liés à l'automatisation, tels que son impact sur l'organisation du travail, la qualité de l'emploi et la composition professionnelle.

La méthodologie de l'étude implique des méthodes de recherche qualitatives, en particulier des recherches documentaires approfondies, des entretiens semi-structurés et des visites sur le terrain. En ce sens, l'étude a consisté à visiter deux établissements différents dans chaque pays pour les deux secteurs envisagés. Les entretiens ont été menés avec la direction, la représentation syndicale/ouvrière et les travailleurs et avec au moins neuf personnes interrogées dans chaque établissement.

Principaux résultats dans le secteur automobile

Malgré les avancées importantes dans l'appréhension de nouvelles technologies, **Romanie** montre beaucoup de faiblesses structurelles qui semblent entraver l'implantation d'une automatisation de niveau plus élevé. L'industrie automobile, géographiquement concentrée autour des deux équipementiers présents dans le pays – Dacia et Ford – représente le premier secteur à avoir adopté les technologies de l'automatisation, en particulier en ce qui concerne l'utilisation des robots.

Le niveau relativement faible des salaires et la flexibilité de la réglementation du travail a favorisé l'adoption d'une production intensive en travail. En ce qui concerne les opérateurs de ligne, il y a des preuves de destruction d'emplois, accroissant l'intensité du travail ainsi que la standardisation du processus de production. Par ailleurs d'importantes améliorations ont été constatées dans les conditions de travail en termes d'ergonomie et de santé et de sécurité, permettant l'intégration de travailleuses dans des postes traditionnellement occupés par des travailleurs. Les nouveaux profils d'emplois demandés (de la maintenance aux spécialises IT) sont en nombre insuffisant et les entreprises y répondent en investissant dans la formation professionnelle et le recrutement dans le secteur automobile.

L'équipe de recherche n'a pas pu s'entretenir avec les travailleurs à la chaîne. Les preuves empiriques, recueillies à travers des entretiens avec les manageurs, le personnel technique et les syndicats ont mis en lumière :

- L'efficacité et la réduction du coût comme principaux moteurs de l'automatisation, complétées par le besoin d'améliorer les conditions de travail ainsi que l'ergonomie.
- La présence de plusieurs obstacles et contraintes qui ralentissent le processus de modernisation technologique, du besoin de réorganise et étendre les installations physiques à travers différents département à la relation avec les fournisseurs de technologies et l'interconnexion des différents département et fournisseurs. Ce vaste réseau de goulots d'étranglement pousse les entreprises à développer des stratégies pour y faire face.
- Les impacts multiples et encore actuels sur l'organisation du travail et l'emploi, de la destruction de profils d'emplois spécifiques accroissant la charge de travail et la standardisation du processus

combinée à une réduction de l'autonomie et du pouvoir discrétionnaire des travailleurs entretiennent encore l'adoption incertaine de la rotation des emplois et de l'organisation du travail en équipe liés au modèle d'une organisation allégée du travail.

— La participation croissante des travailleuses dans le secteur automobile et l'impact potentiellement positif en termes d'opportunités d'emploi en raison des améliorations des conditions d'ergonomie des emplois spécifiques avec une ségrégation traditionnellement élevée de travailleurs.

— La complexité du processus d'automatisation et le rôle crucial joué par les caractéristiques spécifiques des entreprises suggèrent qu'un rôle important puisse être joué par les acteurs sociaux. Dans les deux entreprises les salariés sont syndiqués et les syndicats sont présents dans leurs usines. Toutefois la participation directe des syndicats dans le processus de mise en œuvre des technologies semble assez limitée malgré le rôle plus actif dans les négociations collectives.

L'industrie automobile en **Espagne** produit plus de deux millions de véhicules, elle est le second producteur européen après l'Allemagne et le huitième producteur mondial. Sa production est spécialisée dans les voitures pour particuliers, suivie des véhicules commerciaux et, dans une moindre mesure, les véhicules industriels. L'Espagne a lancé en 2016 un programme spécifique – l'industrie connectée 4.0 – afin d'améliorer l'introduction et la diffusion des technologies de l'industrie 4.0. Ce programme, toujours en cours, consacre une attention particulière aux petites et moyennes entreprises dans lesquelles les technologies numériques sont à peine diffusées. D'importants réseaux de collaborations sont développés au sein des industries, des universités et des centres technologiques. Au regard de sa position dans la chaine de valeur globale, la baisse des coûts, et en particulier le coût du travail est l'une des stratégies les plus communément adoptée par les usines automobiles espagnoles afin d'attirer des investissements par les sociétés-mères. En ce sens, l'important taux de destruction d'emplois et l'utilisation massive de contrats courts ou à temps partiels peuvent être interprétés comme une stratégie de réduction des coûts du travail ainsi qu'une meilleure adaptation aux contraintes découlant de la modernisation des usines ainsi qu'à la transformation des réseaux numériques. Les entretiens menés en Espagne se réfèrent à un fournisseur de premier niveau produisant des rembourrages pour les sièges des voitures ainsi que une entreprise de deuxième rang spécialisée dans le pliage et l'estampage qui réalise le soudage des sous-ensembles des voitures. Les deux entreprises appartiennent à des multinationales et jouent un rôle dans la reconfiguration générale de la société-mère dans la chaîne de valeur automobile. D'autres éléments ont été collectés lors d'une réunion ciblée au pôle de l'*Automociòn* à Aragòna. Les principales problématiques révélées lors de l'étude de terrain sont :

— La mise en œuvre de l'automatisation et de la numérisation est conduite principalement par le besoin d'accroître la compétitivité des entreprises espagnoles grâce à l'amélioration de l'ensemble du processus de production, particulièrement requis pour les fournisseurs qui doivent faire avec des modèles soumis à une grande variabilité.

— Le rôle pivot de l'analyse des données, supportée par MES, laquelle est largement déployée dans les départements logistiques, qualités et maintenance afin d'accroître l'efficacité, face à la position subordonnée des fournisseurs dans la chaîne de valeur et d'un modèle de production en flux tendu.

— L'absence de preuve d'une destruction significative d'emplois mais une tendance contrastée en termes de l'amélioration des conditions de travail et de la qualité du travail.

— Le rôle crucial des formations aux compétences numériques et à l'analyse de données, lesquelles sont réalisées à la fois en interne mais également dans des centres de formation dans les pôles automobiles qui proposent des formations adaptées aux besoins des petites et moyennes entreprises situées dans la région.

— L'impact positif sur la participation des femmes en raison du fait que l'introduction des technologies d'automatisation a réduit les conséquences des tâches les plus lourdes et les moins ergonomiques bien que le secteur demeure fortement imprégné d'une séparation fondée sur le genre et les types de métiers.

— L'absence de rôle décisionnel direct des syndicats sur l'introduction de l'automatisation et de la numérisation mais un engagement fort pour améliorer les conditions de travail et assurer la

fourniture adéquate de perspectives de formation pour les travailleurs, en particulier ceux affectés par l'adoption de nouvelles technologies.

Le secteur automobile en **Allemagne** joue un rôle crucial dans l'économie domestique en termes d'emploi, dans les domaines de l'emploi, de la de plus-value, de l'export et du financement de la recherche et du développement. Les équipementiers investissent massivement dans le développement du numérique, de la conduite automatique, de l'électromobilité et de la décarbonation (environ 150 millions d'euros investis d'ici 2025 selon le VDA). Une attention particulière est également portée à l'intégration de l'assemblage des batteries et de [l'électronique de puissance] ainsi que la fabrication des composés de batteries dans le réseau de production des équipementiers. Dans ce contexte, une tendance vers l'internalisation semble prendre place en Allemagne dès lors que les équipementiers ont dévoilé leur intention de fabriquer le plus de composants possible en interne mais également pour faire face et contenir les pertes d'emplois potentielles en raison du passage des groupes motopropulseurs à la mobilité électrique.

En termes de compétences et d'emploi, le secteur automobile allemand ne semble pas connaître de pénurie significative sur le marché du travail. Dans le même temps, les gros équipementiers développent de nouvelles stratégies afin de devenir plus attractifs et faire face à la compétition provenant d'autres secteurs fortement dynamiques. Les syndicats allemands, dotés de droits de participation et d'information accordés dans le modèle de codétermination, font également face à de nouveaux défis liés au processus de restructuration sectorielle ainsi qu'au faible de taux de syndicalisation chez les petits fournisseurs.

Les informations et les données sont principalement obtenues par de la recherche documentaire ainsi que des entretiens avec quatre universitaires spécialisés dans le domaine des technologies d'automatisation et du travail, de quatre membres de syndicats responsables de l'analyse des politiques, et d'un directeur des ressources humaines d'une multinationale. Il n'a pas été possible d'obtenir un accès direct aux usines des équipementiers situées en Allemagne en raison du défi sérieux et singulier que le secteur rencontre. Les principaux résultats peuvent être synthétisés ainsi :

— Un degré d'automatisation élevé mais hétérogène au sein des fabricants et fournisseurs de voitures, l'émergence de nouveaux obstacles et défis concernant la flexibilité et l'adaptabilité des robots dans un environnement de production complexe.

— L'accroissement de la numérisation de l'ensemble du processus de production permet aux travailleurs d'avoir une perspective complète et actualisée des tâches réalisées ou à réaliser. D'autre part, un degré de coordination encore limité à travers les différents départements dans la collecte et l'utilisation des données, en particulier en raison des contraintes organisationnelles.

— Un déséquilibre significatif dans la répartition attendue de pertes d'emplois – stimulé par l'orientation vers l'e-mobilité et favorisé par une numérisation accrue – ainsi que dans la chaine de valeur, avec d'un côté des emplois protégés au sein des équipementiers et de l'autre des emplois précaires et incertains dans le secteur des fournisseurs.

— Le rôle crucial de la formation professionnelle et de l'alternance qui assurent une mise à jour des qualifications des travailleurs, des compétences et des profils d'emplois recherchés dans ce secteur.

— Le rôle actif dans la participation des conseils de travail garantissent la sécurité de l'emploi et favorise la transition vers les industries émergentes. La focalisation exclusive sur les travailleurs allemands et la compétitivité nationale, mais un manque de coordination bien organisée avec les autres syndicats européens.

1. Introduction

Technological progress has greatly enhanced living standards, but it has also raised concerns about job losses and insufficient job creation. At the European level, comprehending the effects of technology on employment is essential, as evidenced by multiple EU policies and documents. The Digital Jobs and Skills Coalition strives to provide workers with the necessary digital skills, while the European Council focuses on addressing the consequences of AI, stressing data protection, digital rights, and ethical standards. The European Commission's "Artificial Intelligence for Europe" communication emphasizes the need for the EU to establish a suitable ethical and legal framework and to support workers in jobs at risk due to automation, robotics, and AI. The digital transition is a primary driving force in the EC 2020 Work Programme, which advocates for a European approach that is human-centric, ethical, and value-based. The present investigation focuses on the labour market effects of technology, emphasising process digitisation, digital labour platforms, and automation in industrial sectors, particularly garment/apparel industries. This research explores employment shifts, labour processes, working conditions, and gender-related aspects, adopting a systemic approach that considers the diverse impacts of automation within various socio-economic settings.

The main objective of this study is to develop case studies on the socio-economic impact of new technologies, including robotisation and automation in the automotive sector in three European countries (Romania, Spain, and Germany), with a particular focus on the labour market, job quality including gender implications. The research was focused on topics such as barriers and drivers of automation, the impact of automation on work organisation, job quality and task content, including insights on occupational composition, all from a gender perspective.

The methodological approach was focused on two phases.

The first one aimed at identifying a shortlist of company cases, based on the minimum requirement of automation implementation in the establishment. The identification of potential and suitable establishments has involved an exhaustive and methodological desk review for the identification of a pool of potential companies to be considered for the study, and contextualisation of these establishments from technological, geographical, economic points of view. The purpose of this desk review was to obtain as much information as possible, although additional and specific information would still have to be collected directly from the company in the engagement stage. With the support of the stakeholders, the desk research performed, and the consortium contacts and knowledge, a preliminary pool of eligible companies was developed to be contacted in the next step. The output of this task was a shortlist of companies meeting the general criteria and from which additional information was collected to verify the accomplishment of the specific and the pre-selection criteria and also to check their preliminary availability to participate in the study. Along with identifying the establishments, the consortium also designed an engagement strategy.

The identification of the establishments for the automotive sector was carried out following an iterative approach that saw the core research team interact with the country experts. Country experts were selected based on their specific knowledge of, and high-level expertise in, the automotive sector and, most importantly, for having direct communication channels and contacts with car manufacturers in the country (particularly in the case of Germany and Spain these contacts were mostly represented by trade unions), and that could facilitate the engagement of the selected establishments.

This interaction took the form of several meetings, during which the team discussed and reached a shared understanding of the automotive sector in each country, fine-tuned the main avenues for research, and discussed possible options for identification of establishments.

During this identification phase, experts in Germany and Spain also made preliminary contacts, through trade union representatives, with the establishments that could potentially be selected, to make sure that there was a general interest on the side of the OEMs to be involved in the project. In all instances experts received a positive response. In Romania, anticipating the challenges that could be faced by approaching the OEMs through the trade union representatives due to the specificities of the automotive sector and industrial relations panorama in the country, a different approach was followed. In this case the management of the OEMs was contacted directly by the central team, with the endorsement and support of ACEA and the ACEA European representatives of the car manufacturers involved.

The second phase was based on the realization of the interviews. This phase involved the preparation of the template of the semi-structured interviews in close collaboration with JRC, adapting them for the specific profiles of the interviewees. The selection of the key informants was represented by a consensus between the required profile, represented by top management, employee representation (HR and/or Union representatives), technology or IT specialist, and workers affected directly by the automation technologies, and the proposal of the personnel by the selected establishment management. All the interviews' templates were focused on the major topics of interest, as the impact of automation within the establishment, on work organization, job design, occupational composition; impact of automation on the business model, within the supply chain and other relevant complementarities.

Following the approval by the JRC of the proposed OEMs, country experts contacted them to provide more detailed information about the scope and structure of the interview process and start making operational arrangements. However only in the case of Romania this process was successful, and the interviews implemented as planned by end July 2022. In the cases of Spain and Germany, major obstacles were encountered in organising the interviews in the selected OEMs, in spite of the many efforts that were put in place by the core team with the support of JRC and ACEA and of its own network of contacts. Finally, with the agreement of JRC, alternative solutions were explored and implemented. In the case of Spain this meant that the interviews were carried out in two Tier1 establishments in November 2022; while in the case of Germany the interviews were carried with a broad range of privileged witnesses from December 2022 to January 2023, representing the main stakeholders of experts of the automotive sector in the country.

For each of the three countries, the report presents the case studies, the main findings from interviews and a discussion of the topics emerging from the field work. Annexes provide firm profiles and information on the interviews.

2. Case studies of two OEMs in Romania

Overview

The automotive sector in Romania

In the last years, Romania has recorded a growing adoption of automation technology, even if the robot density of the country remains below the EU15 average.

The automotive industry, geographically concentrated around the two OEMs present in the country - Dacia in the Argeș county and Ford in Dolj - represents the first adopter of automation technologies, especially for what concerns the use of robots.

According to ILO (2020)[1] in 2019, more than 180 thousand people were employed in the automotive industry in Romania, out of which 24 thousand by vehicle manufacturers and 156 thousand by suppliers. Indeed, apart from OEMs, in the country are located other automotive companies and small R&D centers focusing mainly on electronics software development in the sector.

Despite important advancements in the adoption of new technologies, the country shows several structural weaknesses that seem to hamper the implementation of more advanced levels of automation.

First, national industrial policy is still scarcely oriented towards a structural investment on digitalization and, more generally, innovation. Only temporary measures have been adopted, such as incentive packages for the purchase of electric vehicles or tax exemption schemes for hiring specific IT job profiles. In addition, there are no specific industrial policies devoted at promoting the development of EV manufacturing and no efforts have been made to attract investments in battery manufacturing capacities.

Secondly, the labour market exhibits a shortage of highly qualified workers to which companies are responding by investing in training and professional development of the workforce employed in the automotive sector. The productive structure is strongly dependent on multinational companies' strategic choice. Indeed, the relatively lower level of wages and flexible labour regulation seems to have favoured, together with the arrival of several European companies, the adoption of a more labour (and less capital) intensive production.

The case studies: Dacia and Ford Otosan

The field study in Romania consisted in the visits and interviews in the plants of the two OEMs present in the country: Dacia and Ford.

Dacia has four companies in Romania and the Dacia Mioveni S.A. (the one included in the field work) must be considered in the automotive end-to-end automotive value chain. Although traditionally the value chain emerged from manufacturing, in Romania Dacia strengthened over the past 10 years to other areas across the value chain, with a special focus on R&D. Dacia contributes with 2,1% to GDP in Romania, and 8% of the exports. The Mioveni plant of Automobile Dacia S.A. (henceforth Dacia) manufactures passenger cars, engines and gearboxes/transmissions. In 2022 the plant produced almost 350 thousand vehicles (the plan is to expand to 400 thousand); 500 thousand engines and 500 thousand transmissions. The 86% of the production is exported abroad. Founded in 1968, it was acquired by Renault in 1999. It employs around 6000 workers. The plant in Mioveni is particularly relevant for the Renault Group, as confirmed by the fact that car models produced here are part of the Global Access programme, which represents the pillar of the internationalization strategy of the Group. The plant is embedded in the national network of Renault plants for R&D and engine production.

The Craiova plant of Ford Otosan Romania (henceforth Ford), manufactures passenger cars and engines. In 2022 the plant produced almost 250 thousand vehicles, largely for the foreign markets. The plant was built by General Motors in 1976, acquired by Ford in 2008 and since 2022 owned in joint

[1] The future of work in the automotive industry: The need to invest in people's capabilities and decent and sustainable work (ilo.org)

venture by Ford and the Turkish company Otosan. With the Ford took over, the implementation of the Ford Production Systems started a deep adoption of automation technologies. It employs around 3600 employees. The recent joint venture starts a path of innovation spurred by the dynamic Turkish ownership.

In both companies, workers are unionized and trade union organizations are present in the plants.

In what follows, we present detailed findings on the main issues emerged from the field study conducted in the two companies. Discussion and conclusions provide an overview of the main issues emerging in the country report.

Interviews findings

The information collected during the interviews were neither aiming at nor sufficient to producing an encyclopedic description of all the technologies implemented in the two OEMs. Because of time availability, we focused on the implementation of robots and digital technologies trying to identifying the main differences across departments and establishments, also with respect to their impact on work.

Automation technologies, robots, digital technologies

Adoption of robots across departments

Different types of robots are deployed in different departments and intensity of robotization differs across departments. In the press department robots are used to upload and download presses, in the body shop big robots are used to create the geometry of the body, in the painting shop robots are used in painting, while preliminary treatment is realized by operators and some operation are realized by immersion of bodies in large tanks, while sealing is manually made; in the assembly line, the lower part is generally assembled on an automatic conveyor, no robots are employed and some tasks are assisted by cobots, manual tasks are still prevailing.

Robotization is different across departments and spurred from different paths in Dacia and in Ford.

In Dacia, automatization in stamping (loading and downloading presses) has involved a significant innovative contribution of the technical team in Mioveni, who addressed in two months the challenges of adapting the complementary parts for manipulating robots to the existing big presses. As reported by one responsible of the technical team, the implementation of robots on other presses was done in a very short time due to the learning effect of the initial experience.

> *When we initiated the first test press I was team leader for that line. I saw that they had some problems with the robots, they didn't know where to place the robots. My boss said we have to do this, I liked it, I learned very fast. (….) We started in 2013 with the first new line, 100% automated. This was the first line. It was made with ABB Spain. After this, we created a team in our department, with engineering and manufacturing and we started making the robotization ourselves. We started with one press with 3 robots. We stayed with it for 2 months, we assessed problems and everything. After 2 months we started with the GP line, the medium-sized presses. We have big, medium and small parts. We put everything head to head and said let's see what happens if we do it with one press. It was very difficult, but after 2 months we said we should continue. By 2019 we were able to automate an entire line (9 robots, 4 presses) in 2 weeks. We do this entirely internally. [DACIA_1]*

The case of stamping is particularly interesting. Following the introduction of robots, workers who were no longer needed to load and unload presses were incentivized to retire or were redeployed in other areas of the company. The majority of workers remaining in this department required an intensive process of training and upskilling [DACIA_9].

In Dacia, all complementary parts were defined internally, acquired by technical suppliers and internally assembled and fixed to the robots. Programming of robots was done internally, and internal simulation of loading for that specific configuration of robots was first defined internally and adopted after ABB confirmed the process and results. Renault was generally supporting automation with the technical support of robots' suppliers, ABB. The latter, however, was not able/willing to adapt their

robots to the specific layout of the presses in Dacia, according to interviews. One of the initial concerns was eliminating the risky and heavy operations done manually by two operators in loading the big presses.

Painting is totally automated, but it was not possible to retrieve information on this specific department (no visit and no interviews)

In Ford, we observed analogous differences across the departments of production, but not a specific in-house project and implementation of robotization.

> *The body shop and the engine shop are most suitable for automation; you have repetitive processes, accurate parts, precise and stable dimensions, stable quality, so automation is much easier to do than in Trim & Final. (….) The paint shop is also a target for automation. The sealing process is being automated. Robots installed last year, replacing 9 people in total. There are further sealing processes that can be automated for sealing. Two painting booths: north and south. The north booth will be done by robots (the interior painting) starting with this summer. Adding 23 robots for that this summer. [FORD_1]*

Digitalisation and artificial intelligence

In Dacia-Mioveni, a great emphasis is put on the goal of increasing digitization to access and easily integrate information in the overall production system. This should not only facilitate information flows and control over the pace of individual operations/phases of the production process, but it should also enable the collection of data on operations, such as possible errors/defects, and allow the immediate correction from the analysis of causes of error. Data collection generates standard reports elaborated centrally (in the parent company), since the IT competences are not yet available in the plants: the Renault strategy is to centralise data analytics at corporate level (like planning and cost control that are centralised).

> *Now we have tablets and a work laptop. The tablet is useful because it allows us to move and have access to information all the time. All team leaders have a tablet. In the morning, people connect to the system and can see all the information from previous shifts. All information is directly available in the system. […] Tablets are meant to allow team leaders to work more in the field. This is for the entire Renault group. Team leaders enter info on how many jobs they observed, they can do things systematically while being in the field close to people and not from their office. [DACIA_3]*
>
> *We have automation without robots. Tables that move on their own, equipment aiding with the installation of the dashboard and many others. These are not robots, but involve automation. They require sensors, PLCs (..) [DACIA_7]*
>
> *Data collection generates standard reports elaborated centrally (in the mother company). However, Renault centrally prepared reports that do not completely fulfil the need at department level. As reported in the interviews, further developments at plant level would be useful, but IT competences are not yet available in the plants. The strategy is centralised data analytics at corporate level (like planning and cost control that are centralised). Several projects with the IT Hub in this field that are improving all the time. We have verticalized as an organization. This means that data hubs are becoming more centralized and standardized. In other respects, we are seeing a regionalization tendency, which means more freedom at a local level. [DACIA_9]*

In Ford-Craiova great attention is devoted to artificial intelligence and digitalisation, but with a lower intensity with respect to Dacia-Mioveni.

> *Process innovation and also how to copy and implement other technologies into the automotive industry: digitalization, cobots, drones, 3D printing for spare parts or for small devices for operators or dashboards. [FORD_2]*
>
> *Some applications for digitalization: until recently daily activities for supervisors or team leaders happened on paper; we have digitalized this with an easy to use template. [FORD_5]*

In both plants, digitalisation is adopted to reach the goal of continuous control over the quality (such as monitoring vibration in the press departments) and efficiency of the production process (receiving notification on quality or missing parts, or using camera for inspections).

> *A large number of presses have such digitalized systems that allow to monitor vibration (vibration detectors). Things are controlled remotely, we can see if there's a problem. This was started in 2017 and it began with one press. Now we have around 20. This system holds for stamping for the entire Renault group. [DACIA_2]*

> *Each fixer has 10-15 jobs maximum, for which s/he is responsible. This is done on the line, while the line is running. This has been happening for almost one year. We are able to manage quality much better now. (….) We implemented, starting 3 years ago as a project, replacing shouts and lights, the digital workstation system. We have devices on our persons, and we receive notifications when operators have problems concerning quality, missing parts, anything. This is a really good thing for quality. I can set priorities for defects depending on how my module is organized. The operator signals me and I might already be working on a defect. A defect can even take me 5 minutes, depending on what it requires. Another operator alerts me, I receive the information on my device, I look at it. Together with the operators we set a list of the most important defects for each job. [DACIA_5]*

> *We have very good vision cameras for engine inspection. Controversy with customers complaining about problems with parts missing from engines and Ford saying the engines left complete from the plant. They bought a special camera that takes pictures of everything in order to prove and/or check if there are missing parts. The inspection is done automatically, and the camera is able to recognize problems. This technical solution solved problems with customers. The important thing is that if there are mistakes, we find them in the plant and they don't go out. We bought a standard camera that we did not develop; we are not capable of that. [FORD_5]*

Impact of automation on work organization and employment

Automation, Lean Production and information flows

As a general issue, the implementation of automation in DACIA was described by managers as the expression of a substantial shift from being a "factory building cars" to become a manufacturing company integrated with quality, engineering and IT

This change is perceived as playing a role also with respect to the position of the company on the national labour market. Indeed, being DACIA an important employer covering the whole value chain, this change also require a dynamic approach to skills management with different levers: training, recruitment, mobility.

> *We are not a manufacturing company, we are a technology company, with manufacturing, with quality, with engineering, with shared services, with an IT hub. Most of the time, people look at us as just a factory building cars. This is important, especially from an automation perspective. It is true that automation meant a lot of changes for Manufacturing, but all the other functions flourished with automation, and this puts a different dynamic for the HR policy. [DACIA_9]*

Automation and Lean Production are pillars of a business and organizational model based on flexible demand and a certain variety of car models. In particular, in the case of Dacia, this diversified production is perceived by the workers on the assembly line both as an advantage and a disadvantage in terms of organizational efficiency

> *An advantage, because the plant has buffers in case a certain model doesn't sell well. At the same time, it's a problem for workers, because the production plan is not always designed while keeping in mind the concrete issues in manufacturing and is rather dependent on customer demand. The order of the vehicles is more or less random, depending on the way customers place their orders and not depending on the problems workers might face in production. [DACIA_10]*

A significant impact of automation on the work organization was identified within the IT Department in Dacia. In fact, the focus on tablets in the assembly line suggests a more comprehensive revision of the information flows within and across departments. Feedback, memo, selected to-do-list allows all staff involved (from line operators to team leaders supervisors, area managers, defect fixers) to be promptly updated and focussed on specific issues that can be checked against their technical standard/benchmark, potential solutions, timing for intervention. If, from the one hand, important advantage on the exchange of information can be envisaged, on the other hand, the increasing degree of digital connection of different tasks of the production process seems to increase the stress for online operators. Indeed, it was reported that they do not feel confident in using tablets (and are generally moved to other tasks) and they face difficulties in managing different IT devices.

On the contrary, in the case of Ford, the IT department (and consequently the IT related jobs) seem to play a less relevant role. A less frequent use of tablets has been observed in the assembly lines and, for example, whereas more ordinary ways are adopted to provide feedback, concerning for instance, the refilling of components to be assembled.

Job displacement

In Ford we found no evidence of technological unemployment since, as reported by the respondents, displacement was compensated by incentivised retirements.

> *Automation is never meant to lead to dismissals. Job reduction is done via retirement. [FORD_2]*

> *People were never dismissed because of automation, they manage to protect people jobs (that hasn't been an issue so far). [FORD_4]*

In Dacia, although no official information is available on the net impact of automation, the figure presented above shows a reduction of direct employment and a contemporary increase in production. In particular, a sharp difference emerges between manufacturing jobs (decreasing) and support (such as, maintenance) jobs (stability or increase). With respect to line operators, the reduction was managed progressively through retirements (and also the incentivised ones), as discussed above.

> *The robots are useful because where you used five people you now use one or two robots, especially in stamping. (…) Automation requires more maintenance personnel. [DACIA_4]*

A share of manufacturing jobs is reserved to people with "reduced capacity to work", either because they have a specific condition, or because they have gone through accidents.

> *We pay special attention to these people in manufacturing. In stamping we had in the beginning 450 people with this, now we have 250. We kept a special focus to identify adjusted work stations, work that they can do [DACIA_9].*

With respect to the reduced number of line operators, in Dacia the significant negative impact of automation on job losses was mitigated through a planning aimed at identifying dismissed positions and compensation strategies through the allocation of workers to different tasks (80%), together with incentives to retirement for people approaching the age of retirement (20%). In 2013 a dedicated team – Integrated Factory Automation (IFA) - was set up to coordinate the automation process. The team was made up of engineers, maintenance, mechanics, and all sorts of technicians. When the process was defined and ready to be implemented, communications of the potential occupational changes started 6 months before the implementation of automation. One-to-one agreements were implemented, also for specific training devoted to blue collars workers. IFA worked jointly with engineering and the local IT team. During this process, the number of employees went from 6593 in 2013 to 5417 in 2021; affecting both blue and white collar workers [Dacia_9]. With respect to white collars, all the vacant positions were made public available, no matter the level and specific career opportunities were identified for this specific population.

With respect to gender composition, also because a larger variety of task became available for women, a certain diversity (27% women) was maintained.

Training, new job profiles and career prospects

Different interviews, especially in the case of Dacia, underline the lack of qualified profiles for different type of roles within the company. For Dacia, technical complementary competencies can be found in their Bucharest R&D department and in the French team leading the projects [Dacia_3]. In addition to shortage of electrical or mechanical people, at Dacia there is also a shortage of data analysts needed in all departments that currently rely on data analysts located in France, who are able to provide the necessary reports. The lack of internal data analysts does not allow the development of specific reports that department managers would need [Dacia_8].

> *[We have] links with the Bucharest R&D department. We work with them when we have a new vehicle. Then they have teams that come here. It is the case now when we are trying to introduce a new hybrid vehicle. This happens at a certain stage of the project, when we are getting close to manufacturing. We meet them once per week and deal with all quality problems. Whatever goes beyond the plant's competencies (requiring, for example, changes to the product or to certain parts) we discuss with them. Once per week we have Quality Seminars, as we call them. A part of the required competencies is present here in Romania, but not all of them. France is leading the projects [DACIA_3]*
>
> *A big problem now is that there are no fresh people coming. I'm talking about electrical or mechanical people. [DACIA_4]*
>
> *In my team, data analytics is a "best effort" task. We don't have a specialist for this right now. It is Renault's goal to have at least one data analyst in each team such as ours. Even if we don't have one right now, there are data analysts in France who are able to give us the necessary reports. But in the future, we will have a data analyst dedicated to our plant, who can develop the new kinds of reports. Right now, we have a list of general reports requested by all the plants, but in each plant the local manager wants to have some specific reports and for these kinds of reports it's a bit complicated right now and for this reason we will have a data analyst in our plant. [DACIA_8]*

At Ford, three main issues are identified with respect to labour market, company prospects and the national capability to advance: i) the school-labour gap and the need to create an ecosystem (*Technology is developing faster than the University manages to train people [FORD_3]*); ii) the increasing complexity due to automatization/robotization and required skills for new positions to be hired (*one example: no skilled people for PLCs [ibidem]*); iii) the development of strategies of internal and continuous upskilling.

> *New technology: there are even some disadvantages since new technologies require very skilled people. We have this problem in Craiova: we cannot find skilled people on the market. Technology is developing faster than the University manages to train people. We have a big problem with this. One example: no skilled people for PLCs. [FORD_3]*

Given that the labour market appears to be quite tense for technical profiles, such as Robot programming and digital skills, training programs are defined over a time horizon of in ten years, as in the case of Dacia (with *a list of competencies that is a mix of what we need today and what we need tomorrow* [Dacia_9]), also considering the new needs related to electric vehicles.

> *We have a list of competencies that we are looking for in every profession. This list of competencies is a mix of what we need today and what we need tomorrow. We are taking into account requirements that are visible right now, not theoretical things we cannot say anything concrete about. A very good example concerns electric vehicle competencies. Now that we know that by 2035 EVs will rule in Europe, we are adjusting our views. [DACIA_9*
>
> *These are EU funds, the budget is of about 1 M EUR (50% co-funded by Dacia) for 24 months, we finish next year in July. We target 1000 employees. We use external training providers (like Bosch, Siemens, UiPath;), and Romanian providers (UiPath have software teaching how to program robots). They share Romanian talents Renault worldwide.*
>
> *When you are hired you go to a basic training. You go to the Dojo, then you go to on the job training. [DACIA_4]*

For a new automation engineer, you need at least 6 months of training in order to be sure you can rely on him. [DACIA_7]

Training and retraining for workers are provided for new projects with some varieties (from training on the job and online courses), with no contribution paid by the workers (EU funds are used). More complex training courses, as in the case of maintenance workers, are done by external international expert organizations - like Bosch, Siemens, UiPath - and Romanian providers. Collaboration with schools and Universities.

For blue collars, in terms of training and induction, we had schools of dexterity, to get accustomed to the new jobs, and on-the-job trainings, plus one-month follow-ups to see how they are adjusting. [DACIA_9]

The plant invests a lot into people, they make us thing in terms of cost savings, performance. There are a lot of trainings. Before we used to do the trainings in person, but now they are online, and we can access many trainings. [DACIA_1]

Training is covered by Renault. There is no contribution from the employee. Training is also done during working hours. Very, very, extremely rarely we do [in house training] outside the working hours. This doubles our investment, effectively. [DACIA_9]

In Ford, training and retraining for workers are provided both internally and externally (supplied by the parent company Ford).

Ford started with us nearly from zero. We received 25 trainings on Ford Production System (FPS), they teach you how to understand the FPS, how to approach, how to work with the tools, how to understand operators' needs, how to build a business plan. As an area manager, you are responsible for all the metrics on safety, quality, delivery, cost, people, maintenance, environment and launch (….)

Training for maintenance people: 1) based on the equipment, you can buy vendor training; 2) on the job training: to know how to debug a line, to diagnose a fault, for these you need to see the line, to see the robot on the line, that is more difficult. You need robot training, PLC training, IT skills, so you need to put together 5-6 types of skills in order to understand what the problem, find the solution and restart things [FORD_2]

Both in Dacia and Ford, maintenance workers are always cited as crucial.

In Dacia, the role of maintenance workers results to be crucial since these workers, that organize in teams and are present in all departments, are constantly required to intervene when the plants stop working.

The tricky part is the maintenance. Maintenance is usually a separate issue [FORD_2]

In maintenance, people are the key. With skilled people you get fewer issues, faster and better results [FORD_8]

as in the case of Dacia (with *a list of competencies that is a mix of what we need today and what we need tomorrow* [Dacia_9]), also considering the new needs related to electric vehicles.

In Dacia, specific career paths are provided for line operators to support their internal career (acquire skills to become team leaders, supervisors, etc.)

We have here in the plant this possibility of career development. If someone wants to grow, the plant helps them grow. [DACIA_1]

Moreover, a specific program called "Democratize mobility" within the factory is supported by DACIA management to specifically reduce barriers for women (see below), but also to allow all the potential technical workers to apply for a different position.

For the white collars, we had all positions published, no matter the level; we identified career opportunities for this specific population [DACIA_9]

In Ford, the company supports career mobility and progression, and specific plans are devoted to female workers.

It is something that is very common in Ford that we look for people with aptitude and encourage them to evolve. In the UK, you can certainly start as an operator, then go to maintenance, and skilled maintenance people can become engineers. It's a long journey and not everyone starting as a line operator will become an engineer. That idea that you are not pigeon-holed in one category of employment, but if you show potential the company will encourage you to evolve. I and most of my Ford colleagues have had opportunities to evolve. [FORD-10]

Notwithstanding to the increasing automated and digital tasks, several skilled operations are still done manually, such as quality control. Interviews at Ford mentioned that they use a machinery that assists people in pre-identifying defects, but then people have to check for defects and fix them. Moreover, automation on visual inspection is easier for straight surfaces. If you have irregular surfaces, machines will have trouble adapting, while for people it is very easy. Machines also have difficulties to learn to distinguish between defects that might look the same but they are very different, while people learn this very fast. Same with the decision process: which parts are still OK, and which parts cannot be accepted. [FORD_8]

Workload and standardisation of the process

Both in Dacia and in Ford, the trade union does not provide a narrative of the overall impact of automation as having a major change in work organization, apart from macroscopic changes in some areas - in stamping or the body shop – that are now fenced off. At the same time, evidence was found over the increased pace of work due to automation, as in the case of the adoption of AGVs that now supply the lines with parts and components, with no breaks.

In general assembly, there was an improvement in terms of flow, with fewer delays due to AGVs that now supply the line with parts and components. Due to these vehicles, the supply of parts to the workers became streamlined, with reduced delays and a continuous work flow. Overall, positive things that people had to get used to. [DACIA_10]

… before the AGVs, because of the delays, workers had some dead seconds where nothing was happening. Now this has been eliminated and workers are forced to work all the time, without these small breaks. [DACIA_10]

In both plants, the reallocation and reduction of tasks within each job, due to the adoption of automation, is accompanied by a compression of the takt time, i.e. the time needed to produce a single component or the whole product. This brings to higher labour productivity and to higher intensity of the overall process. Evidence from interviews in Dacia confirm this point, highlighting their good performance in comparison with other plants..

The line can produce 18 parts /minute but the other plants never went above 15. Romania is the only one who achieved 18 [DACIA_1]

Automation has also increased the pace of work also for those jobs where there are people working – this depends on the specificities of each job, though. The overall speed has increased. [DACIA_6]

In Ford, the saturation of the overall process, is reported to be equal to 80% (maximum 90%), and there is a continuous effort in increasing productivity, looking *at every single item*

Automation has also increased capacity, and this has also meant an increase of the speed of manual labour as well. Effort intensity increased for workers [FORD_3]

Productivity, we need to increase productivity, we need to look at every single item (not necessarily robots, cobots or things like this), even the smallest things, we have to identify opportunities; even if an operator travel takes 7 steps to a shelf and he can take 5 or 6 we need to address this; automation is good for productivity, stability, quality. (…) Efficiency needs to be considered continuously. Every year we are achieving 7% efficiency improvements. [FORD_7]

Moreover, in both plants, the pursue of an increasing standardisation of tasks in the production processes aimed at increasing productivity and reducing errors also determines a reduction of operators' autonomy and discretion.

The welding process is not that complicated. The time of each operation of about 80 seconds, however depends on the geometry. In 90% of the cases, the operator goes to the same spot. There are groups: your team has 20 jobs and 20 operators and every operator goes to his own position; only in the situation when someone is missing there is someone else taking his/her position. [DACIA_4]

We tried to increase production capacity. To be efficient you need to produce at max capacity. To do that you have to reduce cycle time: from one car every 60 seconds to every 54 seconds. For this, you have to split the operations in smaller and smaller pieces, which means one operator has to do fewer and fewer operations. [FORD_9]

I think this is due to both automation and to the targets set by the company. …automation is not a determining factor for the routine character of jobs, but it did have a role in increasing productivity (and the pace of work, therefore). [DACIA_10]

Interestingly, the high workload does not seem to incentive workers to change jobs in the case of DACIA. According to some respondents, this can be explained because the increased specialisation produces a lesser effort that would be otherwise needed in case of changing the job position and related tasks.

Due to the high workloads, people mostly work, function like robots. This has to do with the very high workload. Because of this, people do not change jobs. It's not that they don't want to. It would be better for them, for the sake of diversity. But workloads are so high that people have become highly specialized in specific tasks, they have gained the necessary dexterity to do this very quickly and without quality problems. So when a person like this is missing, even two people are required to replace him/her because of the level of habituation which that person has acquired over time. [DACIA_10]

Job rotation schemes and teamwork

In general, the interviews highlighted that the adoption of automation has different impacts on the way different tasks are organized, in particular for what concerns the adoption of job rotation scheme, the empowerment of roles such as team leader and supervisors. New requirements in terms of skill development emerged given the companies' plan of hiring more automation engineers and maintenance personnel.

In Ford, the impact of adoption of automation on job rotation scheme and the empowerment of roles such as team leader and supervisors was quite significant. Indeed, as underlined by the respondents, changes in work organization models also led to a modification of distribution of tasks and to the creation of new linkages across different departments. Changes in work organization. Initially, maintenance was a separate division. Later, with Daewoo, maintenance was part of production under the same area manager. When maintenance was a separate division, they focused on the equipment and did not care about production, they did not care if there was one less vehicle produced. Once they moved under the same manufacturing umbrella, they had to care about production. [FORD_7]. In Dacia, specific importance is attributed to job rotation for defects fixer, since it is acknowledged as being a way to actively learn about different types of defects to be fixed. The relevance of job rotation is also stressed with respect to the maintenance team because of the greater flexibility it allows.

Rotating jobs: polyvalence. In maintenance, we don't rotate jobs, but we rotate teams, so they get along with each other better. [DACIA_4]

But, according to the trade union, job rotation is very difficult for a line operator that must switch jobs and always ensure a certain level of performance.

Due to the very high workloads, people have become so specialized, so accustomed to specific jobs, that it is very difficult for someone else to come in that job and have the same level of performance within a reasonable amount of time. [DACIA_10]

At the same time, the union encourages job rotation for health-related reasons: mental health and also the physical issues that appear due to the high workloads.

Interestingly, interviewees in Ford report that line operators do not seem to prefer job rotation and that there is in general a "resistance" to the adoption of these models of work organization, despite these are particularly useful to allow workers' replacement etc.

> *Periodically, we rotate the operators to jobs with different movements, more comfortable jobs, or based on medical restrictions. If you have an injury and you can only work on the first shift and you are not allowed to carry parts heavier than 5 kilos, we need to accommodate you and rotation is a solution. Team leaders have a versatility matrix that they update periodically (once per month or every time when they train an operator). [FORD_2]*

> *I tried to find a way to regularly rotate people. You would be surprised that they resist this. They prefer to do what they know how to do very well even if it is repetitive, instead of moving and doing something else. I have difficulties in making them understand. For us it's also good because if someone is missing then we have someone to do that. They resist from the beginning [FORD_9].*

In both plants, teamwork is particularly developed across the most qualified workers that endow specialised knowledge (such as mechanical, electronic, electrical and software programming) and that rely on cooperation to solve daily issues and maintenance problems.

> *The IT department is separated in two teams. One team is the expert team: network, server, workstations. The other team is in charge of the maintenance of all the equipment installed in the manufacturing and supply chain areas. The maintenance team works in 3 shifts, just like the rest of the plant. A few years ago, this team didn't have knowledge of working with tablets but we did training with them and now they are capable to do a complete installation for an iPad for an Elo Touch tablet (the workstation tablets, which have to be more rugged). [DACIA_8]*

> *So, maintenance is a teamwork, with specialized but overlapping skills. [FORD_2].*

> *Organization of the maintenance team: by department, but if there are problems that a team in one department is not able to solve they ask colleagues from other departments. [FORD_3].*

Several collaborations across different departments are fostered to increase both cooperation and transversal training.

> *Three years ago they set up an integrated manufacturing team (IMT) in body shop, engine plant. In the process of setting this up in assembly. Base operators have the chance to learn more, they are introduced in training programs and learn how to operate robots. It's a collaboration between maintenance and production. [FORD_6]*

However, more skilled operations are done manually

Quality control is done manually. There is machinery that assists people in pre-identifying defects. People have to check for defects and fix them. Automation on visual inspection is easier for straight surfaces. If you have irregular surfaces, machines will have trouble adapting, while for people it is very easy. Machines also have difficulties to learn to distinguish between defects that might look the same but they are very different, while people learn this very fast. Same with the decision process: which parts are still OK, and which parts cannot be accepted. [FORD_8]

Job quality and type of job contracts

In both plants, the main improvements concern the ergonomics of both automated and non-automated line tasks and the elimination of risk.

> *For the first press in all the lines we must reverse the part. In 8 hours, to make 3000 parts, the roof of the cars is very heavy. I did this for 2 years. The first robotization we did was for this press, to eliminate this risk. Safety is an important issue. At this moment in our department, we no longer have red ergonomic jobs, for which operators have to change every two hours because of the physical load. [DACIA_1]*

We started with 6 robots. Today we have 100. We have the responsibility to improve the work process, to make work easier for our colleagues. We focused initially on high-risk areas; the solution was only to automate. [DACIA_2]

Reduction of repetitive tasks is also underlined in some interviews

The routine on the assembly line it's astonishing. When I was validated here in 2009, I had the opportunity to work on the line in assembly for one month. It's horrible. You are basically a robot, without knowing it. You have to know the operation and all day you do only that. Imagine doing that for 30 years. I don't imagine myself doing that and I don't want to imagine people doing that. That's why we have the technology. [DACIA_4]

Reducing repetitive tasks was a main driver of automation after stamping. In the assembly line in the vehicle plant, we still have a low degree of automation. We are now focusing on what we could do in vehicle assembly. People still work like mini-robots there. [DACIA_9]

Also in Ford, improving the working conditions is reported to be one of the main goals pursued by the introduction of new automation. In painting, for example, working conditions were particularly harsh, before the full robotisation of painting tasks implemented in August 2022.

If I would have money, I would automate both immediately [referring to painting booths]. It is the worst place to have people [referring to painting department]. These are really difficult working conditions. There are no women there. They have a 15% higher salary, the workers working in those areas. [FORD_1]

Concerning job contracts, we found a reduced number of temporary workers, whose use seems to be related to uncertain prospects of the automotive sector rather than technological reasons.

In Ford-Craiova: fixed-term employment is about 10% decreasing. It is justified by HR is a way to cope with changes in demand, which in the past had seen a forecast development in production (and a considerable increase in new hires), only to have to reduce employment due to the contraction in sales. In Dacia Mioveni, fixed term contracts represent about 13% of directly productive employees in the vehicle plant, no specific target on women.

Temporary agency workers: not many, between 70 and 100 people; they work on the line, they fill some gaps; this is a buffer to have some flexibility and avoid overmanning. They are trained for 2-3 days in the beginning and then they go on the line [FORD_1]

Today, in Dacia-Mioveni, around 700 people are on a fixed-term contract (or agency work) [DACIA_10].

Gender aspects

The share of female employment increases significantly in Dacia, equal to 32% in the overall context of contraction of employment. Some departments, like stamping and maintenance, record a very low participation of women whereas in other their participation is much higher (i.e., painting), even though in some cases the working conditions are hard.

It's not very common to see women in maintenance. In stamping technical staff, we have 3-4 women, while in manufacturing, there are many women (27%). In maintenance, only 4 out of 200 (TESA staff – white collar, including all technical staff). This is not a pleasant area; it's noisy, they were not there from the beginning… I'm not talking about engineering – that's entirely different and there are more women there. In maintenance we have 3 women, and I am one of them. Maintenance is difficult work, it's very technical. […] There are not that many female university students looking for this kind of job." [DACIA_2]

There are women in the body shop, but not many. It depends on the task. Women are more conscientious; they are more careful. The welding guns are big and heavy. If we have women welding in manual stations, it means small parts and small guns. We don't have many women in the body shop. In the paint shop, it is mainly women. They have to do the sealing, which requires dexterity. [DACIA_4]

In Dacia several interviewees state that there are no barriers to career of women. The collective agreement allows women to temporary change their full time to part time job until the kid turns 7 years old.

> *No identifiable impact on the employment of women. No increase in the number of women due to automation. [DACIA_TU]*

Respondents also refer to the choice of the company to have a specific focus on women at the frontline through diversity commitment, and several initiatives: to enhance their awareness level, to "democratize mobility" with potential greater impact for women, to enhance health and maternity benefits as a leverage to attract women.

> *…we did a survey to understand how women feel in the workplace, what prevents them to advance in their career, and improve at work. We generally got the standard answers, except for two: they said they don't feel self-confident enough, this combined with the fact that they are more modest than men, they do not raise their hand to ask for promotions, they expect that promotions are given only as a recognition of merit. [DACIA_9]*

> *We have changed our internal mobility policy. Until 2-3 years ago, you would be moved to a new job based on decisions of the career committee, which was made up by humans. We wanted to change this, "democratising mobility": now, every available job in the company is posted publicly and you can apply freely, without asking your manager for approval (this was not the case before). Now we see more women applying for jobs. In conjunction with other programs we do, we see an improvement. [DACIA_9]*

> *We also have a medical services pack that is over what the market offers for women. Maternity leave benefits that are very specific to women, that other companies do not offer. We used this in order to attract women on the labour market. [DACIA_9]*

Woman are targeted in the diversity programs and specific attention is devoted to technical positions of women providing them ad hoc seminars and also context for networking (at industry level, in engineering and IT positions, at company level)

> *We set a target to have a 50/50 gender balance in recruitment, including for interns. This is very challenging, especially for technical functions. […] On top of that, we created Women in Industry network. This covers women from all industry jobs. We also launched Women in Tech, which includes engineering and IT. Then Women@Renault Romania. We are trying to make sure that women are better prepared to apply for jobs [DACIA_9]*

> *A Romanian-global network of several hundred women. Under Renault Group, Dacia signed the EU Diversity Charter that had been already signed by other Romanian companies (also SMEs). We organize a lot of webinars for all women. We don't take into consideration their managerial level. Every year, we organize a diversity gala, with 3 categories: excellence on the job (rewards for women at all levels, including manufacturing); women leadership and involvement in diversity (involvement of women in supporting gender diversity in their department); he-for-she (rewards for men's involvement in promoting diversity). [DACIA_9]*

Although a management plan targeting gender inclusion is very detailed, from the union perspective, there is no identifiable impact on the employment of women and no increase in the number of women due to automation is reported.

In Ford, 45% of employees are women (overall share, not referred specifically to manufacturing). It is acknowledged that women struggle with career progression, even though there are specific support programmes for access to team-leader positions.

> *We pay extra attention internally and we have a target to promote at least 3 women in each department. We give them trainings in order to be prepared for an interview to become maintenance/manager/leader. We try to give them confidence. It's not always easy, they don't always feel comfortable. They say the supervisors are men and they become afraid. We encourage them not to be. There is significant improvement over the past years in the presence of women in maintenance, manufacturing (higher functions) and management. [FORD_2]*

Automation of heavy tasks determined an increasing participation of female workers in departments that before were male-dominated.

> *In the 1990s, the body shop was a manual shop, using welding guns, which could weigh as high as 200 kilograms; very heavy work; no gender equality. At that time, the body shop was 90% male and was the most difficult one in terms of workload and working conditions; Automation started in the framing line, but it was limited. When Ford came, we started automating more and more. With the B-Max in 2012, 90% of the body shop was automated. The workforce started to change. Now it's 50/50 in terms of gender balance in the body shop. Operations are now easy, they just load parts, the robots do the work. Even for the big parts, they are also automated. Some jobs remain where people have to lift heavy parts, but they can use "manipulators" (small crane, electrically activated), so women can do those jobs. [FORD_1].*

Industrial relations and the role of trade unions in the process of automation

The degree of unionization at Dacia is at around 75%, covering all types of employees. Most union members are blue collar workers. Temporary workers (fixed-term contract employees) are also union members. 3 people are employed directly by the union. The Union involves not only workers in DACIA but also those employed in the Romanian supply chain. In fact, there are 34 union organizations (departments within the union), out of which 22 at Dacia and the rest with suppliers. Among workers' representatives within the plant, there are the group leaders on the shop floor. These workers cover a crucial role, since they know what is going on in each department or part of the plant. The group leaders have the right of 2 hours per week that they can take off work for trade union affairs. The organization leaders have 2 hours per day, within a 40-hours per month limit. They can use this time whenever they need to, just by letting the department management know. These trade unionists are those most involved in taking care of the nitty-gritty aspects on the shop floor, not the top leadership.

In Dacia, the main activity of the union concerns bargaining and the stipulation of a collective agreement, together with its implementation. Dacia has a lot of training programs, but the union are not involved in this.

> *…, but in the future they might become more open to this possibility. [DACIA_10]*

Trade unions are careful in ensuring that all those rights and provisions stipulated within the agreement are then applied and respected by the company. Moreover, the union was reported to be very involved when it comes to job content, working conditions, health and safety (there is a special committee for this). Practically, the Union is involved in all the decisions taken by the management. From the interviews, it emerges that trade Union tries to play a constructive role, being at the same time the critical voice, ready to sanctioning whatever problems might appear.

> *The management has learned over time that in the end we have a positive contribution and that we are not an obstacle. [DACIA_10*

> *We ensured early and transparent communication, to the teams and also to the unions, who are strong and sometimes loud partners. [DACIA_9]*

At present, a general concern for trade unions is due to inflation (over 15% inflation in October 2022). Workers' purchasing power has been negatively affected. Finding solutions to this issue is perceived by trade unions a priority and significant concerns were expressed with respect to the winter months.

In Ford, the rate of participation in the union if 5.500 out of 6.000: 92% of the workers. Only mangers are belonging to another small union unionized. Typically, the management is not unionized. They are not given permission by the top to be part of the union [Information provided by FORD_4]. Concerning their direct involvement in the process of adoption of technologies, their participation in Dacia was of two kinds. The first was to make sure that automation took place at the right pace, such that its social impact would be limited. They knew they had several retirements and voluntary departures and they wanted to make sure that the job displacement and replacement due to automation occurred at the same pace as these departures from the company The second type of involvement consisted in targeting those processes and those jobs that involved certain problems in terms of working conditions. Particular attention was devoted to difficulties in terms of health and safety, physical stress

for workers. The paint shop booths are an *example on departments in which* automation, mainly introduced to reduce costs of production, also occurred in order to improve working conditions.

Similarly, the plant union in Ford seems to be inspired by cooperation with management and does not report significant problems that could give rise to conflicts. At the same time, they seem to play no role with respect to the implementation of automation.

> *The trade union requests more breaks, but the law is always respected. [FORD_3]*
>
> *Trade union involvement? The union would object if people would be dismissed. But we never dismissed people because of automation. We don't have any discussion on automation with the union. We discuss working conditions, wages, transport costs, but not automation, because we are not dismissing people. [FORD_1]*
>
> *The union has a constant struggle with the management on work quotas, because people work more than they should. [DACIA_10]*

The union members can file complaints, if the job is too difficult, if the workload is too high. Then the union does an analysis together with the management to identify the issue and find solutions, and sometimes even contributing to designing new job positions. In general, trade unions action is strongly focused on avoiding excessive workloads for workers.

> *Trade union consultation on the line's speed? No. If the headcount is aligned with capacity and cycle time, the union cannot complain. The union has this information. They check so that the speed is not changed without them knowing. If we want to increase the cycle time, we would have to put additional people on the line, otherwise it would not be possible. The union should make sure that the workload for people is not larger than what we agreed and that the speed of the line is not increased arbitrarily. [FORD_9].*
>
> *When workers file a complaint, we do our own preliminary analysis in the field in order to see if the complaint is justified. Then they discuss with the management and the management does supply them with any technical information they might have. The union does not have access to this information whenever they want, but only when they identify a specific issue. They look at the standard operating procedures, at the actual operations/movement that workers have to do, they also look at data collected by people in charge of time management. It's not very rare that they find that the standard times set by the management are not realistic, that they are below the real times required. In certain situations, the union has managed to even create additional jobs through this sort of effort, by showing that certain operations are impossible to do for a human being within the set times. When they did this with multiple jobs, they were able to create a new job by taking parts from multiple jobs. It's a complex process. So they do not have access to the management information all the time, but only when an issue arises. [DACIA_10]*

Concerning gender issues, the trade union seems to be keen on these topics, particularly for what concerns women increasing participation.

> *The union is promoting gender equality; they encourage women to take jobs in production because there no reason to not to. [FORD_4]*

Drivers, barriers and constraints to automation and technological upgrading

Working space and facilities

One relevant issue concerning the adoption of robots is the need of adequate facilities to ensure the most efficient operation of robots in terms of space and safety. Indeed, robots need more space than analogous manual operations, because of room of manoeuvre and because of safe separation of robots from operators. We found evidence about the need of reorganizing working space in both Dacia and Ford.

> *In 2000, we had a new organization, we replaced spare parts and everything worked properly; it was an organizational and logistical change, primarily; the purpose was to have a process that worked properly, similar to other Renault plants; we also changed*

the floor. We reduced the number of presses to have enough room, the cranes were changed, a new conveyor belt in the basement (for scrap). [DACIA_2]

Moreover, different types of robots are deployed in different departments.

We don't have cobots in the body shop; we have robots that work with people, but they are protected and don't work together directly, like in assembly. In the body shop we have big robots, not like in assembly. [DACIA_4]

When you replace people with robots, you have to change the way the working area is set up. You have to fence it, do various things. [FORD_1]

The choice of technology providers and the implementation of automation

The choice of technology providers seems to be quite different in the two plants and the implementation process of automation presents some important specificity in the plants under study.

In Dacia, technology suppliers are identified directly by the company to meet the needs of implementing or adapting existing technologies. The robots in stamping at Dacia-Mioveni are from various suppliers (ABB, Fanuc, Kuka, …) as they were gradually chosen for their flexibility and efficiency characteristics, according to the specific needs of the company.

In Ford, technology suppliers are selected by the parent company: all robots in the stamping and body shop are ABB, which has an agreement to supply robots to the Ford group. But further implementation of automation (engine department) is defined internally at the plant.

At Dacia-Mioveni, the implementation of automation in the stamping department has been done in-house by experimenting with the best solution, given the technical characteristics of the large presses already in operation. The company in Romania, which certainly learnt from the experiences of the Renault group, had to develop solutions internally to make the implementation possible (without dismantling the presses already in use). This strategy turned to be effective since the workers responsible of these choices have and taught stamping automation in group plants in countries where the automation process had not yet started (Morocco, Spain[2]). The robotization in stamping has been gradual. It started in 2013 and it was completed in 2020[3], reaching 74% of robotic operations[4]. Concerning the workforce, Dacia employs in the stamping department 756 workers, whose average age is 46 years old and 32% are women. After the initial implementation of automation, the work became 2 weeks/line.

Among the gains reached through the introduction of automation technologies, we can list no turning of parts, no red ergonomic stations in stamping and a progressive saving in the realization of in-house robotization[5]. Productivity gain 85 posts and a reduction of retouched parts of 6% was recorded.

In general, the implementation of automation technologies strongly relies on the interconnections with the various DACIA plants in Romania (specifically the IT department in the Titu R&D plant) and within the Renault group.

Romania is an engineering hub for the world, we are doing even work for Nissan in Japan. When you go to our engineering centre in Titu, you see engines from all over the world. We use virtual reality for designing and testing vehicles without building physical prototypes. This is a major innovation in terms of automation and digitalization. It has saved us a lot of money, but it has also required a lot of adaptation. [DACIA_9]

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[2] The Dacia team supported the Cordoba stamping plant in setting up a robotized production line and transferring business skills for the integration of 31 ranges. Source: Dacia internal document, confidential C.

[3] *Ibid.* In 2013 it was initiated by installing a new stamping TGSE line, in 2014: ILOT cutting and ILOT MP; 2015: 3 GP lines; in 2016: 2 TGP lines and 1 GP line; in 2017: 1 GP line; in 2019: 2 MP presses; 2020:2 HS lines [make clear acronyms: HS=high speed; GP=large presses: ILOT are the 'islands' with cutting machines, or presses]

[4] *Ibid.* Pace: 290,000 pieces/day; 5.8 million pieces/month. Structure: 3 manufacturing workshops: 9 robotic lines (4XL / 5L); 4 manual lines (2MP / 1PP / 1L), 1 press & tool maintenance workshop.

[5] *Ibid.* The activity done in-house without external suppliers has involved *IFA team*, Internal maintenance of tools and presses, Engineering and Manufacturing.

At Ford-Craiova, the stamping plant is fully automated, but from the interviews it was not possible to gather specific information on the automation process in this department (which we were not able to visit and for which we did not conduct specific interviews). If it was similar to the automation of the other departments, the impression is that it was a reorganization of production that followed the indications coming directly from Ford, which uses its own organizational expertise (Ford production System) and makes use of the world network of technology suppliers that are a reference for all companies in the Ford group. In such context, the knowledge at plant level is a lever for further implementation of automation technologies, such as Automated/Automatic Guided Vehicles (henceforth, AGVs)

> *Initially we used AGVs from suppliers, we asked them to implement them (two parts: AGV itself and implementation costs; all was done by them). Our plan is for implementation to be done by our team. Our wish is to assemble the AGVs here, in order to be able to customize them as well. Data exchange with suppliers is regular, but we know very well the implementation process, so we want to do it ourselves in the future. [FORD_5]*

Discussion and conclusions

The empirical evidence from the two case studies has provided insights into the impact of automation on work, with information provided by managers, technical staff and trade unions. The missing perspective is that of the workers employed in the two factories: in both cases it was not possible to interview workers, an issue that should be addressed by designing an ad hoc case study. With this limitation in mind, we focus on four main theoretical and empirical issues that emerge about the impact of automation on work at the company level in the two case studies: the rationale for the process of automation; the multiple and potentially divergent impacts of automation on employment; the gender dimension; the role of trade unions in the process of technological upgrading.

The rationale of automation

Concerning the first issue, the most relevant reasons behind the adoption of automation seems to be the need of increasing the efficiency of the production process through a reduction of costs. Secondly, the goal of improving working conditions and, thereby, work efficiency in the short and medium term is usually advocated. Several respondents underline how it was possible, through new technologies, to improve ergonomics for individual tasks, reducing the risk of heavy (as in the case of loading large sheet metal parts for stamping), dangerous (as in the case of welding), harmful (as in the case of painting) and repetitive tasks (as in the case of certain assembly operations). The process of implementation differs across the two companies, such as the strategy adopted to face constraints and potential bottlenecks in the introduction of automation, such as managing the relation with technology providers and the development of automation software. Both plants report the need to enlarge their facilities to meet the need of growing spaces to deal with automated technologies. In fact, they declare to have gone through a rationalization of the space to allow not only room of maneuver, safety conditions of work (right distance between workers and robots), but also to facilitate and increase the interconnection across different departments and suppliers located nearby the plant (or integrated in the plant, as in the case of Ford). The automation process observed in the two plants result to be closely linked to the digitisation. Even if information and communication flows are managed differently in the two companies, in both cases, automation seems to enable the collection of data used for failure/wear prediction of robots/devices parts and components.

The choice of Dacia Romania to progressively adopt new automation technologies came in a relatively independent way from Renault. The automatization of the stamping department (loading and downloading presses) involved a significant innovative contribution of the technical team in Dacia which was actively involved in solving technical problems. Indeed, the successive implementation of robots on other presses was done in shorter amount of time thanks to the learning effect of the initial experience in the stamping department. All complementary parts were acquired by technical suppliers but then internally defined and assembled, according to the specific needs of the plant. Renault was generally supporting automation with the technical support of robots' suppliers, ABB, who, however, was not able or willing to adapt their robots to the specific layout of the presses in Dacia. To overcome these constraints, both programming and internal simulation of robots' specific operation were realized internally at Dacia. Afterwards, the supplier (ABB) technically confirmed the process and observed results. Once implemented with success, the technical solutions elaborated in Dacia

Romania have been applied in other Renault group plants in Spain, Morocco. The process of adoption of automation technologies has been, therefore, gradual, and progressive. Learning mechanisms and cooperation among different teams have played a fundamental role to ensure an effective implementation of new technologies. According to Dacia's Trade Union, there will not be a significant increase in the degree of automation: it is technically difficult to implement, due to the very high diversity in the plant (and significant issue with the return on investment in this case). Human labour is much more flexible than robots.

Differently from Dacia, in the case of Ford the adoption of automated technologies was directed by the parent company Ford which maintained a certain control over the implementation process. Several training courses based on the Ford Production System (FPS) were provided and in different occasions mutual support and cooperation was put in place across the different European units (i.e., Ford Europe Innovation Team). Therefore, the change in the ownership structure with the entrance of the Turkish Ford Otosan - also considering their technological capabilities and autonomous production of components - will be a crucial step for the future of the company and for further implementation of automation.

Impact on work

Concerning the second issue, namely the impact of automation on work, framing any conclusive statement is very difficult, since several issues need to be considered simultaneously. We have identified multiple and potentially divergent impacts of automation on employment, looking not only at risk of displacement, but also at the change in the occupational composition and work organization.

In terms of work organization, we found evidence of increasing standardization aimed at rising productivity and consequent reduction of autonomy and discretion in the way workers perform their tasks. At the same time, important improvements in terms of workstations' ergonomics and safety have been successfully reached thanks to the introduction of robots performing the most dangerous and physically demanding tasks. Nevertheless, it is not possible to estimate the overall impact of robots in terms of jobs displacement, since the internal composition of workforce is dynamically changing over time, as showed by the increasing need of maintenance workers. The companies' training programs were specifically set to enhance internal mobility but also to support workers' dexterity, a crucial issue in a context of very high pace ow work as a consequence of automation and lean production.

A significant reduction in the proportion of line operators, was recorded in both companies, while the demand of other job profiles increased significantly. In particular, maintenance jobs and IT jobs result to be very important. The former represents both the skilled part of labour in the automated processes and a specific object of production process optimisation. The latter becomes pivotal with the progressive integration of the Lean production system with robots and automated devices that makes digital technologies an essential component of machines-human interaction. However, their pattern of growth differs across the two companies: while the demand of maintenance work seems to be widespread and common to both companies, the need of IT jobs seems to diverge more significantly, as it strongly depends on the degree of integration of digital technologies within the production process. Both companies support career progression both for line operators and managers. These plans represent a proactive solution to a shortage of skilled workers in the Romanian labour market, with secondary education not supplying enough educated workers in STEM. For instance, managers interviewed during the field study all have spent their entire careers at Dacia or at Ford. Most of them entered with an engineering degree or even as line operators, studying during their work, some of them complementing their professional competences with a master's in business administration or EV engineering.

As in the case of Dacia, the adoption of automation in the Ford plant has determined both an improvement in working conditions (increasing ergonomics and safety) and in productivity (i.e., reduction of the cycle time and rising saturation of the process). Lean oriented practices such as job rotations are introduced, but still face some resistance from workers. Concerning gender, also in this case, the company seems to be keen in promoting gender equality and the progressive introduction of automated technologies played a role in lowering gender segregation in specific departments.

In the case of Ford, the scarce success of the T-max in 2012 had important consequences in terms of dismissals and successive hiring strategy. This trend was then inverted by the more successful launch

of the Eco-sport model in 2017 and Puma in 2019. Given this continuous hiring process, the average age of workers employed in the company is lowering with potential positive effects in terms of productivity and active involvement. Young workers are described in fact as more opened to the use of new technologies. Due to previous experiences, temporary job contracts seem to be preferred as entry contract in the company, even if their use is subject to specific thresholds defined with the trade unions. Indeed, workers' representatives are reported to have a collaborative relation with the management on what concerns working condition and employment outlook, even if there is no space of bargaining on technologies.

The gender dimension

Regarding the gender dimension, it is important to stress the share of female employment increased significantly in the overall context of employment contraction. In Dacia is equal to 32% of the total workforce, while in Ford, 45% of employees are women. In both companies, the lack of any form of discrimination was underlined (consider also that the Romanian law on maternity leave supports women at work in an effective way.) A side effect of improving ergonomics due to automated technologies is an increased possibility of women to be employed in departments like stamping, that traditionally had very low female employment rate. If any, in the short-medium run the potentially positive impact of automation on maintenance jobs will not directly affect female workforce in these tasks: in both Dacia and Ford, women are less than 5% of maintenance workers, but an increasing demand (planned in the HR management development plans in both companies has to cope with the relatively lower access of women to STEM (science, technology, engineering and mathematics) vocational training and education that unbalances the supply side. Internal career paths (from line production tasks to maintenance tasks) seems less attractive for female than for male workers. In general, automation has fostered an increasing participation of women to those departments that were recording a lower number of female workers. The process of automation, where intended at reducing the need of physical strength and increase work safety, seems to be positively related to increasing female participation. Several respondents in Dacia underlined how the automation of specific phases of the production process turned also into an instrument through which reduce the barriers that were impeding women to access and perform specific tasks. On the other hand, concerning career prospects, the company seems to be keen on developing a more gender-balanced managerial organization, also given the serious need to attract skilled workers that result to be scarcely present in the local/national market. Among the caveats of the interviews, it is important to underline the lack of interviews with line operators.

Trade Unions

Concerning industrial relations, trade unions are reported to play an important role for what concerns risk of job redundancies and excessive workload for workers on the assembly line. In fact, despite their direct involvement in the process of adoption of new technologies seems to be quite limited, they are very attentive and ready to intervene with respect to safeguarding jobs and workers wellbeing

In general, although information is a basic right signed at European level, the union in DACIA does not have access to information on work organization and work load whenever they want, but only when they identify a specific issue due to workers' complaints. The involvement of workers and unions in the automation process is secondary.

According to DACIA' Trade Union, there are three main critical issues: job security, improvement of working conditions, inflation. The number of jobs has decreased due to automation and people have few alternatives on the job market, with reskilling (although very popular in policy debate) has little concrete measures. Improvement of working conditions typically would require investments, but now there is a great pressure about cost cuts. It's difficult if the company wants to cut costs and improve working conditions at the same time. Inflation, a critical issue - not specifically related to the impact of automation on work - is a priority to find solutions for the union members.

3. Case studies of automotive tier-suppliers in Spain

Overview

The automotive sector in Spain

The automotive industry in Spain produces more than 2 million vehicles, being the second producer after Germany in the EU and the eighth in the world. Its production is specialised in passenger cars, followed by commercial vehicles and, at a smaller extent, industrial vehicles.

However, a significant gap in terms of value added emerges with respect to other EU countries like Germany and France.

The sector, that records a high level of automation as it is one of the biggest adopters of robots, is now facing important challenges related to digitalisation, electrification and more generally to the necessity of strengthening its global position, also ensuring the production of high value-added products.

Spain launched in 2016 a specific program – Connected Industry 4.0 – to enhance the introduction and diffusion of Industry 4.0 technologies. The program, that is still on-going, devotes particular attention to small and medium enterprises where digital technologies are scarcely diffused. Important networks of collaborations are developed among industries, universities, and technology centres.

The automotive sector has been chosen by the Spanish government as the first sector interested by the Strategic Project for Economic Recovery and Transformation (PERTE), a national plan aiming at fostering the sectoral degree of innovation and favouring the process of electrification.

At the same time, given its position in the global value chain, lowering costs and in particular labour costs is one of the most common strategies adopted by Spanish automotive plants to attract investment from the parent company. In this sense, high workers' turnover and massive use of temporary and part-time contracts can be interpreted as a strategy to cut on labour costs and better fit with requirements on plants' modernization within the digital transformation network.

Apart from the production of EVs, that is increasing over time, Spain continues to suffer important delays in terms of new infrastructures needed for the twin transition, as shown by the limited number of charging points.

Automation has been introduced over the last ten years with very specific objectives related to traceability, better quality control of the production process and elimination of physical work effort.

However, the overall impact of automation and digital technologies is complex and not uniform. On the one hand, it increased work efficiency and improved ergonomics for individual tasks, reducing the risks of heavy operations, as well as of dangerous, harmful, or repetitive ones. On the other hand, it increased mental stress in some phases of the labour process that remain extremely repetitive and characterized by sequences of rapid and very fragmented operations.

The overall impact on the labour force has not entailed an overall reduction of jobs (modest if any), as opposite mechanisms are on stage with a reduction of line workers and a greater demand of quality, maintenance workers and technicians.

The improvement in ergonomics and working conditions is favouring a rise in the number of women employed in production-related tasks, although it seems that the process of up-grading towards technical or managerial tasks remains still limited for women.

Interviews in Spain refer to Copo Zaragoza - a tier-1 producing car seat padding - and Linde & Wiemann (henceforth, L+W) - a tier-2 company specialised in bending and stamping that realizes welding of subassemblies of car. Both companies, located in Zaragoza, belong to multinational companies, and play a dynamic role in the overall reconfiguration of the parent company in automotive value chain. Further material was collected through a focused meeting at the Cluster de Automoción in Aragóna.

The case studies: COPO Zaragoza and L+W Zaragoza

The interviews with the two Tier 1 companies were agreed with JRC representatives, following difficulties experienced in obtaining interviews with Spanish OEMs, as originally planned by the study design. In both companies, interviewees were selected by the company's management in accordance

with our profile requirements, but interviews with line operators were not made possible. The two company visits were very accurate and informative, allowing the research team to analyse the production process, the techniques used in the different phases, the operations carried out by the workers and those in which automatic machines have already been used for many years.

In addition to the interviews at establishment level, focused meetings were realised to contextualize the two establishments: (a) in the Aragon region and in the development and training policy environment of the Cluster de Automoción de Aragón (automotive and mobility Aragon cluster, henceforth CAAR) they belong to; (b) with respect to the Spanish trade union's focus on the cur-rent main challenges in the automotive sector.

The year 2022 has been very difficult for undertaking a fieldwork research in the automotive sector: two years of uncertainties due to the pandemic, the turmoil of what appears to be the beginning of a new era for sustainable mobility, and a new energy crisis due to the Russia invasion of Ukraine. VW, Ford, Opel, Mercedes, have changed their CEO or president worldwide, as well as in Spain. This year was probably the worst to approach OEMs for a research project. In this context, the interviews to a tier-1 and a tier-2 are precious in as much as they provide significant hints on the ongoing impact of automation on work, illuminating some relevant questions for further research on several issues, such as the different impact of change across the automotive supply chain.

Indeed, these interviews also make clear the need to open the black box of how to approach - in a significant way - a research agenda aiming at informing European Commission policies on the impact of automation on workers. Although it was not possible to interview blue collar workers, the interviews revealed what appears to be a critical issue in the conditions of line workers, first and foremost the precarious contractual conditions associated with extremely low qualification levels. With a turnover rate of 30%, one can imagine that companies are not keen on involving those workers in a survey such as the one we undertook, and neither does the union, which in fact has a low membership base for temporary workers. And, since the selection was made by the management or the trade union, it is hard to imagine that it would be possible to interview workers who move from one job to another, possibly a new temporary contract which prolongs their precarious status by a few weeks. Empirical investigation would require different methods and research tools from those we had at our disposal, which involved very few selected semi-structured interviews. Ethnographic research and action-research would be more appropriate to engage those marginal workers to become protagonist in understanding and interpreting their current conditions and needs.

The unavailability of OEMs to participate in the project is documented by the numerous requests addressed both directly to the management and trade unions of Ford, Volkswagen, Mercedes Benz and Stellantis, to their referents in the automotive clusters (Aragón, Navarra, Valencia), and to the main OEMs' national association, ANFAC. As in Germany, many turbulent changes in the automotive supply chain are taking place in Spain. Working conditions differ in the companies that produce vehicles, "the assemblers", and in their suppliers, as highlighted in the interviews to experts: "working conditions worsen as one moves from OEMs to first and second tier suppliers, but above all they worsen outside the strictly manufacturing sphere, such as in logistics, or in cleaning" [ES_E2]. Thus, in the analysis of the impact of automation on labour, it is important to bear in mind that in Spain a core issue seems to be the trade-off between employment and wages. So much so that, in order to maintain employment levels, the trade union is open to various solutions. One example is the request by OEMs for changes in work organisation to reduce labour costs through increase in the pace of work, as well as changes in the composition of the workforce, with the implementation of a double pay scale. Although illegal, this practice is implemented by applying contracts that provide for lower wages for young people and workers on temporary contracts, as well as the hiring of workers in categories that have a lower wage level. From our interviews with experts, it appears that these changes do not necessarily involve firing people, but merely replacing workers who retire or change jobs to other occupations, with young workers and temporary workers with lower qualifications. Once the plant achieves lower labour costs, it can be a candidate for attracting investment from the parent company, either to fit with requirements for e-mobility or to modernise plants to better integrate them into the digital transformation network. The plant is in competition with plants of the OEM in other countries (in Europe - from France, Germany, to Eastern Europe - or in Morocco). Competitive factors are labour costs, product quality, other cost components, such as energy costs, and proximity to car markets, taken for given the dense and effective network of local suppliers (tiers-1 and tiers-2). The plant that is relatively more cost-effective in Spain can then guarantee investments to keep a certain level of employment. The latest Ford

agreement is a case in point: the parties agreed that for the next three years there will be no wage increases, but there will be an investment to realise the production of Ford's electric vehicle in Spain, to the disadvantage of the Cologne plant. This is a story that we encountered in the course of our empirical analysis, and documented also in the progress report on Germany: the initial agreement of the union and management to participate in the project was followed by a resolute refusal to cooperate by the union as news of the decision to close the Cologne plant spread. The terms of the agreement, essentially secret, were signed directly in Germany and concerned a repositioning of Ford in Spain.

In this context, the unwillingness of OEMs with plants located in Spain to take part in the research project seems understandable: they would have disclosed the dynamics that the various countries are going through, implemented by companies' strategies and stimulated by different investment attraction policies and tensions in the labour market, in a very delicate phase of their transition between automation, digitalisation and electric mobility (and the new labour market regulations that have increased governments' pressures on companies). On the whole, interviews with the two suppliers participating in the project offer insights into the impact of automation on labour in automotive subcontracting companies, but also into how the transformations that are taking place are reverberating along the supply chain across Europe.

The Zaragoza area in which the two companies of our case study are located is of particular interest. In this area there is a pool of technical universities, public and private innovation and technological centres (like ITAINNOVA), agencies supporting various sectors, and specifically the automotive sector (CAAR), about 30 companies providing specific knowledge in the use of robots, cobots, Automated/Automatic Guided Vehicles (henceforth AGVs), artificial intelligence, 3d printing, augmented reality, virtual reality, IoT, block chain. They form a very interesting ecosystem providing learning opportunities in implementing new technologies.

In both companies selected for the case study, the research team was able to benefit from the astounding willingness of the reference people - respectively, the HR manager, in Copo, and the plant manager, in L+W - to all-round discussion.

After a brief overview of the two companies, we present the interviews' findings for each establishment. Discussion and conclusions conclude the presentation of the results on the field work.

COPO Zaragoza

COPO Zaragoza belongs to the multinational company Copo Group, an international network of companies and technology centres with establishments in Spain (Galicia and Aragon regions), in Portugal, Germany and Slovakia, and outside Europe (USA, Mexico, Cuba, Brazil). The Group embraces production of components for seats and accessories of vehicles. Specialists in high resilience and viscoelastic molded foams, Copo Zaragoza, with 220 employees, produces car seat padding. Its production is destined for an Opel tier one supplier which is located near the Opel plant in Zaragoza. Copo does not produce just-in-time for this supplier, but does every four hours daily deliveries, with a day of safety stock. Their tiers- 1customers, on the other hand, make deliveries to OEMs every two hours, according to just-in-sequence scheduled on a daily base.

The plant works in three shifts five days a week. It relies on the technical support of other Copo plants, and in particular of the Technological Centre of Copo Group (located in Vigo, Galicia) for the design and building of various types of moulds (which are produced for different Tier 1 and Tier 2 within and outside the group, using the most advanced CAD, CAM, NCC and Metrology equipment). There is a strong integration of the Copo Zaragoza plant within the Copo group, in which it plays a role molded foam technology. At the time of the interview, the implementation of a new production line was in progress in Zaragoza, with the simultaneous planning of a new plant in Slovakia, for which the current production line is destined, and which will be replaced as soon as the new department in the Zaragoza plant is completed (expected by Spring 2023).

Zaragoza belongs to the multinational company Copo Group, an international network of companies and technology centres with establishments in Spain (Galicia and Aragon regions), in Portugal, Germany and Slovakia, and outside Europe (USA, Mexico, Cuba, Brazil). The Group embraces production of components for seats and accessories of vehicles. Specialists in high resilience and viscoelastic molded foams, Copo Zaragoza, with 220 employees, produces car seat padding. Its production is destined for an Opel tier one supplier which is located near the Opel plant in Zaragoza.

Copo does not produce just-in-time for this supplier, but does every four hours daily deliveries, with a day of safety stock. Their tiers- 1customers, on the other hand, make deliveries to OEMs every two hours, according to just-in-sequence scheduled on a daily base.

Copo has a stable set of customers which demand frequent offers for the implementation of new models and a significant part of their activity is to prepare offers. With respect to production, Copo works with projections of production, but daily adjustments are needed [Copo_5]

Copo has a one-day safety stock, and at most half a day more, with four-hour charging windows. Its first level provider usually has a 2-hour charging window, this means that it must be located at most 50 km from the factory to deliver in time. The OEM has its own logistics department that communicates with the logistics department of the first level supplier, and the logistics department of the first level supplier communicates with the logistics of the second level (e.g., Copo).

L+W

L+W Zaragoza is a Tier 1, belongs to the Linde + Wiemann Group, a multinational company with headquarter in Germany and production plants in Europe (Germany, Czech Republic, Spain, Hungary), Turkey, USA, South Africa, China. The company has three manufacturing plants in Spain (two in Barcelona and one in Zaragoza).

The holding in Spain is in La Garriga, Barcelona, where it stamps the components that are sent to the plant in Zaragoza, which receives components from different companies, though its main supplier is L+W in Barcelona. The L+W plant in Zaragoza, with 150 employees, has no purchasing department, nor a finance department, it is essentially focused on production: 85% of its production goes to Stellantis Zaragoza (5km nearby), while the remaining 15% of production goes to Ford Almussafes in Valencia (370km) and Mercedes-Benz España, Fábrica de Vitoria (200km). L+W Zaragoza is specialized in the welding process of different components. It produces bending, roll forming, welding of structural parts and body components for body parts for Opel Corsa, Citroen Cactus, Ford Kuga, and Mercedes Vito. For its production technology, organization and innovativeness dynamics, it is in the top three most advanced companies in the region.

In order to focus on the impact of automation on work, it is useful to describe at which stages of the production process and which specific operations are affected by automation, which has been introduced over the last ten years with very specific objectives: traceability of the production process, better quality control of the production process, elimination of physical work effort, elimination of defects in products, elimination of misclassification of products.

Interviews findings

Automation technologies, robots, digital technologies

In order to focus on the impact of automation on work in the two tier-suppliers in Spain, it is necessary to describe their production processes and which specific operations are affected by automation, which has been introduced over the last ten years with very specific objectives, together with a lower cost per unit of output: traceability of the production process, better quality control of the production process, elimination of physical work effort, elimination of defects in products, elimination of misclassification of products. After a presentation of the production organisation, we summarise the main facts and figures on employment composition and work organization, skills and training and then we illustrate the impact that the intertwining of automation and digital transformation has on these companies and its future developments.

Copo's production organization: manual, automated and robotized tasks, issues and impacts on labour

In some departments, for the different operations, automation has already been used for many years, in other departments and tasks it is more recent.

Raw materials preparation: control and adjust the chemical reaction

In raw materials warehouse and preparation of the mixture, automation technologies have been implemented several years ago to control the mixture of polyurethane with other five components to ensure resilience, durability, comfort, fire retardant properties. This mixture has been specifically

created by Copo to produce a distinct comfort to the car seats that use their molded foam. Automation technologies are in this case also essential to guarantee the traceability of the production process from the raw material to the various transformation stages.

The entire process of withdrawing materials from the silos and from the various mixing and feeding containers to the silos for sending the material along the production line is now a totally automated process, controlled through a series of flow management programs that coordinate the call from the production process and control the filling of the mixer and the withdrawal of the mixture to be used in the subsequent foam production phase.

> *We have highly automated the part of the chemical process because it is a strategic and delicate process …to give you an idea, polyurethane is such a complex product that we mix at 7:00 in the morning in July we get a product with some characteristics, and the same mixture at 4:00 p.m. in the same facility, there are some characteristics that are different. The only thing that has changed is the ambient temperature. The process is the same, the raw materials are the same, the flow rates are the same. What's changing? The temperature! … [Today, automatic control of] the system solves those problems. [Copo_1]*

> *The chemistry area is a very automated process, which was done 5 or 6 years ago, it was a semi-manual process and now it is totally automated. …, the weighing of the small additives was done manually. It was like opening the lids and weighing and measuring the additives. And it was up to the person to decide whether or not to do the mixing. Now it has been automated. [Copo_3]*

Foam molding area: eliminating heavy, noxious task, speeding up inspection, experimenting how to reduce blurr

Another process that was automated was the one to manage the carousel in the molding area (from foam production to product inspection). The foam production process takes place through the transformation of the mixture which is poured into liquid form [injection] in the mold and which expands in contact with the air contained in the mold.

In the past, injection of material in the mold was done manually, but it was a very heavy operation. An initial mechanisation was implemented in the line to unlock the mold, while the operator manually had to open. Now is automatically opened during the process. At the end of the line, now a robot operates inside a cabin, totally separate from the rest of the department, to inject the mixture: as the mold progresses along the line, the foam expands inside the mold, taking the shape defined by the mold, and consolidating itself over a certain time. It is therefore a circular line (*carousel*) along which the molds and the relative presses (*prensas)* (that allow the opening and closing of the molds) are positioned. Presses are necessary to keep the two parts of the molds firmly closed. Along the same line, the molds for the different models of pieces are mounted on the presses, necessary for the production of the batch of seats or backrests. The molds are produced by Copo according to the requirements of the customer, who is the owner of the molds.

The molds are composed of two parts, one lower and one upper, which give the entire geometry of the pieces. Each part of the seat, the seat and the backrest, will have a pair of molds which gives the specific shape to be produced. Inside the molds, before the mixture (of polyurethane and other components) is injected, a series of elements of metal and other materials are inserted manually: small pieces of "fabric" and strips of green plastic to attach the padding to the fabric cover. The latter have various functions: to allow a better hold of the pieces, which the foam alone would not guarantee, attachment of the padding, once it is covered, to the seat frame, to give durability in the points of contact and friction with other metal parts of the seat, allow fastening, which would not be effective simply by screwing in the foam padding. The insertion of these parts is done manually - along the line - by operators who have behind them the containers with all the different types of pieces that will be inserted inside the molds. These operations involve a continuous movement of the operator to take the pieces, placed behind them, and insert them in the lower part or in the upper part of the mold, implying continuous twists and stretches. Several operators (three-four) are engaged simultaneously along the section of the line which is dedicated to the insertion of all these elements to complete the production of the padding of the seat parts. Each operator basically takes care of the mold that comes to position itself in front of the operator as the line flows.

At present there is no program for automating these operations, even in the new line under construction: given the high variability of models and the very tiny dimensions of the various inserts, to substitute labour with robots would require to reconfigure completely the department, which now fits in a reasonable limited space all the workers and the trolleys with the materials to be inserted.

While robotization of these tasks does not seem to be convenient, an optical viewer (GIPS vision) is now used to check that all the pieces have been positioned in the mold.

> *The general process of digitalisation of the company is part of an improvement with the introduction of the artificial vision and robot. …They put the artificial vision system in the carousel to control the inserts. [Copo_3]*

> *In the older line [that will be transferred in Slovakia], the operator at the end of the line is the one who sees if the rod is going or not … s/he is normally the one who inspects it [Copo_4]*

Before the next phase of injection of the mixture in the lower part of the mold, both parts of the mold are sprayed by a robot with a non-stick material, to ensure that the foam that will be produced does not stick to the inside of the mold.

Along the line there is then the injection of the mixture, using a robot set inside a cabin. After this phase, the presses close the two parts of the mold which advances - according to the necessary time - until the phase of opening the mold, emptying the piece of foam that has been meanwhile formed and deburring of the form. This phase is at the end of the line which is close to the subsequent filling of the molds.

The deburring is done manually, using an electric cutter which is slid along the edge of the foam form. The thin foam burr is produced by the leakage of material which occurs together with the escape of the air from the mold thanks to the fact that there is no complete seal of the closure of the two parts of the mold. The leakage of air is functional to the process of transforming the mixture into foam, but it is a part of the production process on which technical developments are underway to also eliminate the complementary leakage of material that must be removed.

Each piece is machined to eliminate burr and inspected to check for defects, such as the presence of small holes. The defective pieces, on which the point where there is a defect is highlighted with a marker, are placed on the upper part of a conveyor belt, while those without defects continue, on the conveyor belt, towards the next phase of storage in containers.

Defective parts are restored manually, by adapting a small scrap of foam to fill the hole and then manually finished with an electric grinder. This operation produces dust that is not inhaled (they are very large molecules) but sticks to the clothing and body of the operator who, after each operation, cleans her/himself - partially - with a jet of compressed air.

> *We have people recognizing and touching the foam and detecting and fixing mistakes. [Copo_5]*

A team leader supervises all the operations in the department, intervenes to substitute workers who need a break and supervises the need for additional inserts to be applied in the molds.

<u>Filling of boxes by product type: targeting zero errors</u>

The pieces that come from the forming department arrive in a sequence not ordered by type of piece and are then selected to be arranged vertically in layers, inside metal caissons. In the department in which boxes are filled by product type, there are two lines of selection and fill.

One line is totally manual. Along the conveyor belt there are three to four operators, each one takes the piece assigned to him and gradually fills the box placed behind him, positioning the pieces according to the specific filling rules. Once filled, the operator sends a signal to the automatic rail conveyor that runs along the line. The full body is moved laterally towards the handling rails, automatically picked up and brought to the warehouse. Similarly, it is replaced with an empty caisson.

The other line is more recent (Spring 2022): it is equipped with an optical viewer for the selection and pneumatic pushers that fill in bulk the bins placed laterally along the line, from which the operator gradually picks up the pieces to manually arrange them in the caissons, placed behind it, positioning them according to the specific filling rules of the various pieces. The introduction of this line with an

optical viewer reduces to zero the human error in the selection and storage of non-conforming pieces, as can occur when the pieces differ in small details, such as the hole for housing the airbag.

> *We made a lot of mistakes in the packaging, because we put the wrong piece in the wrong box… from the management of this plant the operators are not asked to account for customer complaints. [Copo_5]*

> *There are small differences, for example, related, to an airbag and if it escapes you, and you do not see that it is for the airbag and you put it in the drawer that is for the parts without airbag, and you are sending the customer something that they cannot assemble on the line. And then the line with the artificial visor …is reducing errors that approach zero error [Copo_1].*

> *…visual recognition …helps the operator to identify the parts correctly. [Automation] has reduced the complexity of the packaging area because they had a lot of work, and this system has helped a lot to reduce errors and also facilitate the workflow of the person who is working, because the pieces are very similar and through artificial vision what we do is that the piece is recognized, it goes along the conveyor belt, and the corresponding pusher leaves it in the correct area. [Copo_5]*

The implementation schedule of the vision, started four years ago. The implementation process lasted five-six months because of the need of calibration. The goal is to extend the selection with optical viewer to the whole department.

A department undergoing transformation: challenges and experiments

A similar forming department, located in another shed next to the one we visited, is in the process of installing the machinery. Once the tooling of the new department and the connection with the upstream and downstream phases have been completed, this department will replace the oldest forming department: the machinery it is currently equipped with will be sent to Slovakia and installed there in a factory of the Copo Group. The new department will be equipped with more automatic control technologies, but not yet in the operations of inserting parts into the molds.

> *For example, a new carousel is now being assembled, and one of the tasks we want to automate is the placement of some self-formed inserts that are placed in the lid. They want to try to robotise it, so that a robot is the one that places it. But it is a somewhat complicated task to automate because it has to place the high arms. First the carousel will be assembled and then we will try to robotise it. [Copo_3]*

In the new foam molding line, Copo will experiment with a new functioning of the molds that allows to eliminate the escape of foam and therefore the production of burr and the consequent deburring operations.

> *for a robot [deburring] is a very complicated task. We have tried, but we haven't [yet] managed to avoid the burr in the mold. We have been working on a mold that doesn't produce burrs, but so far it hasn't been possible. [Copo_3]*

> *It's just a pressure detector that adjusts the pressure …generated inside the mold and then, when it reaches a certain value that you have defined, the mold compresses even more. Then you avoid burrs in the mold, that is, the foam does not come out of the mold [Copo_6]*

The new foam molding department is a challenge for the team leaders that will be specifically trained to manage the new line

> *there will be a training … Yes, of course, involving many people [and the workers have to learn something from the new machine as well] and we'll have information [Copo_4]*

The new carousel already comes with everything included. Its development was more external to the Copo plant, with specific engineering help provided by the parent company. The maintenance team was fully involved when its installation started (in March 2022). a.

> *This is being developed by the technology centre of the Copo Group, which is in Vigo. … It is true that technicians are not ready for development. But then, when it comes to start-up and start working, we are very involved. [Copo_6]*

A cross-country development environment: the Slovakia plant

Foam is a bulky product, with very high logistic and transport cost. Suppliers located beyond a radius of more than 1000 km become non competitive. The rational for the expansion in Slovakia is strictly related to the strategy of the Copo Group in their position in the automotive supply chain to support OEMs' redundancy plans.

Planning a plant in Slovakia involves the training phase for Slovakian technical personnel in Zaragoza: it lasted two months for four people (administration, quality, maintenance and processes), who will be employed at that plant, being trained at the Zaragoza plant to learn the operation of the production process, the setting of the machines and the necessary maintenance.

> *They will need some support from here, because we estimate that in approximately 6 months we will have to send technical staff from here to there. [Copo_1]*
>
> *…A top-tier supplier cannot be beyond 50 km from the factory. We are a second level supplier and can be up to 150 km from the manufacturer. From here to Slovakia it is impossible to supply. With a lot of effort, we managed to supply from here to Lisbon that we have 20% of our production in Volkswagen Palmela. What Audi has asked us, and that is why we are in charge of setting up the new factory, is that we are the security plant, that is, if our plant in the destination country, for whatever reason, fire or catastrophe, does not work. We must be able to supply within no more than 36 hours. That is why we are going to do everything that is the transfer of technology from here in collaboration with our staff, so that, if at a certain moment we have to intervene and, hopefully not, we have the possibility to do so. [Copo_1]*

L+W_Production organization: a very functional layout designed with a digital twin

To fully grasp the innovativeness of L+W, we will refer to two main process changes introduced at this plant in the last four years: the Manufacturing Execution System (henceforth MES) and AGVs. *"It would have not been possible to implement AGV's without previously having the MES"*. These technologies have significantly increased the productivity of the plant, which has been using welding robots for almost twenty years.

After a presentation of the production organisation, whose "*added value is welding",* we summarise the main facts and figures on employment composition and work organization, skills and training and then we illustrate the impact that the intertwining of automation and digital transformation has on this company and its future developments.

The plant has **three main areas**:

- single component warehouse, that is, the logistic area: from the end of the single components warehouse, AGVs fleets bring the single components to the welding lines. In this area, they have one forklift driver that loads the AGVs;
- the production area: there are 18 independent welding lines and one roll forming line. Each welding line is dedicated to a batch of components at a time, while only in one welding line it is possible to produce 3 different components;
- finished goods warehouse: there are two forklift drivers to unload the AGVs; in the warehouses, the forklift drivers manage the interaction with the AGVs, and see which spare parts have to charge in the AGVs.

The very functional layout of the plant is the result of the creation of a digital twin of the production process aiming at an effective production flow to enhance, among other objectives, the implementation of AGVs to integrate input and output flows across the plant and the implementation of a Manufacturing Execution System (MES), the digital system to collect data from operation infrastructure, and production control. The company visit was guided by a young process engineer who is engaged in production system implementation of 5s[6] (lean tool, continuous improvement tool focus on organizing, cleaning, standardizing, discipline and order); measure and time methods of the three L+W plants in

[6] https://www.epa.gov/sustainability/lean-thinking-and-methods-5s

Spain. He was the project manager for the AGVs implementation, one of the two main technological changes introduced by L+W in the past four years.

Digital displays represent the state of "production live" and highlight the occurrence of critical issues in specific areas/cell/device.

Welding Line

> *the customer only tells us to add value through welding. [L+W_1]*

The company generally buys the steel from Linde+Wiemann in Barcelona, which makes some stamping pieces, but in other cases, the customer requests a specific supplier and fixes the price.

Each of the welding lines has specific features and technologies. For example, welding pieces to sub-assemble the rear wheel arch needs 50 welding spots. In each welding line, different components have to be loaded and welded together. Containers (one for each single component) arrive to the loading area. Loading is done manually by two operators (each loading the pieces for the welding operated by robots on the left and on the right side respectively). Each robot does a specific set of welding spots, returning the assembled piece to the loading area for further additional pieces to be welded, made manually by the operators. After the complete process, the filled containers are transported from the AGVs to the finished goods warehouse. Each line has a screen with a micro layout showing the state of the process, for example, if the containers are full or empty and if they are waiting for AGVs to come. Selecting options on this screen, the operators can call the AGVs. The computer has a Siemens system and Kuka robots are inside the welding cell (the plant has only Kuka robots) programmed in PLC. When the welding cells were bought, the supplier came and programmed the robots. If there are changes to do, the L+W team leader and the shift leaders can reprogram the welding cells. During our visit, the operators entered the welding cells to change the electrodes of the robots, while the process was stopped.

The welding cell that we observed in greater detail is made by 6 robots (3 left and 3 right). The set of robots have an overall takt time of 30 seconds, while operators in uploading/downloading have 24 seconds. This area was welding 50 spots in the sub-assembled pieces. There are sensors to ensure quality controls, together with manual control when the operator loads the container with welded sub-assembled pieces.

According to the decision made by the customer, glue is used instead of some spot welding to reduce some tension into the pieces used for components within the car (not for the frame!)

> *The customer decides about gluing processes. The say "you must buy this glue because we have made a test in crash test previously to launch the car to the market".*
>
> *… gluing needs a shorter time (for example 1.5 seconds, against the 10 seconds needed for welding; this technology reduces tension in the pattern as well produces faster. [L+W_1]*

The glue makes a chemical reaction that becomes effective in joining the part with 180 degrees: in the process of application the temperature is 50 °C, but when the customer makes the complete body assembly, during the process of painting, they get 180 °C, and then the glue is dried.

> *This main issue here is we must keep the application with 50 °C, and then we have temperature sensors to be sure the application process is under control. [L+W_1]*

Roll Forming Line

In the roll forming line, the process starts with a coil of steel (nearby, there is the warehouse with coils to charge the machine). The coil passes through the different rolling parts that shape the sheet and then there is a press that cuts the pieces, with a sensor that is checking the holes to quality check the pieces. While loading this line requires the upload of the steel coil (using a forklift), downloading is done manually by one operator (whose saturation is approx. 50%), every 9 seconds.

Main automations and digitalization technologies

While automation is not new for L+W, with robotization introduced 20 years ago, in the past three-four years, the more important technological change was the implementation of the MES and AGVs, whose effectiveness is possible because of the introduction of MES. The implementation of digital technologies has been an essential step to enhance the continuous impact of automation on labour

and productivity, as for example through digital twin, that allows the company to manage a finer tune of all the waste time in processing (the welding robots or the handling of material through departments), which is controlled more specifically through simulation of different organisational configurations.

> *right now [with MES] we can get information in real time, how is the production, how is running the machine, how or what type of problems we have in the machine …failures, and what stops we get in the machine.*
>
> *MES is the most important [feature in enhancing] the performance of the plant… and AGV's as well [L+W_1]*

Introduced in 2019, the implementation of MES started a process of training of managers, shift leaders and team leaders, still in progress. The main issue is to change the mindset and culture inside the company at all levels: the tasks and responsibility of middle management, training them not so much with digital competences as in interpreting data and taking decisions on production on a daily/shift base. Decisions that must be taken as a team composed by the team leader, the maintenance manager, the quality manager, and logistics

> *We introduced the technology so far but we are still training our shift leaders to make the interpretation of the data, because introducing the technology is relatively faster, but, implement, half year, running…but the more important point is the people use the data to make decisions during production time and then we are working right in training people with role games to try make understand all people what is each number. This is very important for us because is our challenge, because we have the technology, but we need the people make decisions without "Juan Carlos please tell me what means this or we don't want to do this". We are working in the second level, because first of all, we worked with managers and second level was shift leaders and team leaders. And we are working right now with the shift leaders and team leaders because they must interpret data. [L+W_1]*

Before the MES was introduced, all data were recorded in paper at the end of each shift and then passed to the production manager. The MES has a more intellectual impact compared to the manual, and increased and required specific training on this technology. In fact, with MES, data are obtained in real time, but to become effective they must be interpreted and consequent actions must be undertaken

> *At the level of documentation, it also improves a lot because you have the MES, where everything is registered, practically the paper has disappeared, so that is a positive part. As some negative part I don't think they exist as such… We are in a time when we are so used to digitalization that there is no negative part. [L+W_4]*

Team leaders appreciate that their job has improved with new tasks requiring ad hoc training

> *Before there was more paper when it came to data and now everything is more detailed. [L+W_5] Yes, all positive, in the sense that it takes away the workload because it is done better. [L+W_6]*
>
> *Right now, we say "you don't have to waste time to write the data. You have the data in real time and then you must read the data and then you have to interact consequently. You must make decisions". This is very important for me, and this is the first barrier I have found with the implementation. [L+W_1]*

The meetings discussed above, involving team leaders, shift leaders, logistic, maintenance and quality workers, have been set for the purpose of decision taking.

Implementing AGVs in L+W was not conceived to remove jobs. The AGV'S could be defined as an internal logistics system through autonomous vehicles for the transport of materials to the production lines. Introduced in 2019, for AGVs the same changes as for MES were also addressed. In this case, three main competence profiles are involved: operators and maintenance, internal to the company, and the integrator of the technology, external to the company. The latter are expert in industry 4.0, able to integrate MES, robots of the welding cells and AGVs, according to the specifications provided by the company. Once they reached the specified target, installation and setting passed under the

responsibility of the company, which received a 10-hour training, the beginning of a continuous learning process

> *this is your installation, this is your technology, this is your automation" … and then we start from settle and then we need to maintain the technology, and then we need to learn how to maintain the technology, and then we need to learn, learn, and learn. Because, when technology works [it is ok, but when] we have some problems, failures, stoppages, we need to understand why … we must find the root cause [L+W_1]*

The learning process mobilizes a cultural shift, both internal to the company and of their customers

> *… and then, as well, the users [have] to understand why we have to work in this way, because once we have implemented this technology we train this cultural change [L+W_1]*

A central theme is the impact of AGVs on employment: it has not reduced the number of people employed in handling, but it has changed the way the logistics department interacts with the production area. This change required the involvement not only of workers in logistics but also of team leaders in the production area, because of their twin role in keeping the working of the technology effective and enhancing the value added by the operators

> *… previous to implement this project, we had many, many meetings with the shift leaders… We said "hi guys this is a technology to help you in the production time, it's not to remove your job. This technology helps you to act with more efficiency".*
>
> *At the moment workers are not involved. Just the team leader because the team leader is the key people to maintain all machines working properly. Because they add value to our operators. [Workers] just load single components in the machines. [L+W_1]*

Operators have no control of the machines nor do they intervene when the key performance indicators are below the target. At present their qualification is too low to allow such responsibility, which is entirely in charge of the team leaders

> *… our idea is to roll out with the first level, but at the end the qualification of our operators is totally different from the qualification of our team leaders. Remember that we have been working three years to train our shift leaders, to change their culture on making decisions because previously it was "Juan Carlos I have a problem please help me…". Now we say "we gave you the tools to solve the problems, we gave you the technology, but you have to take your own decisions" [L+W_1]*

Learning about AGVs is still a day-by-day process. It follows the definition of a direction of change (reducing waste time in handling), the design of the process to get a digital twin of the current production flow (to optimize the plant layout), and then the specification of the requirement for the AGVs to be installed. The collaboration of the Aragon Institute of Technology, ITA) and a national grant facilitated the investment decision that was approved and co-funded by the parent company.

> *In my case, because I'm an innovation guy, I said "we have to introduce this technology", we redefined the layout of the factory, we did a simulation, with a digital twin, before to implement the AGV. We worked with the technological centre here in Zaragoza [ITA]. We got a grant for the national government "Hi guys we want to implement 29 AGV". We take the money, and we did a digital twin of this layout, we decided how many AGV's we need. What is the type of services we want to stress the AGVs.*
>
> *We made a digital twin and with this information we decided how many AGVs we need to work, to be sure that this AGVs should give all processes of my cells 100% service. Because it is not possible to the machines to be stopped because we have not enough AGVs.*
>
> *After that, we use it one year to decide what type of AGV, and what supplier will work with us, one year, because we need specifications. With Miguel - who was team leader and project manager of this process – we spent a lot of time in knowing how should work the AGV, how this type of technology will communicate with the machines. One year. Then we made a sheet with specifications that we gave to three different suppliers, asking them to make a quotation. They gave us their quotations and we took the decision using an add*

value methodology, depending on the distance, service, technologies, battery and so on. We decided what was the best supplier comparing different characteristic with the price.

After that we implemented the AGVs, and now we are still learning how to improve their performance. [L+W_1]

The investment was assessed with an accurate ROI analysis of all the complementary changes: fork lifts, robots, electricity, additional maintenance.

I convinced my colleagues in Germany. I was six months working on that and then we implemented this AGV'S. Two years. [L+W_1]

In L+W, AGVs make the flow faster and reliable, but reduce operators' breaks and this increases their stress

if you introduced AGV'S, the process is done faster and workers have less pause time between one process and the other and more mental stress, and that is not talked about. When there are AGV'S, for example, It does not influence the process, that is, the operator does not run more or less because the piece arrives. On my line you can see that there is a container that fills up and you are going to call the AGV while the operator is in another container and forgets about the AGV completely. [L+W_4]

On the other side, the MES records every step in the process and it reduces the stress to avoid accidents

There is also the MES that registers all the stoppages and for that reason there is no greater stress for it. In fact, in particular, the function is to prevent wheelbarrows or bulls from entering the ship, and to avoid accidents. [L+W_4]

Unmanned welding line

There is a welding station which is unmanned, and fully automated: containers of parts to be welded arrive with an AGV, the containers are moved from the team leader inside the machine. Here there is a robotic arm that picks from the container the pieces and a sensor to select the best piece to be selected. In this process, the call for the AGV is automated, when is ready to load "raw materials" and unload "finished pieces". They find that if parts are stored tidily inside the container in the loading phases, time is saved in the process, even though is not compulsory to order the pieces tidily for the process to work properly.

Empolyment and work organization

Employees

In Copo, the total number of employees is 220. Line workers are approximately 150; logistics employs 20 people, quality 14 people and maintenance 15 people. They work in 3 shifts. The remaining approx. 20 people is administration and engineering staff. Gender composition has become more balanced for line workers, management has only 2 women out of 7 people, in maintenance there are no women.

The introduction of automation technologies has improved the company's gender equality

you had to inject in that manual way, which was a job that physically could not be done by a woman, that is, it required an important strength. I remember seasons inside the factory where men were destined exclusively to carousels, and today you have seen that in the carousels there is a majority of women, so obviously that has occurred because technology has helped us to humanize jobs. And since that humanization has made gender absolutely irrelevant today.

…women will be much more skilled than we are men in what is fine mobility, but regardless of that type of conditions by sex in our company today in any position can work indistinctly a man and a woman. [Copo_1]

when I joined the company there were no women in middle management positions and now there are several. … Tasks that used to be more physically demanding have been automated, and now the number of women in production tasks has also increased. [Copo_3]

In L+W, the total number of employees is 150. Composition by main areas is the following: Production, operators: 20 workers per shift; shifts and team leaders: 12; Logistics 5; Quality 3; Maintenance: 15 people, over three shifts: 2 in tooling, 2 in facilities ; 8 technicians and the 3 coordinators, one for each shift. The size of the maintenance department is largely sufficient (*"there are days left over and days that would be missing 15"* [L+W_7]); project development: 2.

There is a very segregated gender composition: operators are mainly women, team leaders and shifts leaders are 60% men, maintenance, quality and logistics are only men. Only one woman was employed in maintenance, but she left the company. The plant manager is willing to employ women in maintenance, but it's very difficult because of the shortage of female students in technical and vocational training in Spain.

> *I think that here we do not have gender issues, there are no differences. [L+W_4]*
>
> *The company fully complies with gender equality issues and digitization does not have a notable impact in this regard" [L+W_8].*

In both plants, the daily rate of absenteeism is normally about 10%, due to medical visits or family reasons. Overtime is used occasionally as a Saturday shifts

Temporary contracts (discontinuous job)

In Copo, temporary workers are resorted basically to meet peak loads. Moreover, university students of any academic field, generally in the second year, are enrolled as part time workers for the weekend shifts.

> *normally when you increase the number of molds they bring you more people so you can reach everything. [Copo4]*
>
> *They [university students] do the same job as any of the people in the line. They need only three days for their training (against the 15 days that are needed for non-student line workers).*

In L+W, among operators, now there is 60% permanent and 40% fixed term (discontinuous) jobs.

> *Now the company has made enough company contracts, quite a few, so there are fewer and fewer discontinuous ones. [L+W_5]*
>
> *They complain more than anything about the variation of machines, about changes in production: today in one machine and tomorrow in another. Because the production has been cancelled, because the loads are going up, going down, because in that they do complain. And especially those of the temporary employment agencies, who are told that they do not have to come. [L+W_5]*

Largely among operators, they have a turnover of 30%.

> *People who, especially people from temporary employment agencies, of course, want stability, and since you cannot give it to them there are people who have left. Of course, you don't work 5 days a week, so elsewhere they offer you more. [L+W_6]*

Tack time in the production line: no stops admitted

In Copo, production lines cannot be stopped, and the pace of work is set to allow operators to manage the various tasks

> *It is a step-by-step conveyor belt, so if you stop the belt you stop the whole production. In the automatic line there can be no parts that reach the end of the belt, all are pushed to an area in front of their container. [Copo_5]*

There are some productivity and quality bonuses, but in general the pace of work is not too pressing, only sometimes the team leader is asked to push the team to increase pace and meet production targets but usually not

> *…they don't take us with too much pressure either…*

if you increase the number of molds, you increase the pace of work, and that means more pressure, more problems, yes, but normally when you increase the number of molds they bring you more people so you can reach everything. [Copo4]

In L+W, the welding cells are stopped any time an intervention in the operations is needed, and the saturation level for the operators depends on the welding cell, or the process, on the cycle time of the machine and the cycle time of the manual activities of the operation.

We can find welding cells in which the saturation is about 90% for example, and we can find welding cells or welding press in which the saturation is 50% for the operator. [L+W_2]

The range is due to the fact that there is a minimum amount of workers you need for uploading a machine, so you can't have just a few seconds there, and then moving in another position just to be saturated at 100%.

And it is, we must accept the quotation in the beginning of the project. When you accept a project, the customer pays you one operator for this machine, or two operators for that. So, you must design the machine in order to that… with the team or the people that you have in this machine you have to achieve the target and the takt time in order to send parts to the customer.

… And in this case Jorge and me both we must search how we can save money in this process, and we are always thinking about how to reduce the cycle time, or then, reduce the number of operators in a welding cell. But we must look, as you say, in the saturation of the operators. [L+W_2]

Variability in production flow is compensated by adding/canceling a shift or by postponing/intervening with maintenance

sometimes yes, and other times, the other way around, there is too much operator because they do not have a load. For example: don't do this piece anymore. The shift is now over. Operators can do maintenance work (TPM) [L+W_6]

L+W_Work Organisation

L+W_Shifts and team leaders

There are three shifts' leaders. The shift leader has the complete responsibility of the factory during the shift.

[A shift leader] supervises the work of the team leaders, helps them in everything that they do not know how to solve or do not arrive, and manage together with the production manager, quality issues operators, etc. Peaks with machines that are above the capacity of the team leader. [L+W_6]

In each shift, there is a team leader responsible of one of the three different welding cells. Their training is not only specific to the machines and robots in the cell they are responsible for, but also for the others, to allow for substitution in case of holidays or any need to cover the vacant position. For the roll forming there is one specific team leader per shift, dedicated to it, because it's a different technology. In the case of the unmanned welding cell with optical bin picking, there is no specific team supervising this area.

[The team leader] coordinates 7 workers, intervenes on self-controls part releases, adjustments of some robots, distribution of operators, controls robots and devices in the welding line [L+W_5]

For a team leader there are challenges to cope with daily changes, but also training opportunities, also from rotation across lines

My challenges are the day to day, moving forward, knowing how to know, everything, the machines, everything, moving forward throughout the company.

[we have training on the job and specific external training] and I know it, then now go changing zone. Continue to learning all the other facilities [L+W_5]

In the case of shift leaders there is a general goal of upgrading the skills of team leaders, to support the dynamic of growth of the company in the next years

> *the team leaders that I am in charge of, who are versatile throughout the factory, because that does not mean much flexibility and to cover casualties or vacations. That are all versatile and that they increase their knowledge. It is very important for the company: it is a personal goal … So do everything, when they themselves can get to be promoted. Because if the company grows, and is going to bring in more facilities over the years, we must also free up for them to learn from scratch when a facility is developed. [L+W_6]*

L+W_Daily coordination

Daily coordination meetings and work organization changed after MES. Now the team leaders meet to discuss the efficiency figures (OEE[7])

> *We have 3 different meetings:*
>
> *One every day at 9:15 in the morning in which shift leader, team leaders, maintenance, logistics and quality workers meet together with the production manager.*
>
> *[In addition to that], every team leader and shift manager has their own meeting every shift change.*
>
> *… Then we have a weekly meeting where the morning shift and the afternoon shift come together, team leaders, shift manager, production manager, and we tell what's happened during the week and things that can be added that are going to be introduced. [L+W_6]*

Incoming and outgoing team leader meet (in total 20 minutes), with an overlapping presence of both leaders

> *before we did not meet, now every morning at 9:15 we have a meeting and we talk about the OEE, half an hour, all team leaders and head of production and quality meeting. Every morning [L+W_5]*

Operators are involved in the meetings when some changes must be explained

> *We meet with [operators] when you have to explain something specifically that has been introduced new, or the way of working, is individually, … New people who come and have to be trained, it is more in specific cases. [L+W_6]*

During the meetings, the core issue is the analysis of the production manager, which participants see on the screen,

> *and we are seeing performance of the installations incidents adjustments etc. all the information comes out … installation by installation everything that has happened in each installation. … Before [the introduction of the MES, this] was done to us verbally only at the change of shift of each team leader.*
>
> *[Now, in the change of shift, they open] the MES and on their own computer and read each one the incidents in the session. [L+W_6]*

Ad hoc meetings are organised with project managers for continuous improvement.

L+W_Production planning: weekly/daily

Weekly planning of production is done by the head of production with the head of logistics. They are responsible for facility, and match logistics loads and customer orders. Normally they do it on Thursday afternoon - Friday of the previous week, for the following week. What happens is that during the week there are quite a few speed changes.

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[7] The OEE (Overall Equipment Effectiveness) or ETE (Effectiveness of the Equipment) is a percentage ratio that serves to measure the INTEGRAL use of any technical or human resource. It can be aggregated to calculate the total effectiveness of an industrial facility, or a set of them. It is the most important key performance indicator (KPI) for assessing industrial efficiency.

Daily planning and interventions in setting the machines comes with a planning of operators. When they make changes, this implies changes with the operators and with the shifts

> *Machines need to be changed or reconfigured in some way. Those machines that have major changes that take an even longer, depends on the machine: … in some cases takes a minute and others, half an hour. They change something in the occupation, the facilities, change order or whatever, the head of logistics changes that occupation. We receive an email and we are all aware that they have made a change [L+W_6]*

Production peaks to adjust to the customer's pace are made

> *as quickly as possible. It usually gets along well. [L+W_6]*

Accidents

In both companies, serious accidents are rare, occurring on average one every two or three years, less in the most recent plants.

> *[Accidents were caused by] entrapments between a fixed part and a moving part. The new lines increasingly come with more safety devices, they demand more, and you have to comply, they are certified. A line that is perhaps 30 years old, because, although they have been improving and increasing safety, then there are always things that should be improved. [Copo_6]*

In L+W, workers have to use protections: earplugs might create problems, while shoes, cuffs and gloves are mandatory

> *[even though] they find it difficult to use special earplugs, if they are helmets, more, especially in summer. People complain of heat, if they are complicated plugs, because the sensitivity of the skin produces eczema. And then, there are people who have allergic reaction, you know, and that's why it costs them an S and index, it is stressed*
>
> *… Everyone is wearing gloves … These are things that are not negotiable. A plug, well, if you're farther from the machine, whatever you want is a cuff, a glove, a shoe, come on, that's non-negotiable. The company is concerned about security measures [L+W_4, also a member of the prevention committee].*
>
> *We are responsible for the safety of people, for any accident that exists, we are responsible for justifying the accident, because it has happened. We are responsible for carrying their PPE8 each person we communicate, and if you get a bad one you have to go home, we are responsible for notifying people to come to cover the shift, in this company security is looked at a lot. [L+W_6, shift leader]*

A specific digital application in the mobile phones of employees let people detect problems and make pics and share these problems with all the people with the app and to suggest how to improve and fix it. Every week there is an audit company that visits the plant and meets all the responsible, the plant manager, and the shift leader, to check and measure if the operators have adequate personal protections.

> *we always make each month a specific round, GEMBA walk [specific lean tool for detect problems in the plant floor, walking in specific tour with a specific methodology to make questions, observations, get problem evidences and fix it] … Just today we did here. We can have potential problems in the safety, we must control, and then we can present potential solutions. …this is for me is a regular work, [and workers] are involved. [L+W_1],*

[8] Personal security features

Human resources management:

Copo: the social dimension in a changing technological environment

Cultural and social changes, together with digital technologies are largely impacting on Human Resources management, a world "*that has not yet been excessively technical*", in which there is a very clear social component for a company like Copo that "*has to adapt progressively for its own survival and for the loyalty to employees*" [Copo_1].

There are also certain processes in which human resources management is affected by new technologies: recruitment and selection processes use social media, such as infojobs[9] or the company website to collect resumés and organize videoconferences.

> *That is, today ... nobody consults the written press to look for a job. Where is a job sought? On social networks, on employment websites. Then you have to get used to adapting to those kinds of circumstances. The first interviews are rarely done in person. If what you are looking for is to fill a position with a candidacy with a 30-year-old person, do not quote her in person here for the first interview. Send it to a video conference and make the first presentation by videoconference. [Copo_1]*

L+W: digital services for workers

In L+W, the people of the Union as well as workers are involved to document the issues and to suggest and undertake solutions. It is very cheap for the company and allows also a more focused code of conduct in the factory, for safer and better working conditions

> *We have here 40 people with mobile phones, and they say, "well this is one NOOK10 position". And they will have to do some actions. And then…this is previous, and then…this is after. We must make here, …we must paint this, because sometimes the people put one box wrong. And then we have realized about potential risks with the people. And then we say "Hi guys you must paint here. This is prohibited to put something here, or here, or here. We can use it when we are working in the factory… and it is very cheap [L+W_1]*

The company has implemented a platform for several digital services for workers, in addition to email for communication between workers and the company, such as digital payroll and other aspects, although it has not yet received a good response

> *what we have been lucky is that the company gives you access to email to communicate with them, convene meetings. [L+W_4]*
>
> *the new generation is already more digitized, it is a matter of double generation… Let's see, there is still some resistance to adapting to these projects, but with time and the use of these they get used to it... I do not rule out resistance because we are averse to change, but they get used to it. [L+W_8]*

Impact of automation on work organization and employment

Automation, Lean Production and information flows

Copo: more effective information flows

In Copo, the overall reduction of line workers due to automation and digital inspection has been modest and there was no increase in the number of workers in the maintenance area:

> *We did not reduce some positions, only some people but not reduce the person, but allow that person to do other jobs such as painting, different jobs not only packaging. …we could not save the work of a whole person, we could save half the work of a person…. therefore, we did not eliminate that job but simply dedicated that person to other tasks. [Copo_5]*

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[9] https://www.infojobs.net/: Spain's leading online recruitment website

10 NOOK. No quality conformity. A quality concept that means something is not being done correctly and must be fixed.

Computer vision is very simple, we have to check when vision does not work properly. In this case it is not a problem. [Copo_5]

With respect to ergonomics, the largest issue of workers' complaints still comes from the physical part of their tasks.

If there is a lot of movement of the upper limbs, especially the upper limbs. In some areas it is easier to improve and in others it is very difficult to improve ergonomics. there are some positions that are easier to improve than others.

…When they retire, normally they are fine, with some cases of wrist problems, but in general they are fine [Copo_3]

The new tasks that the operator does on the automated line is more ergonomic, although it remains repetitive.

In this new case the pusher makes the worker work more relaxed, because s/he has a small space in front of each box …before having to put them in the box. [Copo5]

While welfare and work-life balance were not affected by automation, it had no impact in creating better career opportunities and leadership promotion. With respect to fringe benefits available to employees, no specific information was emerging from interviewees.

The introduction of new technologies has impacted high-very high in improving communication between departments and with the parent company, the layout and design of the plants and the establishment, the models of work organization in the plant.

Because we have a lot more data to analyse. In the end they make you be in contact with other departments such as quality, production. With data management you have to be a little more in touch with others. You don't have your own data, and you share data among everyone [Copo_6]

Due to automation and digital technologies, paradoxically the complexity of the production process has been reduced because, despite of – or thanks to - the greater amount of data, information flows have become less redundant and inter-department communication more focused, and human errors in classifying final products have been reduced, thus enhancing the overall performance of the company.

<u>L+W: radical changes in work organizaion</u>

In L+W, automation has changed the work organization at department level engaging shift leaders, team leaders, logistics, maintenance and quality management in decision-taking according to the OEET (on data analysis, discussed above). It has contributed in standardization and management of repetitive breakdowns, *"allowing removing or extrapolating the breakdowns that are most repeated in the facilities"* [L+W_7], in addition, digital recordings of machine TPM [Total Productive Maintenance] facilitates a better coordination across departments because *"you can see what they have done, what they have not done"* [L+W_7].

Digitalization has specifically improved communication with the operators, training them on a day-to-day basis

for example, just to explain how it works, how they have to do it, how they have to continue, the way of working. [L+W_5]

The use of AGVs has increased the need for maintenance

I do not know anything other than automation. … And in the case of AGV'S they have not meant a change of tasks to be performed, they represent one more machine.

About digitalization and automation there is essentially a positive impact in L+W: the ergonomic of the tasks was significantly improved and people reacted positively:

We must take in account something like for example in Spain the rules are different, one man can move 25 kilos and a woman just 15, and then we define our processes in the limit of 15, when you have to move a box, a small box, your limit is 15. We define our micro layouts around the welding cells thinking about these ergonomic limitations. [L+W_1];

the number of employees, composition of employment and gender have not changed due to automation, while wages have increased for team leaders, maintenance and logistics, because their qualification profile has been enhanced to cope with automation technologies. Moreover, as noted by a shift leader, there is an overall positive impact due to digital technologies removing paper documentation due to workers:

> *Man, yes, [automation] has won. The oldest operator in the plant, with the operators, that has seen the change. They have said that they have also gained something in work, because before I was supposed to fill out paper by hand. At the time he picks up, and goes home directly. You don't have to waste time at the end filling in data.*

Another significant positive impact is that workers have become more aware that AGVs is not only an internal logistic issue

> *because it also attends to the production lines, and then, involves all the departments (production, logistics and more), and, yes, it can strengthen ties between departments. … and now they have to be a little more involved. At first it seems that each one was going his own way, and now perhaps it has made them see them too… No, that there is an interaction between internal logistics and different cells. [L+W_2]*

In L+W, robots were employed in welding 20 years ago, with a lot of improvements in their use, and a continuous source of increased productivity, by reducing their cycle time and increasing their operation also with glue. The overall impact on the labour force is not so much the overall reduction (modest) as the many changes within the labour force composition, by activity and skills. New technologies were employed for measurement, thus reducing people in quality control

> *[Yes, robots] reduce people, but you don't have to forget maintenance people, indirect people, people with high qualification, shifts leaders, team leaders… but we increased the qualification of the people [L+W_1]*

In the welding cells, operators have only to upload and download pieces because the welding process is designed to keep the quality

> *we have sensors and poka-yoke systems[11] to be sure that the pieces are 99% okay because we are not perfect. [L+W_1]*

In L+W, too, automation has highly increased communication between team leaders, between departments, and highly improved the layout and design of the plants and the quality of labor organization, thus reducing the complexity of the process and increasing productivity. When fully implemented, it is expected to enhance the qualification of labor involved in the welding area

> *think that in the end in this type of projects in which, well, we are betting on greater technology, more research, projects that may be more cutting-edge, that you leave behind everything that has been a cell in which the operator loads and unloads, in the end I think that there is an evolution towards profiles maybe with let's say a degree of studies with a higher or higher level. Which opens up a much wider range of possibilities. Although it seems incredible, you are not defining a much more rigid profile, that is, you do not say "with this minimum it is enough for me", no. At the time we ask little by little more and here for example, in this case, as you have seen when you have made the visit on the floor, we have all kinds of profiles, men, women, that is, that also contributes to the fact that if a profile has the potential, that's it. [L+W_2]*

[11] "Poka-yoke, a Japanese term that means "mistake-proofing," refers to any tool or mechanism that keeps a person from being able to perform an action in an incorrect manner. Poka-yoke is used to avoid waste, typically by eliminating or minimizing quality mistakes that lead to rework and scrap as well as eliminating potential safety issue. … When a defect cannot be eliminated, poka-yoke can often assist in identifying the error earlier in the process, decreasing the cost of the rework and the potential of the error reaching the end customer." https://www.isixsigma.com/dictionary/poka-yoke/ Accessed on 1st January 2023

Training, new job profiles and career prospects

Copo: Requested skills, training and labour careers

In Copo, in each task, in addition to specific skills, the most requested skill is a soft skill: proactivity,

> *speaking of qualified profiles, we seek a young person, with little experience, with a high level of knowledge and with a lot of proactivity. In other words, what are we looking for? You have seen that our process is a very particular process. It is not a process that is repeated, that is very common in the industry. And our sector also has its peculiarities. We are looking for a person who is able to develop and develop the needs of the company from her/his job and who, in addition, is proactive. [Copo_1]*

Line workers do not have a significant qualification when hired. Line operators can become team leader, a maintenance technician or a quality technician, if they have enough abilities and skills. Team leaders need technical knowledge and relational skills to interact with team members and with logistics, quality and production manager. They can start their career as line operators, but in some cases they can be hired directly in the position of team leader. Career opportunities as a team leader are reported to be equal for men and women. During our visit two female team leaders were actually at work. However, as observed above, although gender composition has become more balanced for line workers, management has only 2 women out of 7 people, in maintenance there are no women.

Most of the maintenance, engineers and managers have their career inside Copo, after experiences in similar or complementary roles in other companies (specialised in metal working for the automotive sector).

In whatever position they are, some employees had to reconcile work and family duties and changed their career path.

An essential component to retain workers is to provide them with adequate specific training, depending on the academic level and the professional qualification. Training is done internally and in external training centers, as in automotive cluster CAAR for those skills that are not offered by the local training system

> *At the moment they have a student, with experience, in a program of the cluster of engineers, but we also have online training that Copo can manage directly for its workers. [ES_e1]*

The company supports workers in their individual training paths with flexible timetables [Copo_6].

Actual career paths are not always perceived as a need, and in some cases the level achieved is higher than expected and reason for great satisfaction

> *[A future as shift manager, production manager? …entering as a line operator 15 years ago] and after being a Team Leader for five years… I think I have already reached the limit. I reached more than I expected. I did not expect the truth to arrive, when I entered I did not expect it. [Copo_3]*

Strategic training on automation and robotics has been developed to support technical/process projects of internal workers. The union committee and the workers have been involved every year in expressing their concern on the training plan.

> *Workers provide data for improvement and there are working groups that are responsible for this type of proposal with line employees, shift managers and technicians. [Copo_1]*

Some operations along the line can be improved and workers' opinion is essential

> *Yes, of course there are areas for improvement, the molds could be improved, many things could be improved, the demoulding programs, before you have to give it with a gun…these issues are discussed with the shift managers, and they listen. Yes, they listen to you. [Copo_4]*

> *…it's important to value the people who are working on the line. S/he has to give you feedback on what is doing continuously, so it can be improved. If not, badly. Normally the one who is on the line, if you do not help her/him and put yourself in her/his position, we are bad. [Copo_6]*

Right now they hire, as part time workers for the weekend shifts, university students of any faculty - generally in the second year. They do the same job as any of the people in the line. They need only three days for their training (against the 15 days that are needed for non-student line workers).

> *Once acquired an adequate training, workers need an adequate salary and appropriate working conditions. CAAR conducts a survey with 24 companies on the average salaries for 45 profiles in each company, to allow companies to benchmark their own decisions regarding remuneration and other benefits to their workers. The survey has also an important impact on the collective company agreement.*
>
> *the first thing we want is that our employees - we are talking about the entire employees, of all levels - have a competitive salary, that is, for a person to develop with us we need that s/he is not thinking about changing companies. You have to think about your company … it's not a six-month job, it's a much longer job. Of course people evolve. We all want to improve. Probably at some point our life will cross a train and we will say "I have to take it"…. [Copo_1]*

When focusing on maintenance, in Copo, there are 15 maintenance workers and a maintenance manager, only men, working over three shifts. The vast majority in higher grade, some only the middle grade. The average age of the team is about 35. There is no difference in maintenance interventions in the three shifts. Beyond the once that are planned, interventions occur when needed, but in general the production line is very efficient, due to digitalization and automation and on how the department is managed

> *it depends. It is a bit of a time, streaks that we also pass sometimes. Production lines have a fairly high rate of productivity. It's been much improved on that.*
>
> *… In all, preventive maintenance has been improved in everything. [Copo_6]*

They do not use predicting models, but predicting systems can predict a more serious breakdown

> *Predict, no. Help when it comes to improving, yes. Predicting is complicated. An attempt was made [to appl*y sensor to] the pumps to predict when the bearings could break. But it is very [complex], it i*s not yet proven, it is not working well. We have to improve it. [Copo_6]*

Since the most important thing is to ensure that the line does not stop,

> *if it happens, it is 10 ti*mes a year. Stops not scheduled or due to the client. It depends on the severity. There ar*e slight stops: and we stop 5 minutes a line because a wheel is broken. Of those we can have 100. But then we can have serious breakdowns: the other day, for example, we broke a PLC, [it happens] once every 5 years [Copo_6].*

When planned interventions are needed, they are done on Saturday mornings.

> *Although now we work some Saturdays. We also take advantage of production stops for cleaning.*

Keeping the facilities clean is very important for the maintenance of the machines.

> *…for example, before we had a release agent that was very corrosive, and the maintenance time was much longer. We switch to a less corrosive one.*

Skills of maintenance are specific but they are asked to have overlapping skills

> *There are electric, mechanical skills and molds skill, that is very specific. And in the automation part, which we are 3, we are few.*
>
> *.. in each shift there must be at least one mechanic, one electrical, and one mold mechanic, minimum. Then there is one who dominates both a little. In some there are two molds.*

The company provides some training for the maintenance team

> *When a new machine arrives, if it is true that there is a little training for people on how the machine is going to work…*
>
> *The training is given by the supplier of the machine.*

… the external provider sometimes does not give you training, depending on what processes. And I [he is the maintenance manager, editor's note] personally don't need it because you know how it works. What you do is explain it to the rest of the team [Copo_6]

Specific training for artificial vision – provided by the technology supplier - was needed to align the specific requirements of the inspection and classification line in Copo. Learning on the artificial vision is a continuous process according to the requirements

the provider of the technology [supplied the training and the initial settings], but certain people were trained, they were then improving the process, let's say, that is in continuous learning: [with] new references, you have to create the programs … training the machine to self-adjust. [Copo_6]

For other technologies, learning and experimenting are in progress on the job

Yes, we have tested high-pressure pumps that are fundamental elements for our process. It is true that there is still a great deal of things to improve and improve, but we are gradually introducing things. It is important to sensitize these pumps because they are a critical part: … they are the ones that inject into the head. The transfer ones are less important because in the end they are easy to replace, some are duplicated, it is not so critical … [Copo_6]

The automation process has affected the content of maintenance tasks. With respect to digitalization, data are collected and analysed inside the establishment and data analytics becomes a relevant part of maintenance planning to make the production flow more stable

In the maintenance part we analyse the data of line stops, why it has happened, in the end, then, it is carried out to a follow-up of all the data …

There are more data in the day-to-day and we also know what types of pairings we have had, even to improve the line to, improve production. So that the process is then more stable. [Copo_6]

<u>L+W: maintenance workers, team and shift leaders</u>

Operators vs maintenance workers

Operators in welding cells need no specific skill and training, and some of them have temporary contracts. People in the maintenance team are very committed with the production. In each shift there are specialists from each area, but all must be able to intervene

One is more focused on dies, the rest of the technicians have all a profile more varied … we all touch everything. Each one then has its strengths and weaknesses as usual, but we all touch everything. [L+W_7]

They work very close to the shift leaders. They are essential to advance new ideas on how to improve processes and to reduce the failures. They received specific training on the automation process implemented in 2019: on Siemens PLC, robots, pneumatic, hydraulic, industrial communications. In general, maintenance worker need specific training for new machines and devices, with on-the-job training and mutual learning as important components

It was made of the AGVs when they entered. When we moved to the technology of spot welding with electric and pneumatic grippers, welding training with electric grippers and robot handling were done. …

For example, when the spot welding system with electric tweezers was integrated, a joint training was done, and in the end, with the day to day, what you learn and what they learn … What I talk to you and what you talk to me, at the end so it does increase….

Luckily, luckily, this department is a small department and as we all touch everything, in the end the information runs for all sides the same. [L+W_7]

Every day there is a little progress toward smart maintenance. It needs specific training that gradually is "getting into what we are implementing". So far, it is not perceived as displacing maintenance jobs.

New projects need more training, supported by the company but also by the willingness of people to be trained

> *it's a little more on your side, that you want to learn this. … [In] the department, [among] all the technicians there are some who are more curious to learn all kinds of systems others less and remain a little more obsolete, but in the end it has a little bit*

Team leaders, logistic, quality and maintenance workers

Team leaders as well as maintenance, quality, and logistics workers have vocational training degrees. An internal training and ad hoc specific external training allows them to reach the level of competences needed for their position they undertake months of on-the-job training.

> *in our experience maintenance people need 8 to 12 months to know exactly how is running the line, the factory shifts leaders and team leaders, two years. [L+W_1]*

Team leaders are identified among the operators: the company identifies the specific skills they have and the ones that must be trained, also through vocational training at school. Incentives to upskill are work schedule flexibility on shifts and higher wages, when they become enrolled in the new position.

> *We push the people… "you are an intelligent person, please go to the vocational training school to learn and then we will give you opportunities during the shift to go to the school" [L+W_1]*

The company facilitates training to people who want to study and support them in career development program such as the Easter course that CAAR did[12] and international training in robotics, MES, AGVs.

For 2023-24, the company has training plans, involving team leaders, maintenance people as well logistic people and quality people for the different digital enablers under implementation. With respect to the need to improve digital training, there seem to be some reluctance from some workers who prefer old information systems, like paper.

> *[there are] specific working groups in these digitalization projects…, but not because you are in the union, but because you always have to be involved, because of your technical profile [L+W_8]*

> *it is important to train people so that they can get the best out of these technologies. If you don't, you lose a lot of their capacity. Especially in the plant and in the lines, because in the lines is where they impact the most and that is why we are very focused on the middle management of production, they are for us a priority. [L+W_8]*

The company usually applies to mixed finance to fund training programs[13]

> *This year there has been something left over due to the difficulties of applying all the training we plan, but we usually apply it. This year the budget has been tightened a lot. But we always have plenty of it, as long as we have a little credit left. [L+W_8]*

Taking the decisions: a team issue under the team leader coordination

Based on the data that are collected, there is a daily meeting to discuss them and then decisions are taken by the team leader, who is responsible of production, with the maintenance people, the quality and logistics. So, there is a pool of competence that must gather to take decision, under the coordination of the team leader who is the ultimate responsible of production, together with the shifts leaders, and the plant manager.

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12 Course of 64 hours' duration for team leaders offered by Caar, focused on Continuous Improvement, Lean, Quality, and personal skills.

13 Fundae: https://www.fundae.es/. It is a Spanish public foundation formed by unions, employers' associations, and the government, for the management of funds for training that come from a percentage of 0.7% of workers' gross salaries for one year. That percentage of each company generates a credit in please of the companies that can spend it the following year by applying bonuses to their social security contributions, reducing the monthly bill.

Job rotation

In Copo, workers accept and even ask for rotating to a different part of different operations. Normally there is a fixed team that is involved in job rotation.

> *There is the possibility of moving people from one carousel to another. Organizationally, carousels usually work for specific clients. Organizationally, we try to have the same team in a carousel, but there are people who have the flexibility to change lines. [Copo_3]*

In L+W, job rotation is adopted as a solution to mitigate the mental stress, and workers like it

> *for example, the operator who is working on the welding [roll forming] press is very saturated and stressed, because he has to achieve the cycle time, having to do a lot of manual operations to reach the cycle time. That's why for example Miguel said to the manufacturer responsible: "in order to reduce this stress on this operator in this machine let's do a rotation every two hours. Let's rotate the position of the operators to reduce the stress of working" [L+W_3]*

Mental stress is a dimension included in the analysis and setting of takt time, over repetitive jobs or very fragmented operations with tasks with few seconds.

> *Yes of course, when we make a chrono study, we have, on one hand, the time of the machine, the cycle time, the robots, the table, sensors data..., and on the other hand we have the time of the operations of the operator. And of course, we must apply a percentage of stress and personal necessities in these studies, of course [L+W_2]*

Operators rotate positions within the team in a cell or in a line, teams rotate across lines, workers with problems can be relocated to other teams, but not in other areas

> *but if there is someone we see who has problems, they are relocated. We do not cause the fact that people become more versatile, more versatile and the operator is much better at if, you know?, a machine breaks down, the logical thing is that that operator moves to another machine. No rotation between areas [L+W_3]*

Industrial relations and the role of trade unions in the process of automation

Union: organisation, issues and activities

In Copo, union membership in the company is around the average for the sector. Collaboration with other unions has always been active, and did not increase because of challenges due to automation. At the moment there is quite a lot of sensitivity to the issues of working rhythms and economic aspects, because of rising inflation. At the negotiation level, in addition to qualification level, rewards are related also according to the number of pieces that are produced.

> *They are called 'technical units per hour', and there is a little table that, depending on how many are produced, the operator gets a bonus at the end of the month. [Copo_3]*

Worker are involved in decision-making by participating in the *work climate surveys* conducted at company level, allowing workers' opinions to be taken into account, and that is also part of the negotiation.

In L+W, workers are members of OSTA and UGT unions and membership is about 40-50% of operators, maintenance logistic and quality workers. The pre-covid collective bargaining experience was mainly on the implementation of the 4th shift on Saturday morning, needed to cope with a growing demand from OEMs, that eventually was reduced.

Union & automation

In Copo, Unions have no specific working groups on automation as a member of the committee. The introduction of automation and digitalisation has had no impact on relations with management *[Copo_3]. in L+W, t*he Union representatives are informed of the technological changes once they have been defined and implemented. Their concern is about ergonomics. Trade union representative seems in favour of automation, with no concern about machines replacing people

No. I think it's a very high investment and there are processes in which you can't eliminate labor.

[and the people who were once running the bulls and wheelbarrows] have been moved to logistics, that is, forklifts, there are more than before. You have a picking area that prepares the containers, and you have an area that changes the container, you need people for that. There are no robots that change you and place you let's say empty and full containers. For that you have to be people. Before we had 3 forklifts, now we have 5 or 6. [L+W_4]

nor with respect to control due to data analytics of workers' activities, which even before was to be documented and which is now at least effective because it allows the team leader prompt action to be taken to correct the production process, if necessary

That is, you may be more controlled. [However] also before you had to justify the times. Also at the head of the team to have the digitalization as we have it now in the machines gives you vision to make decisions and in one way or another minimize, well, maybe the negative impact it has on the production [L+W_4]

Collaboration between unions in the company is good and has not been affected by automation.

Union is informed about new automation projects but has no role in the decision-making process

We also understand, no matter how much the European Union says so, that possibly in technical decisions the union does not have to be. Nobody by being a member of the union, that is, of the committee, for example, [L+W_4]

Drivers, barriers and constraints to automation and technological upgrading

Drivers of automation: competition and supply chain

In the case of Copo, automation has moderately improved the competitiveness of the plant and has not produced substantial changes in the supply chain. Conversely, compared to others in the region, the competitiveness of L+W is highly increased, but there has been also an impact on the supply chain: due to the internal changes in logistics, their suppliers are asked to improve their logistics, also with their support.

we have noticed a change, especially in the operation of logistics, in the way of changing from a traditional cell of discharge of components, to something more automated. [L+W_3]
… because I believe that reliability has also been gained [L+W_2].

…

when you go towards this type of technologies, or projects, you make a qualitative leap in quality and technology and, intrinsically, you are also forcing your suppliers to advance in that because you say: "look, until now you brought it to me in a container all scrambled. But because of my process, now I need it to come like this. If you want I can give you support, but from now on I will need this to be structured in one way or another". Then, let's say that in the end, every participant within the entire value chain has a small qualitative leap. Whether or not everyone is going to be forced to give it. [L+W_3]

For L+W, competition is the main driver of automation. Given that the quality is out of question, except when the customer is developing new products, price competition can be only gained by reducing cost per unit of output

Don't' forget that we are a production factory with a focus on processes, so we must take in account to reduce cost, cost, cost… [L+W_1]

For example, now we are moving from thermal to electrical cars, and we can develop new concepts in the body manufacturing. In this moment we will develop one new product and then we show this new product to the customer, OK? The customer does not know exactly the cost of this new concept. In this case we can earn more money. But to make cars from blueprints or CAD files we must compete in price as the OEM is expert in producing cars,

they know the rates of the machines, they know what robots' costs and performance is, and so on. [L+W_1]

Competition with other firms performing the same products depends on the design of the entire process

… the movements, the design of AGV'S lines: we have to reduce the indirect costs because customers don't pay this [L+W_1

The reduction of unit cost is obtained by improving processes, with target key performance indicator. Credit availability, subsidies, are important variables to make the decision, but the search for funding comes along the idea of the investment project

The most important factor is productivity. And when [parent company gives the ok to our project], we implement this technology. Our way to work is: to do one leasing or renting of this AGVs; and then we paid this AGVs month by month during six years… then we don't have to put upfront our money, our liquidity is better, because it was like a renting, or leasing concept.

…Very often people say "I have money, I'm going to buy the biggest robot, the biggest AGV'S". But…Do you have data? Do you have a system to have real time information? And this is a very, very important point [L+W_1]

The company focuses on improving processes and this is an everyday activity in reducing the cycle time of the robots and type of robots.

Every day, this guy, and another's guys main job, is thinking about the processes and improve, improve, improve [L+W_1]

… and balance the robots, and how we can change this point of the robot to another to reduce the cycle time … of the welding process, with the movements of the robots, how we can change this robot from this other [L+W_2]

The impact of automation process is to enhance the competitiveness of the company because of increased productivity, to improve safety, also with the implementation of AGVs, and to make more comfortable, relaxing and more effective the work of all the labour force: from plant manager to the operators. The impact of automation in welding is essential: it increases the performance allowing to reach a higher value-added

Yes, we add value since we define the process and the movements of the robots, and as well, the welding activities. Because sometimes we can improve, for example, at the beginning we must make some welding spots and we need 3 seconds. But we have high technology [MES] and then we analyse [the process of welding], and we can make it in 2.5 seconds, keeping the quality of course. And then this is the point where we can improve our add value. [L+W_1]

Who defines the technologies: local vs global innovation projects

In L+W, innovation projects are not designed in the context of the global European strategy of the parent company, they are more a local initiative of the plant in its more local market situation

[innovation] projects are quite local, from the local management. Yes, there is some similar application in some other plant, but it is not part of a global strategy of the group. [L+W_2]

…

[with respect to the bin-picking project], the benefits are palpable, … so that it can be a pull for the company to try to transfer it to others. [L+W_3]

The role of internal innovation and development is extremely important.

The management of the plant is very, very much for the work of introducing this type of technologies … this type of projects requires a fairly long time in the definition, in the development, in compiling all the documentation and elaborating the project on paper. [L+W_2]

The technology is defined at the plant level, the products are defined by the customers.

> *We define the process… and then sometimes we help the customer in the design of one specific product, but regularly we receive blueprints. Is like drawings, and then the customer said, "you must produce this". We define how we build, how many robots, depending on the volume of the cars … Then the customer makes some tests, and they define the welding spots number, for example, where twelve for those welding spots are produced, using a CAD system.*
>
> *The customers regularly make some prototypes before launching a new car [and] test them - like cross-lateral crashes - and, according to it, they decide to reduce spot welding points or increase it, as well as new glue applications [L+W_1]*

The two persons in charge for project development are two young engineers with a previous experience in the development of MES and AGVs in the company. The company has different KPI's for the production and every year defines a target.

> *We must improve this target, and this is our goal, for the whole plant and for Jorge and me. So, we don't have a parameter for every year, how we must improve, but every year… I think that for next year it's about 3% in the OEE [Overall Equipment Effectiveness]. This is the KPI of the productivity, but we don't have a rule. [L+W_2]*

This target is achieved by a complex process of analysis

> *As Miguel said, we tried to focus, for example, in the welding cell, if we cannot achieve the target OEE. So, we focus on this welding lines to see, making some videos, speaking with the team leaders, the operators, in order to see what the difficulties are they are facing doing his job. To understand why they cannot achieve the theoretical OEE. And, after that, we make an analysis and trying to make a balance, welding balance, an operator and operational balance, or maybe trying to make some ergonomic studies in order to reduce the time and the movement s of the operators. All the operators. So, during this year we made 2, 3 or 4, I do not remember, and in different welding lines, of this type of studies. For example, if the limit of the OEE right now, let's say, or the other problem is the efficiency of the cycle time of the machine, OK, let's say, let's check the movement of the cylinders, let's check the in and out of the robot, the tune table, how we can, let's say, not speed up but improving. [L+W_3]*

In L+W, approximate investment for AGVs was of 300 K€ and for the and bin picking, 600K for the welding cell and 100-150K € for the software, respectively

> *For AGV'S, we could be talking about an investment of €300. 000 and the financing would be the company's own funds, although in this case we have an AEI,14 with a subsidy in which we participate in the design phase. The amount was not very high, approximately 30 thousand €. In the case of bin-picking: the welding cell as a whole, is about € 600. 000, while the software and the development of the specific robot for this application, it is about € 100,000-150,000 [L+W_2]*

In both Copo and L+W, the main obstacles for future developments are their implementation

> *[obstacles are] money, and then the day to day. The implementation of a project cannot be followed as you would like. In this factory the management is very involved in the day to day. [Copo_5]*

In L+W, in addition to specific technical profile, another obstacle to overcome was creating the conditions for a team with open mind, willing to be part of a cultural shift. And time can help

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14 The Innovative Business Clusters Program (AEI) of the Ministry of Industry, Trade and Tourism, launched in 2007, participates in the European strategy to promote competitiveness through the creation and development of Clusters Innovative. It supports with public resources the innovation and business competitiveness strategies developed by the Innovative Business Groups (AEI) that are recognized as such as a result of their registration in the AEI Registry of the Ministry. CAAR, which is an AEI registered with the ministry, manages this type of innovation aid for its associated companies.

above all, when we talk about projects like digitalization and automation, you, your teams need to have a professional profile, a very important specialization in new technologies. And with at least a little open mind, to take on that cultural change…

Any change, let's see, always carries some small obstacle, but, hey, it's a matter of time to adapt. [L+W_2]

L+W_Cross supplier cooperation/competition/partnership

MES is an essential feature in enhancing the performance of the plant, and a standard for its competitors (such as Gestamp), and for other companies in the area (like Magna and ADIENT, that operate in other businesses).

Other tiers-1 suppliers are competitors, but also customer and partner in CAAR.

In RFQ we are competitors. But for example, when Opel say "Gestamp you will be the manufacturer of this assembly, maybe Gestamp call me and say, "Hi Juan Carlos, can you produce this roll forming or profile in your machines?", I say, "yes OK". We were competitors previously and right now we are partners. And then for me is an open mind. We can have these three different [relationship profiles], depend on the moment. [L+W_1]

Through these multiple relationships companies exchange a lot of information on technologies and they can take advantage of all those information exchanges.

Automation in the next two years

Copo: AGVs and artificial vision

Digitalization and automation technologies that will be implemented in the next two years focus on "automation of processes where the added value of people can be invested elsewhere, … to reduce errors to zero, to increase security and reduce distances".

Well, for example, we are in a factory with very long distances and the intention we have is to shorten them, because, for example, with the installation of Automated/Automatic Guided Vehicles [AGVs]. [Copo_5]

Automation projects [should aim at more] machine vision and to the pushers, to complete automatic classification. The issue of vision is to improve production, that is, not to have operator errors, which leaves an insert or any piece. In the welding cell it was a new process that had to be developed from scratch. And on the production lines, in the end, improve the quality of production and the productivity of the plant. [Copo_6]

This is a group policy, with the investment projects more at the local level.

We detect the needs we have here. They can advise you or they can stop you a project, they can tell you "we do not see it necessary". After all, we are the ones who work every day and see the needs we have. [Copo_5]

There are both types. … a part that was introduced in the molds, which was the GLOBALC, to control the piece, the pressure it had in the interior for the understanding of the mold. That came in a group and they did it there. We implemented it in the carousels. [Copo_6]

The steering committee decides what kind of innovation, what kind of machine, what kind of process to adopt. The maintenance manager interacts with management

I can give my opinion, they ask me for advice, but I don't know who decides…. I can suggest improvements [Copo_6]

New projects are analyzed at the beginning of each year and discussed in the context of the company strategy, under the automotive industry-specific standard IATF 16949 that sets out the requirements for quality management system processes that drive continuous improvement, defect prevention, and reduction of deviations and waste in the supply chain. The critical aspects are highlighted and focused for further developments in production process and with innovation

because, as you know, innovation has to be put into any process, production or logistics. And IATF, it is based, remember, on customer satisfaction, then we have to try to get the best to the client. [Copo_5]

Some process improvements are consequences of any legal, technical, regulations, normative regulations, as in the case of the low emission with Isocyanate products.

In the end new circuits were implemented in global one to be able to produce. Trying to work with two isocyanates, one low emission and one normal. In the end it was an extension of the machine, an improvement of the process and not the introduction of digitalization. [Copo_6]

In the case of Copo, the laboratory in Vigo, that belongs to the same parent company, supports the innovation laboratory in the plant in Zaragoza:

they are provider of innovation solutions and of the improvement that we need…in the end they have to receive our feedback. They are not involved in a foam plant. [Copo_6]

L+W: Bin picking in the unmanned welding cell

The bin-picking project is an automation by artificial vision of the process of loading components into the unmanned welding cell. It is yet under development. Both AGVs and bin picking have the same overall aim: trying to be more competitive and be aligned with the client, above all, with the focus on attracting new projects (of clients) by being more competitive.

An important point in both projects in which the two coincide is the cost savings, both in indirect and direct personnel, and in particular, that of autonomous vehicles, guaranteeing the supply to the welding lines of the materials, reducing the safety risks in transport that is an important issue. [L+W_2]

Regulations that apply in the car market define a quality benchmark that is the target for the production of any component. In the case of bin-picking the goal is to ensure the quality of one hundred per cent of the pieces.

The bin picking project provides a test for the relative effectiveness of random display vs packed stuff

the profit of the bin picking is that we don't need to order the parts in the box. This is the difference between the bin picking and the traditional picking or pick and place. … when we configurated the machine…, we had 25 different configurations to pick this part. We realized than one of the positions is better for the cycle time. So, we don't need to order but, if we order this part, we earn in the cycle time of the machine. I know the supplier can provide us the part we need, or we produce, with a different possibility, so, in this case we can work in the two scenarios. [L+W_3]

…

In this case, we receive the parts in the blue box, with a pallet. I don't know what's the quantity in a pallet, but what we were looking for when we design the cell with bin picking, is not to charge, or put more tasks for the team leader, so, for the team leader, for example, if we take the blue box and put the parts in the final box in random positions the machine works perfectly. [L+W_2]

The final result is that a random distribution is ok

In this case we must build a new box for this application, but we don't think about this in the time of the project design [L+W_2]

L+W_Cobots

The company is studying the implementation of cobots in one line, but it is a very complex problem because of safety issues related to the types of metal shapes the operator has to handle

to introduce cobots it's very easy. But when you have a cobot to move a piece in this shape, maybe they can cut your neck. Because normally in its coverage it's not necessary to use

one fence and protection. But in our cases always we use components as you have seen. The danger is in the piece not in the cobot. [L+W_1]

L+W_New projects and fundings, challenges

<u>New project: exploiting the digital twin</u>

The digital twin is the multi-purpose technology allowing to define and select the most appropriate process development, both at micro level - such as in the case of handling of components by the operator in the loading/downloading of the welding cells – and at the meso level of a welding cell. Its application can be distributed, relying on integrators specialists, and refining the settings with a real pilot setting, before the full identification of the investment to be realised.

> *Last year we did one project with the digital twin with one machine here. The preliminary step was to validate if the digital twin will give us the same information that we have in real, or physical welding line. We presented one AEI with Electroingenium15, an integrator specialist in Siemens digital twin. And then, the result was 90% matching between the virtual machine on the physical machine. After that, we spoke with the electric engineers and we said "hi guys, how we can improve the process? And where?".*
>
> *Our partner made one simulation and then, we reduce 5 seconds the process.*
>
> *For us 5 seconds for one part, are many, many seconds because is around 10 or 15%, right?*
>
> *And then we implement this digital twin. And right now, his partner has our machine in digital twin and then, when we must do some modifications, we use this possibility to improve the process.*
>
> *With the digital twin we have made some analysis regarding the micro layout, how do the people during the loading process made the movements without add value. How many works or how many steps that people do during the day [where] single components are just to move for nothing.*
>
> *We have another previous experience in another plant in Germany. We produced exactly 6 of the same welding cells. We did the digital twin while we build the first one. Then, as well, we made the comparison. We set up the physical welding line. We moved this welding line from the integrator to our factory and the rest of the five welding cells just were developed at the integrator plant with the digital twin directly. In our factory, five more welding lines with improvements were made by our supplier using digital twin. [L+W_1]*

<u>L+W_Using Ai in taking processes decisions</u>

Right now, they are starting to work with new players in one new collaborative project funded by Ministry of Industry (through AEI`s funding and grants open call AEI), in collaboration with a university research team

> *We were the first ranked project. The concept is to join different technologies, artificial intelligence plus Internet for things plus blockchain plus digital twin, in one welding cell, to learn how we can combine these technologies and then how these technologies can collaborate to make decisions automatically without people. [L+W_1]*

The implication of this improvement is not yet fully presented, but it appears to be the next step for the team leaders: "*to be relaxed: just read the message*".

[15] AEI are collaborative projects funded by Ministry of Industry, promoted by CAAR as registered AEI, and designed and managed by CAAR with the collaboration of two CAAR partners: Linde and Electroingenium. It's a fundamental tool to improve digitalization and automation. Funding levels by Grants can reach the 50% of costs in pure Research projects, and 25% in development and innovation projects.

L+W_Other collaborations

The company has some projects within Aragon Institute of Technology and in particular with the 3D Printer laboratory, AITIIP[16], which are CAAR partners. In these collaboration projects, the partnerships are very important. They involve tiers-3, providing technology, research centres and also a tier-1 that is the leader of the project.

L+W_Future developments in car industry: electric vehicles

In the transition towards electric vehicle, the company is undertaking a long term research project about aluminum and different welding tools needed for aluminum.

In principle, the materials to be used for the frame of a car are: aluminum, aluminum and steel, only steel, carbon fiber, while for internal parts plastic can be used to have lighter weight.

> *"But if you are producing Opel Corsa, with a selling price about 20-25.000 €, is very difficult to introduce aluminum because the cost would be higher … In premium cars you can use aluminum that is more expensive than steel". [L+W_1]*
>
> *the area is working for long term to offer aluminum processes to our customers. Not thinking about the product itself (the car). We are very constricted about the product specifications by the OEM.*
>
> *… aluminum welding needs no new robot capacities but changes in tooling and other questions. [L+W_1]*

L+W_Customers' reluctance to share information on technologies: CAAR Vice president' point of view

Customers do not give suggestions to automation. Focusing on the company learning from its customers provides a significant clue on its independence, but also from the OEMs strategy with respect to a supplier like L+W Zaragoza

> *Did they implement AGV´S, did they implement MES? [MR]*
>
> *It's a good question. Now I'm not Linde plant manager, I'm CAAR Innovation Vice-president. Then we had two meetings with the Stellantis plant where we exposed the same question you have request me. "OK guys, if you implement new technologies inside your factory, why you don't transfer it to your suppliers?" Because we together we can be more competitive. And then we can keep here the labour, we can keep here the factory, the production, and so. Two times with David Romeral, the CAAR cluster manager. And then it's still here: that people is very closed, or they depend too much on the French headquarters, and then, at the moment we don't have any feedback about this point. [L+W_1]*

But the same occurred with partners in the cluster,

> *We have gone two times with our partners in the cluster automotive, very different companies to our customer plant to show our skills and say "then, you can use our technology to improve your processes". As well, they never used*
>
> *…*
>
> *that they don't want to do it, or they can't do it, because they depend on the headquartered in French. But the main point would be the OEM transfers the experience they has to us because if you have, you are more competitive, you can produce faster, you can implement one technology regarding the quality to be sure that always we send you good parts and then we cannot stop to you …, for example, if we ship one part not okay, maybe we can stop your plant half an hour… I think there's something like a wall… [L+W_1]*

Because when you can save money, you can produce a cheaper car, for example.

[16] https://www.aitiip.com/en/

my point of view as cluster vice-president, not as Opel supplier, we must think about … we want to keep the labour people fix in Zaragoza. We need to work with our suppliers around us, to develop or… to transfer… or to speaking about the technologies. What is the best technology you have to do this? to enhance the quality and so on. Because we will be cheaper. The price of the part will be cheaper, I know that. Thinking just about in the processes, in doing more "lean process", not to thinking about the purchase, the purchase department. Because this is another word. Just to think about in this way. But this is very complex. The people are closed in mind. And then…This is an advantage for all.

OEMs are implementing digitalization in the level that they are supposed to do.

Yeah, I think so. They have some specific projects that they can translate to the suppliers, interesting for us. In one workshop, I can transfer to you, and I don't have any problems. And then you transfer to me. Yes, but this is very difficult.

Discussion and conclusions

Both company visits were very well organised and the research team received detailed explanations on processes, technologies, labour organisation, strategies to cope with the customers' needs. In the visit to Copo Zaragoza, the HR Manager allowed the research team to take photos and videos for internal use. In what follows we first summarise some issue common to both case studies and then we discuss results emerging from each of the two companies.

Common issues

The most relevant issues emerged during the field-study in Spain are:

— Implementation of automation and digitalization mainly driven by the need to increase the competitiveness of Spanish companies, through an improvement of the entire production process, particularly stringent in the case of suppliers that must deal with high variability of models.

— Pivotal role of data analytics, supported by MES, largely deployed in logistics, quality, and maintenance departments to increase efficiency, facing the subordinated position of suppliers within the value chain and a strict just-in time production model.

— No evidence of significant job displacement, but contrasting trends in terms of working conditions improvement and job quality.

— Crucial role of training courses on digital skills and data analysis, done both internally and through training centres in the automotive clusters that propose tailored courses on the needs of SME located in the area.

— Positive impact on gender participation, since the introduction of automation technologies has reduced the incidence of the heaviest and less ergonomic tasks, despite the sector remains highly segregated in terms of gender and type of occupations.

— No direct decision role of trade unions on the introduction of automation and digitalisation, but strong commitment to improving working conditions and ensure an adequate supply of training opportunities for workers particularly affected by the adoption of new technologies.

COPO: automation to guarantee quality

The production process of the foam forming of the seats is made from a blend, not patented, which makes their padding particularly comfortable and durable. The blend is made by Copo to meet the needs of their customers, including Opel located in Zaragoza. Copo is a second tier supplier: the production of seat upholstery is destined for tiers-1 suppliers, which complete the seats with upholstery and all the accessories needed in the seats that goes directly to the assembly line, according to in-just-sequence.

Daily planning of production takes into account the many models that must be produced by the OEM supplied by their tier-1 customer. Different models request different molds or inserts: in whatever the sequence they are produced, they must be stored in boxes according to the specific model.

The production process is largely automated even if the insertion of the various types of components (fabrics, metal) in the molds, the deburring, and the storage of the finished pieces in the boxes is done manually. These operations are not yet automated and they would require a completely different design of the area surrounding the forming line to allow the use of robots in the gripping and positioning phases of the various inserts.

Four years ago, the adoption of digital optical viewers for the automatic selection of finished pieces, to be sent to storage for shipment, was their solution to eliminating errors in classifying pieces that differ only for some tiny details, but can produce problems in the just-in-sequence organisation of production flow of their tier-1 customer. Those errors had to be eliminated, thus increasing the overall quality of Copo's products.

The goal is the complete automation of the transport lines of the metal boxes that contain the finished products to be sent to customers. Rail conveyors are currently used along a linear path parallel to the manual sorting line. AGVs will complete the automation of transport to storage for every four-hour daily delivery.

The production of the padding must be carried out close to the assembly: it is in fact a very light and very voluminous material, on which therefore the transport cost would have a very high impact. The expansion of Copo production destined for tiers-1 of the German OEMs will be carried out in Slovakia, where a plant - currently in use from Copo in Fuentes, Zaragoza - will be moved.

Automation, robotization of certain operations, digital optical controls and data analytics to plan maintenance interventions have been implemented with the aim of improving the production process, in a context such as the automotive supply chain that requires compliance with stringent quality standards, traceability of production processes and challenges the organisation of production processes with high variability of models, planned on a daily schedule in a just-in-time model of production with a four-hour daily delivery for tiers-1 located in a range of one thousand kilometers, who produce in a just-in-sequence model of delivery according to the schedule that daily the logistic department of the OEM communicates to their logistic department.

Over the last ten years, Copo has implemented automation in the most repetitive operations (such as mould opening), robotization in noxious (mould spraying) or heavy operations (such as injection of the mixture), and the replacement of manual inspection with optical devices, both to check that all the inserts have been positioned and for the selection for boxing the finished product. Gender disparity has been reduced by eliminating the heaviest task.

Most of the implementation takes advantage of the competences within the Copo Group, while Copo Zaragoza itself plays a dynamic role in enhancing productivity of other plants of the group being part of investment projects that upgrade their performance in Zaragoza. The competitive performance of the plant keeps the pace enhancing labour organisation and retaining the internal competences trained in various technical jobs (from logistics to quality control and maintenance and team leaders) through flexible hours when training is needed, adequate wages and good labour relations.

Producing foam for seats is an essential component for any vehicle whatever the engine is used. However, the future of the ongoing transformation towards electric mobility will impact because of the expected overall reduction of the number of vehicles that will be produced. Uncertainty will be addressed by increasing the quality of their products with more cost-effective processes. Automation is a solution, but at present it seems marginally focused on reducing labour, more to improve quality of their products, keeping the wide range of models and their not ordered sequence as a critical challenge in organising production flows with zero errors.

L+W: a polyphonic account on automation process implemented in the company

The various interviews provide a polyphonic account of the introduction of the two technologies – MES and AGVs – that mark the process of automation in the plant of L+W in Zaragoza. The research team was guided in the interviews by a detailed visit to the company (lasting more than two hours) with a technique-based narrative that aimed to capture the implications of the choices made over time. The interviews with two project developers, two team leaders, the logistics manager (a union representative), and the maintenance manager do not reveal contrasting elements, but rather complementary elements that enrich the dimensions under analysis from the point of view of the different roles covered by the interviewees and their individual experiences. The interview with the

plant manager (lasting more than one hour) provided us the overall of those individual narratives in a framework that appears unitary, fruit of the long experience that united that group of people in the process of change that they have built together over the past four years of automation focused on enhancing value added from welding.

We missed the point of view of operators in the welding cell and the rolling form areas. From our interviews it appeared as a marginal group of workers, numerically shrinking, with very low qualification and a significant share of temporary workers. Their current involvement in the virtuous circle of benefits from automation is essentially for an ergonomic and safety working place, without a perspective of a more stable employment or a better qualified job: they enter in their job with such a low level of technical competences that they seem in a transition state. They are part of a labor reservoir that remains needed in the transition to the full implementation of completely unmanned welding cells, when all the workers that will be needed will be qualified workers with polyvalent competences, working in qualified teams, that are essential in the process of continuous improvement of the productive performance of the plant. The company's goal is not a reduction of the overall number of employees as much as a more competitive and increasing the volume of their production capacity, given the present endowment of machinery and robots, by reducing waste time of robots and of automatic handling.

In the gender composition of the interviewees, we could only interview one woman. All interviews emphasised that the company has a balanced development with respect to the involvement of women in all tasks and roles of responsibility. Safeguards for workers in general, and specifically for women, are guaranteed in the enterprise but there remains an underlying issue with respect to their greater involvement, due to the substantial scarcity of supply of technical skills in the region (and in Spain) among women.

A crucial impact of automation appears to be a new perspective on day-to-day decision taking by using data analytics in a collective understanding that engages the team of logistic, quality, maintenance workers, under the team leader coordination. This change has pushed an *ad hoc* training of team members not so much on specific digital skills (such as programming) as in interpreting data in relation to the specific production technologies and in relational and organisational skills. With respect to such training, CAAR plays an important role, offering specific training programs, tailored on the SME' needs in the area, not offered by other technical and vocational training agencies in the area. Interviewees have stressed the importance of being curious and eager to improve and learn, and to share with others what has been learned: an individual attitude that seems to be an essential lever for supporting the company innovative dynamics, that must be further consolidated (beyond the present group of middle managers) with ad hoc training (in learning how to learn and to collaborate) and incentives (from higher wages, to fringe benefits, such as flexible working schedule, to stable labor contracts). study

With respect to the parent company in Germany, the plant in Zaragoza is the first plant in the group that implemented AGVs technology and that is now experimenting the unmanned welding cell: front runner available to support the implementation in the other plants of the group. But, in general, it is a company that urges, through the actions of its production director, also vice-president of CAAR, the implementation of automation to increase the competitiveness of Spanish companies and those in the study cluster, which includes automotive OEMs and tiers 1 and tiers-2 suppliers.

Last but not least, the reluctance of OEMs in enhancing the innovativeness of their suppliers is something to be deepened as a specific issue of the development path of the automotive sector. It is important to understand why the OEMs seem to keep the level of technology of their suppliers controlled below a certain level as they are unwilling to reach a different configuration of the market in which cheaper cars might be produced, and where suppliers might be more competitive without simply squeezing labour costs on the shoulders of temporary workers.

What can we learn from the two case studies

The impact of automation on work is complex and not uniform. On the one hand, it increased work efficiency and improved ergonomics for individual tasks, reducing the risks of heavy operations (i.e., loading large sheet metal parts for stamping), as well as of dangerous (i.e., welding), harmful (i.e., preparing mixture for foams) or repetitive ones (as in the case of certain assembly operations). On the other hand, it increased mental stress in some phases of the labour process and challenged

occupational perspective of fringe workers: these either seem to be "in transition" workers, waiting for full automation displacing their tasks without an alternative one in which to be employed, or "temporary/precarious workers", to support the waves of extra almost daily/weekly variability of demand.

However, for the time being, the overall impact on the labour force has not entailed an overall reduction (modest), as the many changes within the labour force composition, by activity and skills. New technologies reduced the number of line, less qualified workers, while increasing the number of maintenance, technicians and people in quality control.

Since tasks that used to be more physically demanding have been automated, this allowed an increase in the number of women in production tasks, although it seems that the process of up-grading towards technical or managerial tasks remains limited.

4. The case study of automotive sector in Germany

Overview

The automotive in Germany

The German automotive sector plays a crucial role in the national economy both in terms of employment, value added, export and R&D expenditure. The regional location of German-based OEM, largely grown over time, is distributed over the entire country, with a higher concentration in the South and fewer sites in the East. Its international dimension is extremely relevant given that exports account for two-thirds of total industry turnover and German OEMs' overseas locations produce around 11 million vehicles. The degree of automation, that largely took place already in 1980s-90s, is very high and the rate of robots/worker in the car industry – with 1,300 robots per 10,000 employees - makes the German car industry the sixth most robotized car industry in the world.

Beyond robotization and increasing digital transformation, the automotive sector is recording a larger transformation process of its entire industrial landscape related to the twin transition. After an initial delay, the reaction of German companies has been faster to face increasing competition coming from the US and China.

Ongoing changes are particularly critical given the historical relevance and the international position that the industry plays. The German government, already pioneer of the "Industry 4.0" paradigm in 2013, is committed to ensuring a green, competitive, and productive transformation of the national economy. OEMs are massively investing to advance on digitalization, autonomous driving, electromobility and decarbonization (approximately 150 millions of euro by 2025 according to the VDA). Particular attention is also devoted to the integration of battery assembly/power electronics and battery cell production within the OEMs' production networks. German trade unions, endowed with participatory and information rights granted by the codetermination model, are also facing new challenges especially related to the process of sectoral restructuring and the low unionization rate in smaller suppliers.

Digitalization and further development of automation technologies are nowadays strictly linked to the process of decarbonization since the former can be further developed to foster the process of conversion towards electric mobility. The effect of the conversion towards electric mobility is expected to be highly diversified across production areas and companies, with suppliers of components and power trains more hardly hit.

Accounting for the role of the German value chain in the automotive sector across European countries becomes pivotal to study the implications of big OEMs choices concerning investments and production. In this context, a tendency towards in-sourcing seems to take place in Germany, as OEMs have announced their intention to manufacture as many components as possible in-house, also to face and manage potential job losses due to the shift from powertrain to electric mobility. In terms of skills and occupations, the German automotive sector does not seem to be experiencing any significant shortage in the labour market. At the same time, big OEMs are developing new strategies to become more attractive and face competition from other highly dynamic sectors.

The case study

Information and data are mainly obtained through desk research and interviews to four scholars in the field of automation technologies and labour, four trade union staff members with policy analysis responsibility, a multinational company HR manager. It was not possible to get direct access to the OEMs plants located in Germany, a consequence of the specific and serious challenges that the sector is facing.

Before presenting the main results of the research conducted on the German automotive sector, some clarifications on the strategy adopted in this report are to be provided.

At the beginning and throughout the period of the field study, several contact channels were explored to obtain the willingness of companies and trade unions for interviews (see Annex for a detailed list of contacts activated and reasons for denial); such willingness was initially confirmed but denied at a later stage, for various reasons.

Following discussions with German researchers in the automotive field[17], the research team reached the conclusion that labour research in Germany is going through a very critical phase due to several factors. Many companies have been willing in the past to engage with the scientific community, such as Volkswagen or Ford, but for different reasons they are now less open to this type of collaboration. Scandals related to the Diesel gate, massive restructurings taking place today are such that OEMs' choices are quite controversial and object of internal debate[18]. This specific context does not favour a confrontation with companies' managers and trade unions aimed at contributing to policy recommendations that should come out of this European research project.

One episode encountered in our research is particularly explicit: the case of Ford's trade union. Trade unionists initially declared great interest in participating in the project, but upon the announcement of the decision to close one of Ford's plants in Saarluis[19], they withdrew their availability, stating that neither union representatives nor workers would take part in the interviews, even if management had given its approval to the research. In the case of Volkswagen, the trade union certainly did not favour the management's willingness and showed no interest in discussing the research topics. Even moving from OEMs to Tiers 1 did not bear the hoped-for results, contrary to the case of Spain.

Given the complexity of the German case and the aim to collect interesting information of ongoing transformations (that seem to hinder the realisation of our interviews and field-study), it was agreed, in accordance with JRC, to carry out a series of interviews on our research topics with experts of German industry, trade unions and companies' managers when available.

While it is quite different from the previous reports on Romania and Spain, we believe this report still sheds lights on crucial issues that risk being overlooked when focusing too narrowly on technological change without taking into account, particularly in the case of Germany, for the degree of automation across car makers and suppliers (tier1, 2 and 3), the role of trade unions in the German codetermination process, the impact of automation on work organisation, and the challenges of the transition to the production of electric vehicles.

Given the impossibility to perform field studies on specific companies, the main content of this section will refer to the automotive sector at the national level. Information and data are mainly obtained through desk research and from interviews to four scholars in the field of automation technologies and labour, four trade union staff that are policy responsible and policy analysts, a multinational company manager in the HR area of project development and innovation. In addition to the specific literature on the sector, the main reference is the publication in German by Antje Blöcker (2022)[20], which offers an updated and comprehensive overview of the German industry. In Germany, the automotive sector has a great relevance in terms of employment, R&D expenditure and export. It represents the second largest industrial sector, behind a complementary sector, i.e. the mechanical and plant engineering one. If we take into account upstream and downstream value-added sectors, the car industry employs around 2.2 millions of workers (BMWI, 2019 as reported by Blöcker 2022). What is more, the car industry can be considered a key driver of national innovation, with a 38% share

[17] Namely Gerard Bosch, Thomas Haipeter and Steffen Lehndorff (see Annex 2 for details)

[18] Obstacles for the field-study (specific evidence from interviewees).
Thorben Albrecht, IG Metall (*Industriegewerkschaft Metall*, the German metalworkers' trade union), refers to the impact of e-mobility on the sector and on the potential employment loss: "So these are the changes we are facing here, and maybe […] it is why it was difficult to get to speak to people because they are very much involved in this transformations and they are quite busy."
Thymian Bussemer, VW plant, points out that there are guided tours of the VW plants every day, which can simply be booked, but "At the moment you start to interview people, bureaucracy starts, the works Council is of course involved, very much on attention with work as being interviewed (…). So getting an idea of the plan is no problem at all and we have so-called professional tool where it's possible to talk with someone selectively then picked from the management about specific aspects, but to go with the research project in one of our plants, that really means that there's plenty of work to be done and to get it prepared".

[19] https://www.igmetall.de/im-betrieb/im-saarland-brennt-der-berg-ford-saarlouis. For a more recent, and still uncertain, perspective of the Saarluis Ford plant, see the news of negotiation between Ford and Byd on the Saarluis plant https://www.electrive.com/2023/01/25/byd-in-talks-with-ford-for-factory-in-saarlouis/, and the news on Ford moving R&D to the US https://www.igmetall.de/im-betrieb/ford-jetzt-soll-auch-produktentwicklung-rasiert-werden

[20] Blöcker Antje, "Die Automobilindustrie: es geht um mehr als den Antrieb: eine Studie im Rahmen des Projekts", Sozial-ökologische Transformation der deutschen Industrie, Berlin: Rosa-Luxemburg-Stiftung, 2022

of total industrial R&D expenditure and 29% of total R&D expenditure of the economy (VDA 2021)[21]. Likewise, the international dimension of the German car industry is extremely relevant: exports account for two-thirds of total industry turnover, while German OEMs' overseas locations produce around 11 million vehicles, more than double the 4.7 million produced in Germany (Blöcker 2022). Moreover, they play a strategic role in leading international trade networks in vehicles, components and parts (Gorgoni et al., 2018[22]; Russo et al., 2023[23]).

Interviews' findings

Automation technologies, robots, digital technologies

As it is well known, the degree of automation in German automotive OEMs is very high, its introduction in the German car industry dating back in the '60s and '70s. However, its adoption is still heterogeneous across production departments. What is more, new obstacles and challenges are arising nowadays with respect to robot flexibility and adaptability to complex production environment, as evidenced by several interviews[24].

> *… I try to give you a broader picture. First of all, the degree of automation in the automotive industry is rather high compared to other industries. So the first industrial robots at the Wolfsburg plant was introduced in something like 1961. So there is almost 60 years of experience with automation (…). If you look at the production areas, there is no unified picture: in some of the Body Shop (the part in which metal is formed in the chassis of the car) we have a degree of automation around 90%.*
>
> *If you look at other areas, like final production (this is where those famous assembly lines are being installed) automation is far lower because there the majority of work need to be done where it's necessary to go into the car: you do still need human craft because it's far too complicated. Robots are too inflexible, too heavy in order to do this kind of work. So there's a rather high intensity of human labour in the last area of the production process, in other areas of production, it's rather high. [DE_1]*

Thus, the general reduction in the cost of investment in robots and cobots has not completely displaced jobs due to the need of exploiting the greater flexibility of humans in their movements, although artificial intelligence is raising some expectations regarding the possibility of further substitution of labour:

> *Something like almost 10 years ago, we had a very intense debate about those new generation of small cooperating robots. Maybe expected that in the new generation of robots which can be trained more easily due to artificial intelligence, which are much more flexible, could take over works being done by humans….*
>
> *And I think this idea hasn't really fulfilled yet… robots became much cheaper. I mean price is an argument as well.*
>
> *Cooperating robots cost something like €60.000 or €80.000 compared to one or two millions, which you need to invest for a heavy one. But technical development didn't progress as fast as we expected, and it was interesting that it was our production department which stated we do not want anymore automation. It's very cost intense to do this investment and by the end of the day, humans are more flexible. So if there is a change in production or if they're different models on one assembly line then humans are still better than machines. [DE_1]*

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[21] VDA (2021): Annual Report Automotive Industry 2020. Berlin

[22] Gorgoni, Sara, Alessia Amighini, and Matthew Smith. 2018. "Automotive International Trade Networks: A Comparative Analysis over the Last Two Decades." Network Science 6 (4): 571–606. https://doi.org/10.1017/ nws.2018.18.

[23] Russo, Margherita, Fabrizio Alboni, Jorge Carreto Sanginés, Manlio De Domenico, Giuseppe Mangioni, Simone Righi, and Annamaria Simonazzi. 2023. Regionalisation and cross-region integration. Twin dynamics in the automotive international trade networks, *Structural Change and Economic Dynamics*

[24] The text of the interviews has been edited, albeit minimally, to facilitate understanding.

Impact of automation on work organization and employment

Job displacement

Several scenarios are described by analysts, with different estimates in terms of the total number of jobs that will be created and destroyed. According to Dispan (2021)[25] quoted by Blöcker (2022), 440,000 employees and approximately 93,000 apprentices in the automotive trade will be particularly affected by the key trends of decarbonisation, electrification, digitalisation and new business models. Most studies distinguish between the potential positive impacts related to the electromobility "rump-up" and the expected negative impacts on employment for producers and suppliers of the traditional car industry based on combustion engine. Indeed, while the main threat to job security appears to come from electric mobility rather than digitalization, the process of restructuring due to the move towards e-mobility, and fostered by increasing degrees of digitalization, is likely to see as potential "losers" mainly suppliers who produce components for combustion engines, where job losses are likely to be concentrated. Thus, a significant unbalance in the distribution of job losses is likely to be recorded along the value chains, with well protected jobs within OEMs and more precarious and uncertain jobs in the supplier sector, as also reported by the IGMETALL report of 2021 (Blöcker 2022).

Work organization and job composition

Getting a clear and detailed picture on the impact on work organization and job composition of digitalization and automation through the interviews was extremely difficult, given the impossibility to talk with workers and visit the plants. In general terms, positive impacts on health and safety conditions were confirmed. Interestingly, also the creation of more administrative jobs was stressed by one respondent.

Gender equality has been claimed, or rather taken for granted (as argued by Thorben Albrecht), perhaps a little too hastily, dismissing the questions in this regard as irrelevant. Indeed, when the VW manager (Thymian Bussemer) is was asked if VW currently paying specific attention to gender equality and whether specific gender related policies are adopted to favour the inclusion of women, the answer was that these issues are taken on board and these data are permanently analysed. Concerning the potential increasing intensity in the pace of work and the level of autonomy and routinariety of workers in performing their tasks, the picture remains quite blur both because of the impossibility of visiting the plants, and because of lack of details provided by the respondents on this specific issue.

Answering to the question on the possible saturation of work in the production line because of the adoption of digital and automated technologies, the interviewee DE_1 says that:

> *It is impossible to judge. So I think this is the normal task time is one or two minutes (..) but I think just within one factory you have so many different task systems on one assembly line. I mean this is really the result of what is the task to be accomplished, which kind of technology is installed, which people are working there, and I mean we have parts of the assembly line in which (…) the the takt time is intentionally slower but there is neither a unified shift system nor a unified takt time in VW. It really depends on the specific situation. [DE_1]*
>
> *Yes, I think when it comes to production automation rather help to make the jobs better because some of the very heavy work is becoming easier now and still, it's going slowly enough that it's not really leading to job losses in the in the short term. In the long run, that might be part of that, but not as important as this change from combustion to electric engines.*
>
> *And the administrative field, yes, and the danger of automation is stronger there, depending a bit on what people in administration do, but of course there we can see that automation in administrating wages. Sometimes cars suppliers also provide insurances for cars, and there, of course, the automation of these kind of tasks will affect the number*

[25] Dispan, Jürgen. 2021. "Branchenanalyse Kraftfahrzeuggewerbe: Digitale Transformation, Technologiewandel und Beschäftigungstrends in Autohäusern und Kfz-Werkstätten." Working Paper 223. Working Paper Forschungsförderung. https://www.econstor.eu/handle/10419/240592.

of jobs there, but at the same time, there are new administrative jobs that are being created. So I think and there maybe it's easier for administrative workers to change from one part of administration to the other. So but the fact of automation is there in the administrative field, maybe a bit more heavily when it comes to numbers even than in the production part. [DE_3]

New jobs: engineers and software specialists

Engineers and software specialists are among the most demanded jobs. Given their strategic role, the choice of German big companies is to hire them as dependent workers instead of relying on external workers (consultants, temporary agency workers, etc.). This is confirmed both by the trade unionist of IG Metall and the company manager of VW.

I think the German car companies really try to have most of their software issued inside the company, either by pooling their software engineers, for example Volkswagen do that: they have founded an own daughter company caveat, where they have the software engineers from the different branches of Volkswagen and that is growing a lot, but this is an official daughter, they are part of the Volkswagen system.(…) I think the general trend in Germany is if the companies need some new software experience, they don't have inside their company, they rather buy smaller software companies. So they become also part of the company. Of course there are some freelance for special tasks that might be their only for let's say a year or so. And there's some outsourcing there, but I think it's not the general trend. [DE_3]

In particular engineers seem to be at the centre of important changes in terms of job reconfiguration for what concerns the tasks they are supposed to perform and the knowledge they need to acquire. In fact, companies confirm the need to update and enrich the profile of automotive engineers previously specialised on combustion engines and now asked to move to electric batteries and more complex technologies.

The Mechanical Engineers as well: they are part [of the OEMs], we have these engineering centres of the car producer.

There's more. The problem that there we will also see a lot of job losses because the Mechanical Engineers you needed to engineer combustion engines, a lot of them have to find new jobs as well. So even though they're highly qualified, they are under pressure from unemployment or at least having to change the work because they're special knowledge is no longer needed when there are no new combustion engines designed and they will be hit before the production workers, because they are before the wave. So if from 2035 there will be no combustion cars in 2030, nobody will design you motors for this cars where they might be still produced for another 3-5 years. [DE_3]

New (and old) job profiles and the role of vocational training

It is important to stress that the general level of qualification in the automotive sector in Germany is quite high: the possibility of relying on a well-trained and skilled workforce has been one of the main goals pursued by big companies back in the 70s. According to IW Consult (2018), "the share of the workforce without vocational training in vehicle manufacturing decreased from 20.3% in 2000 to 10.9% in 2017, while the share of university graduates increased from 10.2% to 19.9%, and qualified skilled labor hardly changed at 65.9% and 64.0%, respectively" (Blöcker 2022: 9, our translation from German).

Extremely relevant is also the dual education system which is training an increasing number of students. However, while a rising number of skilled automotive mechatronics is now employed in the production process, indirect areas such as electric and maintenance workers are downsized in favor of functional areas (i.e., marketing, administration, and finance), which are on the rise.

In addition to the job reduction, a reorganization of the employment structure within the German automotive industry is foreseen by several experts who underline the need to invest in new professional profiles related to mechatronics, electrical and energy occupations, such as electrical, mechanic engineers and industrial technicians. This is confirmed also by the necessity of making workers more involved in this on-going process, also through the adoption of new training programs by OEMs especially for what concerns all the challenges related to electromobility. As reported by

Blöcker (2022: 32) "VW trains all 7,000 employees in Zwickau in short one-day seminars, is building a training center[26] for car dealers in Dresden, and BMW has trained a total of 52,000 employees since 2009. There is evidence of such measures at almost all locations."

Also, the increasing need for IT specialists and other job profiles related to digitalization (i.e., digital engineers, technicians, programmers) pushes towards the adoption of adequate training models.

In this process of ongoing re-composition of jobs and tasks within car companies, vocational training plays a crucial role in ensuring an update of the skills and competences needed for the new workforce in the sector.

> *(..) we are doing changes in our vocational training. If you take the profession of the mechatronic, which was a very successful profession over something like 30-40 years, where we have now learned that training people in digital and engineering knowledge at the same time is no longer sufficient, so technology has become too complicated, they need to do it either or. (……)*
>
> *So we are shifting vocational training and numbers from we produce more digital affiliated.*
>
> *Apprentice and then traditional ones for the shop floor. But of course we go on with shop floor training.*
>
> *So for xx in Germany applies the upmost majority of our factory line workers to a skilled craftspeople [DE_1]*

The model of vocational training and dual education system seems to be very specific of the German case and hardly comparable to the other countries analysed in this project.

> *The effort in Romania to upskill production operators to maintenance tasks, quite plausible because you do not have very well-developed programs of vocational training, difficult to develop your own people. In CEE there is a very tight labour market, so trying to develop your own people, this might not relate to technology but to the labour market condition and the difficulties in finding the right people in the market.*
>
> *In Germany, it would be very unusual to train your maintenance workers at university: you train these workers though vocational programs, whereas university is for engineers etc. (…) Hardly any universities will be equipped with specific equipment needed in companies. I thought in Germany what we see, not only for the automotive industry, is the development of the so-called dual vocational system and we have a growing sector of dual universities where university graduate engineers also do vocational training for maintenance etc. These people are engineers, but they also have the very hands-on knowledge they need in order to do their job. It might be very specific of the German perspective, but maybe also in Romania there is some development of this hybrid form of university/training. [DE_2]*

Skill and job shortages

In terms of skills and job shortages, differently for the other cases under study, the German automotive sector does not seem to be experiencing any significant shortage on the labour market. At the same time, big OEMs like VW are developing new strategies to become more attractive and face competition from other highly dynamic sectors.

> *With regard to potential skills shortage that is becomes obvious that the world is changing and for a couple of years we have discussed about if Volkswagen is attractive enough for to attract talent and said specialists, which we do need for our new business models. Now we get to learn that finding skilled work has become more difficult and I mean Wolfsburg*

[26] As reported by the company, during these programs of training called "eMotion Day", production workers enter in "escape rooms" and engage in solving puzzles and problems related to the evolution of mobility from 19th century to the new electric and digital vehicles. (source https://www.volkswagen-newsroom.com/en/press-releases/wolfsburg-plant-volkswagen-will-train-22000-production-employees-for-e-mobility-by-2025-15480)

is 1 hour by train from Berlin. Why working in three shift system in a plant in lower Saxony if Berlin has a labour market where is able to easily find jobs and services or elsewhere.? So to keep the classic industrial professions attractive even if they have rather high paid and very safe becomes more difficult. [DE_1]

The relation between German OEMs and suppliers

One of the crucial issues that emerged in almost all interviews is the position of German players and their productive and hierarchical relations with suppliers, both located in Germany and across Europe. Accounting for the role of the German value chain in the automotive sector across European countries is therefore pivotal to study the implications that digitalization and e-mobility can determine in European automotive plants.

First of all, with respect to the adoption and implementation of new technologies there is evidence of a strong heterogeneity across suppliers.

Of course, it depends on in which country we are operating. So, where wages are high, the degree of automation is higher as well, where wages are lower, we do more by hand, but in general I think we have reached a peak of technical development which is not progressing any longer at the moment.(…)

There is not "the supplier": supply begins with very simple product, plastic components, whatever which could be produced everywhere in China or India or elsewhere and ranges to companies like Bosch which have technology without (…)

We couldn't produce not one car at all. So it has been starting with the catalyst in the 1980s, which is a Bosch invention. It's for sure that those, let's say, simple commodity products, their likelihood of automation or offshoring of production is far higher than those suppliers really based on intellectual property, on patents, that sort of thing. So, I think that that working at Bosch is very similar to working at Volkswagen, working at a Portuguese supplier for some minor parts is certainly another thing. [DE_1]

Not big differences between OEMs and strong TIER1 (i.e. Bosch). Bosch is an equipment builder and automotive supplier, so you have strong suppliers that are surely not behind OEMs. Automation levels are very high, still some fields in the assembly process and logistics are very labour intensive, experiments in assembly but not huge automation, whereas huge efforts in logistics, but it might take long (not still in statistics). [DE_2]

Consistently, the process of restructuring and re-organization is on-going along the entire value chains but with potential different outcomes across countries, with new challenges arising at the EU level. This perspective is well perceived by other European social actors, as emerged from the interview to Italian metal workers trade unionists. For instance, Simone Marinelli, underlined how those Italian producers of mechanical components that were able to diversify and orient their production towards Germany, which is now in a better position with respect to other European competitors, are now in a better position with respect to most national producers that strongly rely on Stellantis.

"The IT sector becoming more and more important, and this is affecting all automotive companies in Germany, from the producers themselves through the whole line of suppliers of course, because especially some suppliers have been working on special motor parts that are no longer needed in the future of the 2035 when there will be no combustion cars allowed in Germany and in Europe. So this of course also leads to a lot of restructuring of companies. You could see that some of producers are partly insourcing part of the supply chain, which puts suppliers even more under pressure" [DE_3]

Drivers, barriers and constraints to automation and technological upgrading

Technology implementation, obstacles and complementarities

When it comes to the adoption of digital and automation technologies, the German automotive sector can be considered a "pioneer" worldwide (Blöcker 2022). Indeed, much of the introduction of automation happened during the 1980s and 1990s with the adoption of CNC (Computer numerical

control) machines and industrial robotics. The main novelty nowadays concerns the introduction, in the recent years, of Industry 4.0 artifacts such as 3D printing, 3D glasses/tablets, collaborative robotics and AI systems that are progressively entering the companies, but without causing disruptive change with respect to job displacement.

Apart from the implementation of new technologies, the main issue that interests the sector seems to be the move towards electromobility, given the constraints imposed by the European regulation on the C02 targets for new vehicles. According to Blöcker (2022), car manufacturers want to massively increase their electric share of total production, moving from an average between 8% and 12% in 2021 to over 50% by 2030. In this sense, it is not appropriate to separate the adoption of digital technologies and the conversion to e-mobility since the two processes are strongly linked. This has fundamental implications in terms of the reorganization of the sector along its value chain, network of intermediaries, demand for new inputs and raw materials (i.e., chips, batteries), necessary infrastructure and so on. In this context, a tendency towards in-sourcing seems to take place in Germany, as OEMs have announced their intention to manufacture as many components as possible in-house, also to face and manage potential job losses due to the shift from powertrain to electric mobility. This issue has been specifically addressed by Thorben Albrecht, IG Metall, with respect to the regional policy targeted to support this transition.

According to VDA (2021), the investments of the OEMs to advance on digitalization, autonomous driving, electromobility and decarbonization will amount to approximately 150 million of euro by 2025.

While until recently almost 100% of battery production relied on purchases of cells from Asian manufacturers, particular attention is now devoted to the integration of battery assembly/power electronics and battery cell production within the OEMs' production networks. At the moment, European companies are hardly represented among battery manufacturers, except for a few plants, such as the Swedish Northvolt and few French giga-factories (Blöcker 2022, 16). However, the European battery market is expected to develop and consolidate in the future, with the establishment of up to 40 new plants, especially in Eastern Europe and Eastern Germany.

Digitalization and data

Concerning the degree of digitalization and use of data, the applications seem to be still limited. This point has been confirmed by several respondents, who stressed the limited use of collected data, the absence of national software and the lack of specific skills needed to implement these organisational innovations.

> *If I look at these so-called indirect areas: research and development, finance, human resources and so on. All big companies like ours are (..) not in a very major point of digitization of processes. We have so many IT systems, some in-house built, others legacy systems, and it's an enormous effort to integrate those uncoupled IT infrastructures in one cloud-based system. (..). And this is a general trend in all big companies. (..) Office work is really automized in a considerable degree. From my point of view, if it ever comes something like five years ahead that like all the others we are doing experiments with bots with APA but I mean this is more fixing the whole than anything else. That has nothing to do with the unified system, which has to automize the knowledge of office work. It's just bridging gaps between different types of data, between Excel and whatever we do have. For so I'm to come to a first conclusion on the effect of automation on work: we haven't really seen it yet in our industry. [DE_1]*

More precisely, concerning data analytics in the assembly line and all other production departments, their application seems to be still minor and under development because of organizational constraints, with no relevant impact in terms of employment (at least in the case of Volkswagen).

At the same time, there is an increasing degree of digitalization of the different phases of the production process, since most information are available digitally, allowing the workers to have a comprehensive and up-to-date perspective on the tasks to be performed and already executed.

> *I can't see much impact there. I mean of course we are doing experiments with augmented reality that at some point people in production do have those specific glasses and then they get information for which part for which model to be installed where. This informal time was written on a card which was placed in the car. Now they get this information*

digitally, people like it, it makes their work easier. It may be kind of little progress in terms of productivity, but I can't really see an impact on work. [DE_1]

The degree of coordination across different departments on the collection and use of data is on-going, but still very limited. At the department level, other technologies, e.g., for quality control, are relevant.

Of course there is certain, let's say, centralization of data in our plants, so you have a kind of a digital control. There are places where you can see the overall KPIs[key performance indicators] of the ongoing production, but I think that the degree of connectedness of data at the end of the day the degree of interconnectedness is not too high so each division operates rather independently.

[the divisions] do check the quality features, they check their volume, if they've reached their production target: this was done before the personal computer was invented.

…

So I think that a more interesting technology is the laser to find defects in the bodywork while the human eye can't see them. But these KPI [key performance indicators] which report information from production could also be done by hand as well, so there is nothing magical [i.e. digital] about it [DE_1]

Picking up on the issues raised by Martin Krzywdzinski, we can state that the possibility of integrating different types of data still represents a challenge for automotive companies, also because of the simultaneous adoption of different software within the same plant.

Also, a joint cloud-based data pool for different location and plants is still ongoing process for various reasons, partially because you have complex landscape of software and data system, once a discussion with process planning, they have 15 different plants, some old some new, difficult to change, you have to proceed step by step, it is continuing but very gradual and not disruptive. Also, big and increasing attention to cyber security which becomes very important when you move towards cloud, etc.

It is much more driven by the product than the process, skills change related to the new types of products (i.e., connected car, electric mobility). Automation and digitalization related changes are slower also because companies need to look for profitability, customers' demands, etc. [DE_2

Dependence on foreign software

A critical issue is also linked to the sovereignty over cloud platforms and software and the related need to ensure cyber security once company's data are shared online through cloud.

I think what is more dangerous and that is not decided yet is whether the car companies will rely on US software companies like Google, like Apple to be part of the cars software system. This is rather the debate we are having in Germany than having smaller German companies outside the large OEMs. [DE_3]

Why is it going so slowly? Political discussion in Germany: lack of cooperation among companies, many of them are very reluctant in sharing data, fear of competition etc. Not enough eco-systems where you can develop cooperation, too much insecurity, discussions on how to change this (it is hype in Germany before the war). GAIA X promoted together with France to develop European cloud meta structure, now only AMAZON, GOOGLE provide this service and the feeling was to be sure of the use of data and not depend on American providers. A group working on automotive cloud system: KATLINA X, but we do not how much they are advancing. [DE_2]

Transition to electric mobility

Differences across departments

The main challenge the German automotive sector is facing today is not related to digitalization and automation, but rather to electric mobility. All respondents underline that, while in the former case no significant employment losses were recorded, a much higher risk of job displacement is expected in

the latter case. However, important differences emerge not only between OEMs and suppliers, but also between different regions and territories of the country.

> *We will have less people working on production because you need less production workers to produce an electric machine compared to combustion engine. So we talk about this kind of shift: we will have rather stable employment in the producers, but pressure on jobs in the suppliers. (…)*
>
> *We can see that there will be more software engineers and less production workers in the future. So we are facing a lot of changes, both inside the companies, but also in regions. And we're looking very much at regional effects where we have a lot of people working in the car industry and working on parts that are needed for the combustion engines. [DE_3]*

As well explained by Béla Galgóczi, ongoing changes in the German automotive sectors are particularly critical given the historical relevance and the international position that the industry plays in the national and European economy. In this sense, digitalization/ automation and decarbonization must be analysed in a comprehensive way since the former can be further developed to foster the process of conversion towards electric mobility. With respect to other European players, after an initial delay, the reaction of German companies has been faster also to face increasing competition coming from US and China.

The conversion of the production towards electric mobility is expected to have a very significant impact on the volume of the production. However, its effect will not be homogenous across production areas and companies, but highly diversified, as it has been underlined by several respondents. While the final production of OEMs will be only slightly affected, at least in the next years, suppliers of components and power trains will be more hardly hit by the reduction in production.

> *And the least affected area is final production because there you do precisely the same, which you have done before: putting the seats into the car, fixing mirrors, installing the navigation unit, that sort of things.*
>
> *So at the moment, for final production, required works for BEV (Battery electric vehicle) vs ICE (internal combustion engine vehicle) is almost similar.*
>
> *This may change at a day when we have fully developed our new electric platforms. (…) The real impact factor will be in the realm of components and especially of the powertrain. If you take the projection of production volume for VW for I think the year 2026 (…) if you take it in the mix in the manufacturing of the powertrain, we lose something like 70% of the volume even if you still go on to produce traditional engine model or so there. There will be a major change. [DE_1]*

In some cases, companies decide to reorganize themselves to preserve jobs, as in the case of the Mercedes plant in Berlin that was transformed in a digital competence center. [27]

> *Consider the example of the Mercedes plant: the trade union was focused on keeping the workers that were working for the company before transformed the plant into a digital competence center, keeping the same number of employees, mainly mechanical engineers that had to be reskilled with digital competences. It is much on the competence of the company. Trade unions are often keen on negotiating on reskilling programs (IG Metal is doing this). [DE_4]*

The creation of new departments to offset expected job losses related to the transition to electric vehicles seems to be a widespread strategy, adopted also by VW, which implies a novel reshaping of the canonical boundaries of automotive industries to manage emerging trends.

> *We are in kind of the lucky situations that our components division has begun very early to think about those employment effects and then create many new business fields. So we are building for example the "load infrastructure". (…) So we're losing employment on the one hand but we are creating new jobs at the same time, which means that insourcing*

[27] https://group.mercedes-benz.com/company/locations/transformation-berlin-site.html

is not all too big at the moment. (…) The components are, as far as they are located in Germany, an integral part of the Volkswagen and under the same agreement and under all the same conditions. Some companies like the power core, which is really about providing electricity we have built as an independent company, because we think that this company could be attractive for other investors to jump in, but with regard to working conditions, the power core is at the same status. [DE_1]

Newcomers in the sector: the (not so) disruptive case of Tesla

The arrival of Tesla and its founder Elon Musk in Germany has fuelled debates on its potential disruptive role on working conditions and industrial relations in the country. However, respondents showed to be confident about social actors' strength in managing this transition, despite the attempt to establish within Tesla a trade union very close to the management.

Tesla is a different case, of course. It's known that Elon Musk is not very Works Council friendly and trade union friendly, to put it mildly and, we always thought they would try to prevent setting up of a Works Council. But what they did was the opposite way: they started a list of people running for Works council, which is very close to the management, and they set up a Works Council election long before the normal date for Works Council elections. Why? Because if you build up factory, you start with the management and then you employ the lower ranks and the production workers later on. And you need to be six months in the company to vote in this Works Council election. So what we've seen there is that they started the early election of the Works Council because probably they thought they cannot prevent it completely, so that was their trick they're doing. And now we have a situation there where we have some lists that are not officially labelled IG Metall but were close to us, and we now have the strongest fraction inside the Works Council of Tesla that is close to the management, but there are other groups and also the Vice President of the Works Council, for example, is an IG Metall member. And, because the company is growing, usually in Germany, Works Councils are elected every four years, but because the company is growing, they will need to elect new car work's council in two years' time, because the number of employees grew at the number of the workers in the Works Council then will grow again. And of course in two years' time we will try to have the majority in the Works Councils for IG Metall. And I think that's quite realistic. We're organizing people a lot there. So far it's they are not really trying to prevent us from going into the company, because the legal framework is quite clear, but we also set up at the train station that is near the factory where the workers, if they come by train from Berlin for example, where they get out of the train and walk to the factory. We bought the old Station House building there, and we have our IG Metall office there. So people, when commuting between the factory and their homes, they come along and we can we can talk to them.(…). And so what we're doing now is to have this Works Council in two years' time and then organize so many members and we have our numbers saying we need a certain percentage of workers being member of IG Metall, before we go into a strike to force a collective agreement or force them into the collective agreement. So it will take us some years, but we are optimistic than we organize the workers there and then Tesla will also become part of the collective agreement system we have in the automotive sector in Germany. But that's the struggle we have to open. [DE_3]

Together with Tesla, other important challenges concern the limited diffusion of Work Councils (and codetermination rights) across German companies, especially among the small ones where the degree of unionization is much lower. This point was stressed by Martin Krzywdzinki, who pointed at the increasing number of non-unionized plants where working conditions can be worse than the ones usually observed in big (unionized) plants.

Where there is Work Council there is protection of workers but growing number of plants not unionized where there is no Work Council, very difficult to get access there. Some issues are relatively well controlled such as occupational health and safety, working time. While other issues are less controlled: For instance, every plant with more than 10 employees should have WC, but on the other hand WC needs to be elected through workers' initiatives: that's why we do not have a lot of WCs and so in many plants there are not these rights: trade unions have right to bargain collective agreement, but not

rights in companies. All the rights are attributed to WCs: without them it is very different situation (in particular in Eastern Germany and smaller companies). [DE_2]

Industrial relations and the role of trade unions in the process of automation

The degree of unionization in the automotive sector is very high if we consider that, on average, the collective bargaining coverage is equal to 60%. However, important differences emerge when we consider the position in the value chain, where OEMS record a significantly higher coverage rate (from 70% to 90%) with respect to small suppliers, who have few or no trade unions and work council (Blöcker 2022: 8)

The role of trade union in the process of introduction of new technologies

Trade unions in the German automotive sector are well rooted and cutting-edge. They are endowed with participatory and information rights, granted by the codetermination model according to which workers' representatives sit in the company board of directors. In the interviews, they are also described as competent actors, aware of the on-going process of change within factories and therefore able to deal with management demands and to influence complex decisions on layoffs and production. As reported by Thorben Albrecht, a huge majority of workers in automotive companies are union members. In the case of VW 95% of the production workers and around 70% of the engineers are members of the trade union (source: Thorben Albrecht).

The approach of trade unions is to push on automation and digitalization: high wages are possible only if there is a technological comparative advantage. You know the German codetermination says that work councils must be informed on time on technology implantation: the strongest right they have: all technology tools that can be used for behavioral and performance control, have to be agreed with work councils. This is a big issue, because the process is becoming very transparent: not so easy for companies to do so, at the moment no use of performance control and individualized data, but this deal (which is solid) also brings to conservatory solutions that impeach innovative solutions. [DE_2]

At the same time, trade unions are also facing important difficulties and uncertainties related to the challenges faced by the sector, in particular concerning the conversion towards electric mobility, the production of chip and batteries. These drivers of change are perceived as a much stronger threat with respect to digitalization.

We have the issues of trying to get both European resources, but also make it possible for national resources to invest in certain sectors, like the IPC's we have for hydrogen, which we need for steel production or for battery production, for chip semiconductor production, which are all parts of also the automotive sector. [DE_3]

To be part of this process of change and decision making, trade unions rely both on their knowledge on what is taking place within plants, through work councils, and what are the on-going trends at sectoral or regional level, through trade unions organization (IG Metal).

[DE_1]The role of the Works Councils (we have, in Germany, the system of the directly elected Works Councils as workers' representatives) is also changing because sometimes, especially in smaller supplier companies, the management does not really have a real idea what would be the business model of the future, if the old one is phasing out, and sometimes is the Works Councils that really have to come up with new ideas because the management is rather saying "well, we're closing this factory down". [DE_3]

IG Metall is an example of a trade union to learn and improve within the sector. IG Metall was very sceptical about electrification, better keep things as they were. But IGM now has changed its opinion and it is aware that there is a need to speed up the electrification process. [DE_4]

What is more, there is an increasingly use of external counselling to further improve and deepen the knowledge on specific issues that are of interest.

This (external counselling) is very often applied when it's really trying to work out the business model, to calculate (..) what kind of investment is needed, because there you

need some special knowledge which probably is not there, either in the Works Council nor for these specific cases in the trade unions. But there we have counselling firms, counselling companies that are close to the trade unions too, very often made-up of from former either Works Councils' members or trade union officials, that have specialized in having this economic knowledge you need for this kind of business models, business calculation, investment calculations. So, this is somewhat threefold the knowledge we put together in this kind of cases from the Works Council, from the trade unions and from this consulting firms that are not just consulting firms from the management side but also close to the trade unions. [DE_3]

Trade unions want to invest in Germany. Powerful unions have more resources. Trade unions hire consultancy companies (by law their cost must be paid 50% by the company) to implement a possible way of restructuring. [DE_4]

Trade unions' attempts of coordination across plants and regions

One strategy embraced by automotive companies to face the collapse of sales during the corona crisis and the Ukrainian war has been the adoption of short time working schemes within collective agreements, also to reduce potential conflicts related to jobs redundancies.

With respect to the differentiated impact that the process of restructuring can have on employment and the potential risk of polarization from OEMS towards the workers in the national supply chain, IG Metall is attempting to provide a coordinated response, for instance through a progressive embedding in new companies that produce batteries. At the same time, this is very difficult, and it is not always possible to ensure job security, and trade unions tend to encourage, where possible, the transition towards emerging industries.

So, we have the platform (the trade union) to bring all these people together from different regions, from OEMs and suppliers, from engineers, software engineers to line workers and administrative workers. So of course, we try to get an overall picture and find ways in which the whole industry is strengthened, and the number of jobs is kept and, of course, try to prevent single factories from being closed down, also with solidarity action and in other factories. So, we try to get this all together.

(…) But of course, there are some conflicts and some trends where it's very hard to keep all the jobs we have now, especially in the production of part of the industry.

our first approach is always try to keep the jobs inside the company. If it's not possible, try to find ways for workers to move from one company to the other inside the sector. But we are also discussing whether it's needed for some of the workers. Maybe not the workers of today, that we always try to keep them in work in the automotive sectors, but for the workers of the future to find ways what are might, might be new sectors. [DE_3]

The transition is also oriented towards different territories and regions (take the case of Leipzig and Wolfsburg) and other sectors apart from the automotive one, with the final goal of ensuring stable employment in Germany (and increasing wages, where they are lower).

So, together with the government, we set up a network of what we call "regional transition networks" that look at a certain region. I don't know how to describe it. In Germany we have this, we have cities and we have like counties, smaller units of the administration, and there you would take together two or three towns and counties that make up a region. So it's not a large region like Northern Westphalia, but a sub region where we can see there we are very reliant on the automotive sector. We have a lot of suppliers and there we met together with companies, not only from their automotive factors, but from different sectors, with the Employment agency, and try to work out plans for the future, what could be growth areas? Which sectors? Where can we create jobs in in another sector? If in the automotive sector, the number of jobs is decreasing? So there we are also looking beyond the automotive sector to make sure that industry stays in Germany, that job creation is there. And there are a lot of fields, like for example, if we want to bring our houses and have green heating inside the houses, we will have a huge grow in companies that are providing houses with new heating systems and maintain them, and that for example probably is a growth sector. [DE_3]

The institution of the regional network shows how crucial is the role of industrial policy, not only national but also regional actors, to manage this process of change. This is well stated by the representative of IG Metal, who underlines their active participation.

> *Well, this initiative, these regional networks, I was talking about that was implemented on the German national level, and it's also supported by the federal government, with two pillars of support. One is from for those networks themselves to work out concepts, to work out ideas for the future. And the 2nd is then for supporting single companies to introduce new technologies or build up new technologies. So there is some support from the national level and so this is the overall project input. And then you have the activity on the ground, you have the different structures on the ground. So the solutions detail will be very different from each other and every region depending on the regional situation. But there's support, there's also we are also organizing exchange between the networks. So there's some coordination, some exchange of knowledge and experience throughout Germany, and the national support, yeah. [DE_3]*

Emerging sectors, related to software and digital technologies, also create new challenges for IG Metall because the composition of workers is changing over time and it is becoming more international.

> *To give you just an example, last year we had a conference for newly elected Works Councils members in IT companies in Berlin. And what did the trick to get them there? It was the first conference we did in English because it's IT software, people from all over the work world that are attracted by the city of Berlin, working there and they have no connection whatsoever to IG Metall. They don't speak German because in the company, the working language is English. But they started of putting up Works Councils too, with the help of IG Metall and Verdi. So we're trying to organize them. [DE_3]*

European workers and the role of trade unions

However, the active and participatory role of work councils seem to be confined exclusively to the national territory: while work councils at the establishment level are coordinated through company-level and, as we have just described, they also play a role at regional level, the European coordination among trade unionists is still far from being implemented in an effective way.

> *So, I think that is where we are working on that, as well as for us to have a general approach to keep industries and manufacturing in Europe, because, I mean, all the trends we're talking about, we have to discuss them against the global competition background. We can see now with the United States IRA, when the US government is trying to protect the American market by saying "everything was sold here, at least when it's supported by the government, must be produced in the United States". So we always have this, this global competition there and I think that we are united as European workers to trying to make sure that industrial production car production, especially in being kept in EU. That does not mean that it's that there's never a competition inside Europe too. [DE_3]*

The unbalanced power relation between plants located in different European countries also implies different choices in terms of technological investment and trade unions' demands. The outcome is that competition among plants in different countries can become very harsh.

> *It becomes more complicated if it's a European issue, because we have European Works Councils, but you know they are rather weak. They are only informed, they have no codetermination rights and there is more difficult when we had, for example, the competition between Saarlouis and Valencia, that was a bit more complicated, even though of course there has been an exchange between the Works Councils and the corporation in the European Works Council. But there is the issue of competing against each other and the management, of course, is doing this all the time, having factories compete against each other. [DE_3]*

> *The OEMs have subsidiaries in Europe. This means that this strength of organization (for trade unions) is limited to Germany. The subsidiaries outside Germany are completely dependent on the headquarter in Germany. If they are introducing key technology those are made in Germany, they don't want to spread the knowledge outside. The European subsidiary are extremely weak. (….) There is an asymmetry with abroad suppliers, and*

IGM has requested that new components for electrical vehicles have to be produced in Germany. [DE_4]

Discussion and conclusions

Five main topics have been discussed during the interviews: the degree of automation, digitalization and new challenges related to decarbonization; the relation between German OEMs and suppliers; the role of trade unions in the process of introduction of new technologies; the impact on employment and work organization of digitalization and the ongoing changes in the transition to the production of electric vehicles.

The main findings of the case study on the impact of automation on Germany automotive sector can be synthesized as follows:

- High but heterogenous degree of automation within and across car makers and suppliers, emergence of new obstacles and challenges with respect to robot flexibility and adaptability to complex production environment.
- Increasing digitalization of the entire production process, allowing workers to have a comprehensive and up-to-date perspective on the tasks executed or to be performed. On the other hand, still limited degree of coordination across different departments on the collection and use of data, mainly because of organizational constraints.
- Significant unbalance in the expected distribution of job losses - spurred by the move towards e-mobility and fostered by increasing degrees of digitalization - along the value chains, with well protected jobs within OEMs and more precarious and uncertain jobs in the supplier sector.
- Crucial role of vocational training and dual education system in ensuring an update of workforce skills, competences and job profiles needed in the sector.
- Active and participatory role of work councils in ensuring job security and favouring the transition towards emerging industries. Exclusive focus on German workers and national competitiveness, but lack of any well-structured coordination with other European trade unions. New players (Tesla, in primis) are having an impact on role on working conditions and industrial relations in the country, where working conditions are worsening – especially in SMEs - than the ones usually observed in big (unionized) plants.

Two critical issues concern the productive and hierarchical relations of German OEMs with suppliers, both located in Germany and across Europe and the transition to the production of electric vehicles. The upgrade of automation in the value chains is pivotal to study the implications that digitalization - and e-mobility - can determine in European automotive plants. With respect to the adoption and implementation of new technologies there is evidence of a strong heterogeneity across suppliers. with potential different outcomes across countries, with new challenges arising at the EU level. From the interviews it clearly emerges that the main challenge the German automotive sector is not related to digitalization and automation, but rather to electric mobility, with a much higher risk of job displacement is expected. Important differences emerge not only between OEMs and suppliers, but also between different regions and territories of the country.

Digitalization, automation and decarbonization must be analysed in a comprehensive way since the former can be further developed to foster the process of conversion towards electric mobility. Given the long term technical and productive connections, German companies have been faster in catching up competition coming from China and US. Suppliers of components and power trains will be more hardly hit by the reduction in production. The restructuring of OEMs' assembling plants implies a novel reshaping of the canonical boundaries of automotive industries to manage emerging trends.

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List of abbreviations and definitions

ACEA	European Automobile Manufacturers' Association
AGV	Automated/Automatic Guided Vehicle
ANFAC	Asociación Española de Fabricantes de Automóviles y Camiones (Spanish Automobile Manufacturers' Association)
CAAR	Cluster de Automoción de Aragón (automotive and mobility Aragon cluster)
CNAE	National Classification of Economic Activities
ETE	Effectiveness of the Equipment
HR	Human Resources
KPI	Key Performance Indicator
MES	Manufacturing Execution System
OEE	Overall Equipment Effectiveness
OEM	Original Equipment Manufacturer
PLC	Programmable Logic Controller
R&D	Research and Development

Annexes

Annex 1. Establishment profiles automotive sector

Table 1. COPO Zaragoza

	Establishment template	**Screening questions**
Basic information about the establishment	Name of the company/establishment	Copo Zaragoza
	Type of business entity (stand-alone or part of a corporation/organization)	Part of corporation
	Name of corporation (if applicable)	Grupo Copo
	Geographic location of the establishment under investigation	Fuentes de Ebro - Zaragoza (Spain)
	Sector of economic activity	Automotive parts (seat cushion manufacturer)
	Year of establishment	1992
	Size of establishment (number of employees)	220
	Type(s) of goods/services provided	car seat padding
	Main market (national/exports, single buyer/multiple buyers)	National market, suppling for Tier 1
	Annual revenue (US$ million)	Missing
	Form of employee representation within the establishment (for example trade union, workers' council, etc.)	Establishment's Trade Union
Information on adopted technology	Year when technology was introduced	2019
	Reason(s) for technology adoption	Efficiency, productivity, reducing human errors
	Application areas (for example production, service or product delivery, interaction with customers)	Raw materials warehouse and preparation of the mixture: to always have the mixture and data under control Foam production and product inspection

		Filling of boxes by product type: to avoid putting similar products in the same box
	Main purpose/ use of the technology	See above
	Maturity level in the uptake of technologies	Very high, not uniform across departments

Source: authors' notes based on information received during the field work

Table 1. LINDE y WIEMANN ZARAGOZA, S.L.U.

	Establishment template	**Screening questions**
Basic information about the establishment	Name of the company/establishment	Linde y Wiemann Zaragoza, S.L.U.
	Type of business entity (stand-alone or part of a corporation/organization)	Part of corporation
	Name of corporation (if applicable)	Linde + Wiemann
	Geographic location of the establishment under investigation	Pedrola (Zaragoza), Spain
	Sector of economic activity	Automotive part & components (body part)
	Year of establishment	2006
	Size of establishment (number of employees)	150
	Type(s) of goods/services provided	Bending, Interior parts, Stamping, Structural parts and body
	Main market (national/exports, single buyer/multiple buyers)	National
	Annual revenue (US$ million)	approx. 9 M €
	Form of employee representation within the establishment (for example trade union, workers' council, etc.)	Establishment's Trade Union and eternal audit
	Year when technology was introduced	2019: MES and AGV implementation, 2021: bin picking

Information on adopted technology	Reason(s) for technology adoption	Efficiency, productivity, safety and ergonomics
	Application areas (for example production, service or product delivery, interaction with customers)	Digital Twin, MES and Integration of AGV to move the production flow throughout the value creation process
	Main purpose/ use of the technology	See above
	Maturity level in the uptake of technologies	Very high

Source: authors' notes based on information received during the field work

Table 2. Automobile Dacia SA

	Establishment template	**Screening questions**
Basic information about the establishment	Name of the company/establishment	Automobile Dacia SA
	Type of business entity (stand-alone or part of a corporation/organization)	Part of corporation
	Name of corporation (if applicable)	Renault-Nissan- Mitsubishi
	Geographic location of the establishment under investigation	Mioveni (Romania)
	Sector of economic activity	Automotive (Vehicle plant, engine & transmission plant)
	Year of establishment	1968 (Renault ownership from 1999)
	Size of establishment (number of employees)	6000
	Type(s) of goods/services provided	cars
	Main market (national/exports, single buyer/multiple buyers)	International market
	Annual revenue (US$ million)	n.a. 300-350 thousand vehicles per year, with previous plans to expand to 400 thousand; 500 thousand engines and 500 thousands transmissions
	Form of employee representation within the	Establishment's Trade Union

	establishment (for example trade union, workers' council, etc.)	
Information on adopted technology	Year when technology was introduced	Since 2013
	Reason(s) for technology adoption	Efficiency, productivity, safety and ergonomics
	Application areas (for example production, service or product delivery, interaction with customers)	Body shop: Welding robot for car's geometry (around 50% of the robots present in the body shop), Hemming robot (around 10% of the robots present in the body shop), Manipulating pieces and transportation robot (around 10% of the robots present in the body shop), MIG MUG -Metal Inert Gas - Metal Active Gas- /CO2 robot for welding the small parts, Gluing robot. In general, the level of robotization corresponds to 47% of tasks; the target is not 100% automation, for Renault the target is 50%. Stamping department: 76% of stamping line are automated; only small pieces are loaded and download manually. Assembly department: robots for manipulation and assembling of window; pneumatic devices to assist the operator in moving heavy pieces, AGVs transport of racks; automatic matching of under mechanical part (engine, axel, rear, …) and body.
	Main purpose/ use of the technology	See above
	Maturity level in the uptake of technologies	Very high, not uniform across departments

Source: authors' notes based on information received during the field work

Table 3. Ford Otosan Romania

	Establishment template	**Screening questions**
Basic information about the establishment	Name of the company/establishment	Ford Otosan Romania
	Type of business entity (stand-alone or part of a corporation/organization)	Part of corporation
	Name of corporation (if applicable)	Ford Otosan
	Geographic location of the establishment under investigation	Craiova (Romania)

	Sector of economic activity	Automotive (vehicle and engine plant)
	Year of establishment	1976 (under Olcit), then Ford from 2008
	Size of establishment (number of employees)	3600 employees
	Type(s) of goods/services provided	cars
	Main market (national/exports, single buyer/multiple buyers)	International
	Annual revenue (US$ million)	n.a. full capacity of 200-250 thousand vehicles per year expected in the following years
	Form of employee representation within the establishment (for example trade union, workers' council, etc.)	Yes, trade unions
Information on adopted technology	Year when technology was introduced	In 2008, when Ford tookover, the implementation of the Ford Production Systems started a deep adoption of automation technologies. Increasingly in the past five years, with robots in stamping
	Reason(s) for technology adoption	Efficiency, productivity, safety and ergonomics
	Application areas (for example production, service or product delivery, interaction with customers)	Stamping department: completely automated Body shop: All welding is automatic, except for manual operations of small welding and outer clinching (turn-up before welding): these operations are very difficult to be robotized. In numbers, more than 300 welding spots made by 600 robots, 6 axes +1 linear, all robots are Kuka, Robots are used for manipulating and loading the machines Paint shop: 5 sealing robots per car; automated cleaning of the body, apply base, preparing for chemical reaction, anticorrosion; but manual painting by workers protected by full mask assisted by air recycle/oxygen Manual will be replaced by robots in August 2022. Engine shop fully automatic tooling with manual loading and downloading (a matter of space), cylinder heads' loading assisted by pneumatic devices for heavy parts, internal assembling of engines, crankshafts, cylinder + imported engines.
	Main purpose/ use of the technology	See above

	Maturity level in the uptake of technologies	Very high, not uniform across departments

Source: authors' notes based on information received during the field work

Annex 2. Information on interviews

Table 4. Information interviewees, Copo Zaragoza (Spain)

Interviewee	Age	Sex	Job title	Main task	Tenure in the firm	Contract type	Union membership	Interview date	Interview duration
COPO_1	62	M	HR manager	HR Director	1982		/	25 October 2022	38:18:00 and 38:22:00
COPO_2	34	F	Sales project manager	project manager & commercial		/	no	25 October 2022	26:23:00
COPO _3	51	M	Production Chemistry manager	Chemical process manager in the production department	2011	/	yes	25 October 2022	29:09:00
COPO _4	42	F	Team leader	Team leader	2007	/	no	25 October 2022	27:40:00
COPO _5	41	M	Automation and logistic manager	Logistic manager	2006	/	no	25 October 2022	30:09:00
COPO _6	36	M	Automation and quality manager	Quality manager	2009	/	no	25 October 2022	46:38:00

Table 5. Information interviewees, L+W (Spain)

Interviewee	Age	Sex	Job title	Main task	Tenure in the firm	Contract type	Union membership	Interview date	Interview duration
L+W_1	57	M	Plant manager	Plant manager	2001	/	/	26 October 2022	27:10:00 and 01:08:47:00

L+W_2	33	M	Production manager	process optimisation and time improvement	2014	/	/	27 October 2022	38:08:00
L+W_3	32	M	Production manager	process optimisation and time improvement	2015	/	/	27 October 2022	Info to be added
L+W_4	49	M	Profiling Section Team Leader	team leader of a specific assembly line	2010	/	yes	27 October 2022	22:24:00
L+W_5	38	F	Team leader	Team leader	2014	/	no	27 October 2022	43:58:00
L+W_6	49	M	Production leader	Production leader	2009	/	no	27 October 2022	Info to be added
L+W_7	40	M	Maintenance Coordinator	Maintenance Coordinator	2018	/	no	27 October 2022	20:45:00
L+W_8	62	M	HR Manager	HR Manager at Linde Barcelona	2017	/	/	28 October 2022	16:28:00

Source: authors' notes

Table 6. Information interviewees, Dacia (Romania)

Interviewee	Age	Sex	Job title	Main task	Tenure in the firm	Contract type	Union membership	Interview date	Interview duration
DACIA_1	37	M	manager	Head of new projects and robotisation	2007	/	/	25 July 2022	57:25

				(stamping department)					
DACIA_2	51	F	manager	Head of maintenance (stamping department)	1995	/	/	25 July 2022	38:03
DACIA_3	58	F	manager	Head of APW (Alliance Platform Way)	1997	/	/	25 July 2022	49:31
DACIA_4	37	M	manager	Maintenance manager for the body shop	2008	/	/	25 July 2022	51:49, then 3:46
DACIA_5	33	M	?	Fixer of defects in the assembly line (assembly shop)	15 years	/	/	25 July 2022	25:42
DACIA_6	25	M	Engineer	Automation engineer in the body shop department	2017	/	/	25 July 2022	46:27
DACIA_7	28	M	Worker	Team leader (assembly department)	2016	/	/	25 July 2022	57:12
DACIA_8	/	M	Manager	Informational System Manager (Informational System department)	2002	/	/	25 July 2022	56:27
DACIA_9	/	M	President	Trade Union representative	1990	/	yes	15 September 2022	58:12

DACIA_10	/	F	Manager	Human resources	2018	/	no	28 October 2022	59:30

Source: authors' notes

Table 7. Information interviewees, Ford (Romania)

Interviewee	Age	Sex	Job title	Main task	Tenure in the firm	Contract type	Union membership	Interview date	Interview duration
FORD_1	48	M	Assistant production manager	Assistant production manager for the entire plant (excluded engine plant)	1995	/	/	27 July 2022	48:22
FORD_2	47	M	Manager	Production area manager and innovation manager	1997	/	/	27 July 2022	52:52
FORD_3	53	M	Manager	Powertrain engine area manager	1995	/	/	27 July 2022	58:40
FORD_4	59	F	President of Ford-Craiova trade union	President	1982 (entry in the firm)	/	yes	28 July 2022	1:08:58
FORD_5	61	M	Manager	Fire production, innovation and maintenance supervision for the entire plant manager	1998	/	/	28 July 2022	52:36

FORD_6	52	F	Manager	HR Director	1989	/	/	28 July 2022	38:34
FORD_7	58	M	Manager	Engine plant manager	1984	/	/	28 July 2022	59:06
FORD_8	41	M	Engineer and manager	Maintenance engineer and manager	2004	/	/	28 July 2022	45:23
FORD_9	58	M	Manager	Vehicle operator launch manager	1984	/	/	28 July 2022	56:57
FORD_10	About 50	F	President of Ford Otosan Romania	President of Ford Otosan Romania	1996	/	/		online meeting, 60:00

Source: authors' notes

Table 8. Information interviewees, Germany

Interviewee	Role	Organization	Interview date
Gerard Bosch	Senior Professor and Senior Fellow	Hans-Böckler-Stiftung Institut Arbeit und Qualifikation Universität Duisburg-Essen Fakultät für Gesellschaftswissenschaften	14/07/2022 (several email exchanges)
Steffen Lehndorff	International expert in industrial organization	Employment relations and working-time. Formerly Research Director at the Institute Work and Technology (IAT), Gelsenkirchen / Germany and later as the Head of Department on Working-Time and Work Organisation at IAQ.	30/11/2022

Thomas Haipeter	Head of the Working Time and Work Organization	Research department at the University of Duisburg-Essen's Institute for Work, Skills, and Training	(several email exchanges)
Martin Krzywdzinski	Professor of Sociology, expert in the Automotive sector, industrial relations, German economy	WZB Berlin Social Science Center (Wissenschaftszentrum Berlin für Sozialforschung) (Germany)	11/01/2023
Valentina Orazzini	Trade unionist (Automotive sector, industrial relations)	FIOM-CGIL (Italy) [Federazione Impiegati Operai Metallurgici - Confederazione Generale Italiana del Lavoro]	17/01/2023
Simone Marinelli	Trade unionist (Automotive sector, industrial relations)	FIOM-CGIL (Italy)	17/01/2023
Béla Galgóczi	Researcher (Automotive sector, industrial relations, German economy)	ETUI European Trade Union Institute	19/01/2023
Thorben Albrecht	Trade unionist Automotive sector, industrial relations	Industriegewerkschaft Metall-IG METAL (Germany)	24/01/2023
Antje Blöcker	Researcher Automotive sector, industrial relations	Rosa Luxemburg Foundation (Germany)	30/01/2023
Thymian Bussemer	HR Strategy and Innovation Manager Automotive sector	Volkswagen	11/10/2022 31/01/2023

Source: authors' notes