BARMETAL

Digitalization, Automatization and Decarbonization: Opportunity for strengthening collective bargaining in the Metal Sector

Grant Agreement n. 101052331

Deliverable Title	**D 2.1 - Report on the conceptual and analytical framework and systematic literature review on trends and challenges related to digitalization, automatization, decarbonization**
Deliverable Lead:	SSSA
Partner(s) involved:	CELSI
Related Work Package:	Work Package 2
Related Task/Subtask:	Task 2.1
Authors:	Armanda Cetrulo, Giovanni Dosi, Linnea Nelli, Angelo Moro, and Maria Enrica Virgillito (SSSA) Pavol Bors, Marta Kahancová, Katarína Lukáčová, Gabriele Medas, and Tibor Meszman (CELSI)
Dissemination Level:	Public
Due Delivery Date:	02 May 2023
Actual Delivery:	02 May 2023
Project Number	101052331
Instrument	SOCPL-2021-IND-REL
Start Date of the Project	03 October 2022
Duration	24 months

The deliverable is composed of two contributions, one from the SSSA unit, providing a conceptual roadmap to assess "Automation, digitalization and decarbonization in the European automotive sector" and a second from the CELSI unit modulating the theoretical concepts developed in the contribution by SSSA to a direct application for the BARMETAL project.

Co-funded by the European Union

This project has received funding from the European Union's Social Prerogative and Specific Competencies Lines (SOCPL) programme under grant agreement N. 101052331.

Automation, digitalization and decarbonization in the European automotive sector: a conceptual roadmap*

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Abstract

This position paper outlines the characteristics of the trends at stake in affecting the twin transition in the European automotive industry. The paper presents the rationale behind the approach and case-selection strategy of the project. We first describe the automation and digitalization processes in the automotive sector and their effects on employment (Section 2). Possible scenarios are analysed, illustrating actual cases of electrification conversion of some European plants of the key OEMs companies as practical examples to understand the employment effects (Section 3). We then consider the role of the regulatory push in fostering the transition of the automotive sector towards electrification, highlighting the non-neutrality of the process (Section 4). Finally, we discuss the space and capacity of trade unions actions in order to orient the twin transition toward a path of just transition (Section 5). Our conclusions are laid out in Section 6.

Keywords: Social dialogue, twin transition, labour markets

JEL classification: J5, L6, O2, O3

*This project has received funding from the European Union's Social Prerogative and Specific Competencies Lines (SOCPL) programme under grant agreement N. 101052331.

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1 Introduction

Technological innovation and decarbonization processes are changing value chains' composition and companies' organization, having deep consequences on the labour market. The duality of employment effects of technical change exerting both job creation and job destruction has been at the centre of the debate for decades, especially as a consequence of accelerated automation and introduction of Industry 4.0 at factories level (among others Autor, 2003 [4]; Acemoglou and Restrepo, 2019 [3]; Dosi et al, 2021 [25]; Staccioli and Virgillito, 2021 [76]). Digitalised productive processes have also allowed to increase the speed of globalization and relocation abroad of productive activities.

While the post-1990 phase has been defined as the hyper-globalization phase, the 2008 turned into a turning point for international exchanges, with the Trade Collapse, then followed by the rise of protectionism in the Trump term. The arrival of the pandemic and the restructuring of GVCs nowadays hugely impacted by the Zero-Covid strategy implemented in China have furthermore put pressure on the international division of labour and ensuing production to such an extent that nowadays there are commentators putting forward the notion of slowbalization. The extent to which globalization turned into an halt is not a matter of our analysis, but certainly new strategies to reduce the number of stages and to relocate production processes towards the most profitable/less costly proximity of lead firms are currently under the spotlight of MNCs (multinational corporations). The *just-in-time* model has gradually been reconsidered in light of the pandemic, with a *just-in-case* new approach.

As a consequence of the globalization processes, there is evidence of relocation of labour intensive processes towards low-cost countries, with specific concentration into low- and medium-value added phases. Relatively less skilled labour, paid at low-wages and employed in standardised production processes and with low technological upgrading has been required in the destination or peripheral countries. At the opposite, core, innovative productions remain in leading plants in high-wage countries where high-skilled labour is available to meet the digitalization and automation challenges. Indeed, there is high asymmetry across lead and peripheral plants and countries, with respect to R&D expenses and innovative efforts with consequent effects on upgrading of production activities and skills to meet technological challenges. Globalization and GVCs have to be considered in order to analyse the automotive sector with a European lens, being the sector strongly stratified into a core-periphery structure characterised by the central-continental lead area, decreasing number of employees and strategically maintaining only some specific segments versus the peripheral Visegrad area.

The effects on the reorganization of industries and employment of the decarbonization process are less straightforward, since at this stage it has not been as disruptive as automation and, despite the urgency to face climate emergency, policies and actions are moving at a slow pace. As for automation and the digital transition, the climate transition is expected to have heterogeneous effects with respect to sectors and countries, particularly in their capability to address the decarbonization process, according to regulations, corporate strategies and globalization process effects. Decarbonization of internal combustion engine and shift toward electric vehicles will fast reconfigure the geography of European production, putting under stress the second and third tier suppliers characterised by SMEs located into the East and South of the EU.

In what follows, we will focus on the digitalization, automation and decarbonization trends in the automotive industry. The automotive sector can be considered as a benchmark example for the whole metal sector, considered for instance that automation of mechanical processing of metal parts and the deployment of CAD for prototyping are used both for automotive and other products of the metal industries. At the same time, the automotive sector is an archetypical example of the shortcomings of the decarbonization process, especially about the uncertainty of its employment effects, but also one of the most targeted by European regulations in terms of emissions, with ban of producing internal combustion engine vehicles from 2035, although recently relaxed.

To understand trends of digitalization, automation and decarbonization and their current manifestation in the European automotive industry, we outline the relevance of the following factors:

- The role of European geography of production and distribution chains: differentiated impacts for the North vs the South; for the East vs the West, for focal/lead/core plants vs peripheral ones.

- The role of managerial strategies of the companies, in relation to globalization processes as well.
- The role of trade unions and space of actions mediated by the institutional settings, from national, to sectoral, to plant level bargaining.
- The role of national, European and international regulations which speed up or hamper the transition.

This position paper outlines the characteristics of the trends at stake in affecting the twin transition in the European automotive industry. The paper presents the rationale behind the approach and case-selection strategy of the project. We first describe the automation and digitalization processes in the automotive sector and their effects on employment (Section 2). Possible scenarios are analysed, illustrating actual cases of electrification conversion of some European plants of the key OEMs companies as practical examples to understand the employment effects (Section 3). We then consider the role of the regulatory push in fostering the transition of the automotive sector towards electrification, highlighting the non-neutrality of the process (Section 4). Finally, we discuss the space and capacity of trade unions actions in order to orient the twin transition toward a path of just transition (Section 5). Our conclusions are laid out in Section 6.

2 Digitalization and automation in the automotive industry: trends and employment effects

After their scattered introduction already in the 1920s, 1940s and 1970s in selected companies[1], the massive digitalization and automation process in the automotive sector has started in the late eighties, in the body shop in particular. With the concept of automation we define technologies with the ability of replicating specific human tasks in an autonomous manner, while with the concept of digitalization we refer to process monitoring, control and optimization of the work activity by means of software systems, connecting machines with

[1] Already in the 1920s, Ford has introduced the automation of mechanical processing of metal parts; numerical control (NC) machines in the 1940s; computer numerical control (CNC) machines in 1970s. (M. Krzywdzinski, 2021) [47]

digital databases, able to collect analytical information converted into a digital format.

Already in the 1970s and 1980s, welding robots and presses were introduced in car body manufacturing such that in the 1990s, automation levels were at 90%-100%, particularly in countries like Germany (Krzywdzinski, 2021) [47]. Most recent developments in automation concern the "cyber-physical systems" and lightweight robots working in the assembly line as well, where automation has been slower and more difficult to apply (Krzywdzinski, 2017 [45], 2021). Massive digitalization instead started in the 1990s, thanks to the development of software systems improving the exchange of data across plants in different locations and networks. The digitalization of the automotive industry relates to the planning, development, quality and security control of products. The latter have improved over time in relation to fuel efficiency, increasing variety, performance and security needs. For instance, the Computer Aided Design and the Computer Aided Quality developed since the 1990s are used for product development, as prototyping, and for quality controls, thanks to the development of sensors, respectively. Digitalization improved already in the 2000s with the birth of the "Digital Factory", thanks to the development of virtual reality devices and the Ethernet (Krzywdzinski, 2021). Therefore, plans to foster digitalization and automation of the auto industry, as the so-called Industry 4.0 paradigm, essentially turned out to be more national plans to foster country-level production capacity, as the German one, rather than an effective convergence towards the humanless factory.

If technological adoption does not necessarily shed labour force, a direct consequence of the processes of automation and digitalization is the impact on the employment structure at the plant-level, and of the sector therein, together with the demand of specific skills required by the two processes, in relation to the degree of substitutability of manual work (Cirillo et al., 2021 [14]). The automotive industry employs a high share of workers across Europe, around ten millions among direct (2 millions) and indirect (8 millions) workers (Gaddi and Garbellini, 2021 [31]). Figure 1 presents the absolute numbers and the shares of employed workers in the manufacturing sector (NACE Code C) (top panel), the absolute numbers of workers in the automotive sector and the percentage share over employment in the manufac-

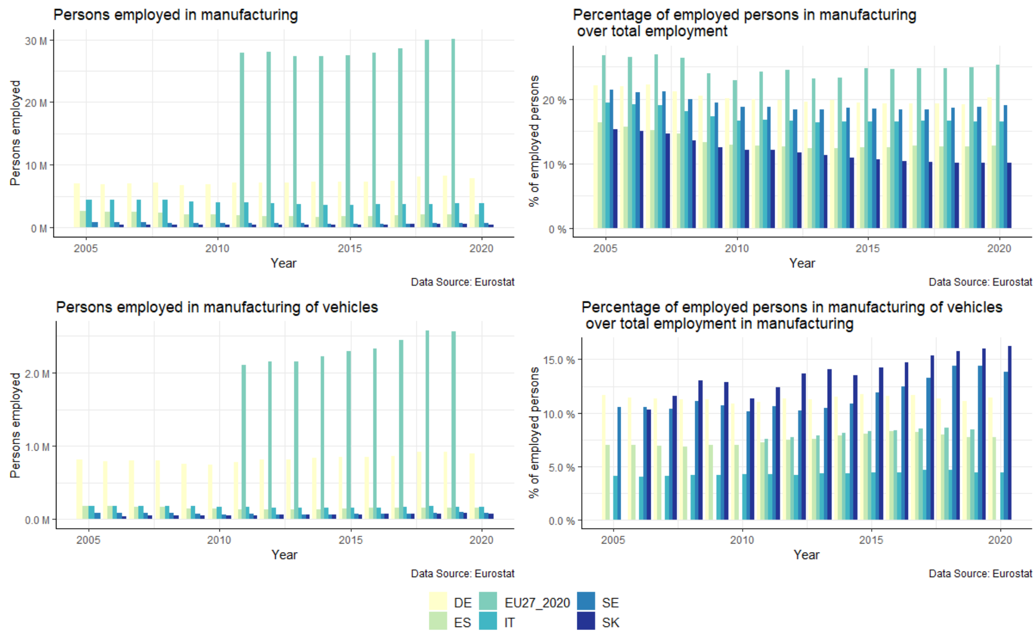


Figure 1: Employment in manufacturing and percentage of employment in the automotive sector

turing sector (bottom panel) across Germany, Slovakia, Sweden, Italy and Spain[2] (NACE Code C29). The data refers to direct jobs in the automotive industry, namely manufacture of vehicles, trailers and semi-trailers. In 2019, in the European Union 30 million people worked in the manufacturing sector on average accounting for 30% of total employment, while more than 3 million people worked in the automotive industry in the European Union in 2019, accounting for 7.5% of workers in manufacturing. The highest share of direct jobs in the automotive sector with respect to employment in the manufacturing sector is in Slovakia, where in 2020 more than 15% of jobs in manufacturing were in the manufacture of vehicles, trailers and semi-trailers. Sweden has employed a share between 10 and 14 percentage points between 2005 and 2020, while Germany around 10% and 12%, the share for Spain is similar to the European average close to 7.5%, while for Italy is below 5%.

In Table 1, we can see the change of employment structure in the German automotive indus-

[2]The selection strategy of these countries is not representative but rather informative of the overall EU dynamics

try from 1997 to 2018. Two opposite trends are evident: on the one hand, the percentage of metal working occupations and occupations in metal construction and welding have decreased, while plants and machines operators and automation related jobs have increased over time. Overall, employment has increased in the sector (+93,300 units), suggesting that the employment structure has changed, the decrease of manual work in metal occupations, possibly given by the increase of complexity of technological innovation and the introduction of process innovations, has been offset by a higher number of employees in automation related jobs (Krzywdzinski, 2021). Complementary evidence is reported in Montobbio et al (2022) [58]according to which machinery and maintenance operators is the second occupation, out of the top twenty 8-digit occupations, to be most exposed to robotic automation and potential substitution (Table 2). Technological innovation is claimed to have pushed automation in the last decades (Frey and Osborne, 2017) [30] and the dichotomy of its employment effects, being labour friendly, on the one hand, and labour saving on the other, has always been at the centre of the debate. For the automotive industry, we highlight that automation has replaced manual work in the upfront production stages, with welding and mechanical machining requiring less labour and lower production costs and, therefore recorded to be labour-saving; product innovation, creating new markets and requirements of reskilling of the workforce, potentially creating high-value added occupations, as ICT and engineering functions related to develop both process and product innovation, acted instead as a countervailing force.

At the same time, key aspects of the success of automation are the organizational structures of the production, the internal division of labour and knowledge, and the degree of automation in place. Indeed, technology can be defined as a recipe, a combination of a coded program and of tacit knowledge that can't be codified, as disembodied knowledge in expertise, past experience and organizational routines (Dosi, 1982) [23]. Particularly, organizational routines involve organizations' members knowledge, competences and capabilities in managing production processes activities, their memory and experience in problem-solving, meta-routines to change organizational practices and complementary processes to organizational governance (Dosi and Nelson, 2010) [24]. Disembodied knowledge is particularly important since the effect of automation and technical change in general unfold upon internal organizational structure. In particular, lean organization has resulted to be the key factor and a prerequisite for the success of automation and digitalization. Organizational

Table 5. Occupational composition of production workers in the German automotive industry

	1999	2007	2013	2018
Total	394,200 (100%)	410,400 (100%)	458,800 (100%)	487,500 (100%)
Assembly related occupations	113,100 (28.7%)	135,500 (32.9%)	163,800 (35.7%)	169,800 (34.7%)
Metal occupations	185,500 (47.0%)	180,300 (44.0%)	152,000 (33.1%)	161,300 (33.1%)
Of which:				
Metal-making occupations	*5,100 (1.3%)*	*4,500 (1.1%)*	*7,400 (1.6%)*	*7,700 (1.6%)*
Metalworking occupations	*93,800 (23.8%)*	*89,900 (21.9%)*	*68,700 (15.0%)*	*69,300 (14.2%)*
Occupations in metal constructing and welding	*59,900 (15.2%)*	*57,700 (14.0%)*	*25,900 (5.6%)*	*26,200 (5.4%)*
Precision mechanics and toolmaking	*13,600 (3.4%)*	*13,000 (3.2%)*	*12,700 (2.8%)*	*11,500 (2.4%)*
Plant and machine operators	*13,000 (3.3%)*	*14,600 (3.6%)*	*37,200 (8.1%)*	*46,500 (9.5%)*
Other production occupations	61,800 (15.7%)	60,400 (14.7%)	82,000 (17.9%)	91,000 (18.7%)
Of which:				
Color coating and varnishing	*20,600 (5.2%)*	*16,200 (3.9%)*	*12,300 (2.7%)*	*11,900 (2.4%)*
Technical occupations in quality control	*19,500 (4.9%)*	*21,400 (5.2%)*	*25,400 (5.5%)*	*26,100 (5.4%)*
Automation-related occupations: technical staff in maintenance, mechatronics, automation and control technologies	19,000 (4.8%)	19,200 (4.6%)	39,100 (8.5%)	43,400 (9.0%)
Supervisors in production	11,200 (2.8%)	11,400 (2.8%)	19,200 (4.1%)	19,000 (3.9%)

Source: Author based on BA. There was a major revision of statistical classifications between 2007 and 2013 that limits the comparability of data.

Table 1: Occupational composition of production workers, German automotive industry. Source, Table 5, Krzywdzinski (2021)

Rank	Code	Title	CS
1	53-7051.00	Industrial Truck and Tractor Operators	1.0
2	49-9043.00	Maintenance Workers, Machinery	0.97
3	53-7063.00	Machine Feeders and Offbearers	0.94
4	53-7064.00	Packers and Packagers, Hand	0.91
5	49-2091.00	Avionics Technicians	0.87
6	51-9111.00	Packaging and Filling Machine Operators and Tenders	0.81
7	49-3041.00	Farm Equipment Mechanics and Service Technicians	0.81
8	49-3092.00	Recreational Vehicle Service Technicians	0.78
9	49-3042.00	Mobile Heavy Equipment Mechanics, Except Engines	0.77
10	47-2111.00	Electricians	0.76
11	49-9098.00	Helpers–Installation, Maintenance, and Repair Workers	0.75
12	49-9041.00	Industrial Machinery Mechanics	0.75
13	51-9082.00	Medical Appliance Technicians	0.75
14	47-3011.00	Helpers–Brickmasons, Blockmasons, Stonemasons, and Tile and Marble Setters	0.75
15	51-9191.00	Adhesive Bonding Machine Operators and Tenders	0.75
16	51-9023.00	Mixing and Blending Machine Setters, Operators, and Tenders	0.74
17	13-1032.00	Insurance Appraisers, Auto Damage	0.73
18	51-4111.00	Tool and Die Makers	0.73
19	49-9081.00	Wind Turbine Service Technicians	0.72
20	51-8013.04	Hydroelectric Plant Technicians	0.72

Table 3: Top 20 occupations by (rescaled) similarity.

Table 2: Occupations most exposed to labour-saving technologies. Source, Table 3, Montobbio et al (2022)

capabilities result to be crucial elements to achieve competitive advantages in the market, being organizational capabilities, technological innovation and production efficiency strictly linked (Dosi and Nelson, 2010; Cirillo et al, 2021; Krzywdzinski, 2021). Of course, heterogeneous organizational structures are adopted across OEMs, belonging to different countries, according to culture and objectives. Generally speaking, countries, and more specifically plants in different countries, address technological innovation and employment changes according to their corporate strategies, institutions at stake, regulations and bargaining power of trade unions. These factors are particularly relevant in shaping the degree of automation with respect to investment choices and employment skills composition.

In what follows, we focus on the heterogeneity across lead and peripheral countries and plants describing the role of the aforementioned key factors. In particular, as explanatory archetypical examples we compare Germany and the Central-Eastern European (CEE) countries. The German Original Equipment Manufacturers (OEMs) have relocated part of their production in these countries over time and a gap in R&D activities, skills composition, degree of technological innovation is still quite evident. Exploring the sources of the asymmetries across Germany and the CEE is helpful to understand what are the main challenges that Southern and Eastern European countries are facing. Many of these challenges not only characterize the digitalization and automation process but also the decarbonization one, being the latter a new trend displaying upon pre-existing asymmetric structures and country positioning.

2.1 Asymmetries in addressing automation and digitalization: core vs peripheral plants and countries

While heterogeneity across countries is more expected, there is even evidence of plants heterogeneity in the same country. In addressing technological innovation to compete in the market, firm history and corporate strategy, particularly in relation to R&D investments and ensuing consequences on the upskilling of the workforce and local labour markets turn out to be strong factors at work, giving rise to forms of workplace production regimes, heterogeneously implementing ex-ante homogeneous technological innovation advancements (Moro and Virgillito, 2022 [59] for Italian automotive sector).

Krzywdzinski (2019) [46] reports that only 20% of companies in the CEE declare to be highly automated, while in Germany they are more than 50%. The CEE automotive industry has been developed by the relocation of the German automotive sector, basing low-end manufacturing plants in lower costs and lower wage countries. In particular, automotive suppliers have relocated activities in the CEE, accounting for 44% of their employment vis-à-vis 11% of final car assemblers (Krzywdzinski, 2019).

On the one hand, those in CEE have become the main automotive suppliers of components and parts for Germany and, over time, thanks to learning by doing, cumulated knowledge, experience and knowledge exchange by networks with German actors, as universities and R&D units of the parent companies, they have tried to fill the gap for what concern product innovation, quality and productivity. Thus, they started competing also with German automotive suppliers, having an advantage on the market because of low cost production. On the other hand, the innovation upgrading does not hold for all plants in CEE, the advantage in innovation activity is not the same for all suppliers, and Germany could in principle relocate to other low cost countries breaking the existent knowledge exchange networks. In particular, the highest innovative advantage is given by the proximity of R&D centres and cumulated investments which have accompanied the evolution of the automotive industry over time (Pardi, 2022 [62]; Krzywdzinski, 2019). As evident from Figure 2, the first adoption and testing phases of new technologies is more frequent in German plants with respect to CEE ones. The figure highlights the non-neutral strategic choice of where conducting high-level innovative activities by parent companies. At the same time, plants in high wage countries, as Germany, which are not leading and would need to invest in R&D and in technological innovation, could decide to relocate to low cost countries to compete in the market, with possible implications of negative employment effects due to relocations[3]. Italy and France are countries apt to the example. Indeed, the gap in the wage share across Northern, Southern and Eastern European countries is high and represents a huge incentive of relocation of production activities, particularly the production of parts and components, of high wage countries to low-wage ones in order to compete by lowering labour costs and

[3]Krzywdzinski (2019) states that relocations implying jobs reduction in automotive suppliers in Germany have been reported by the 33% of the works councils of the interviewed sample

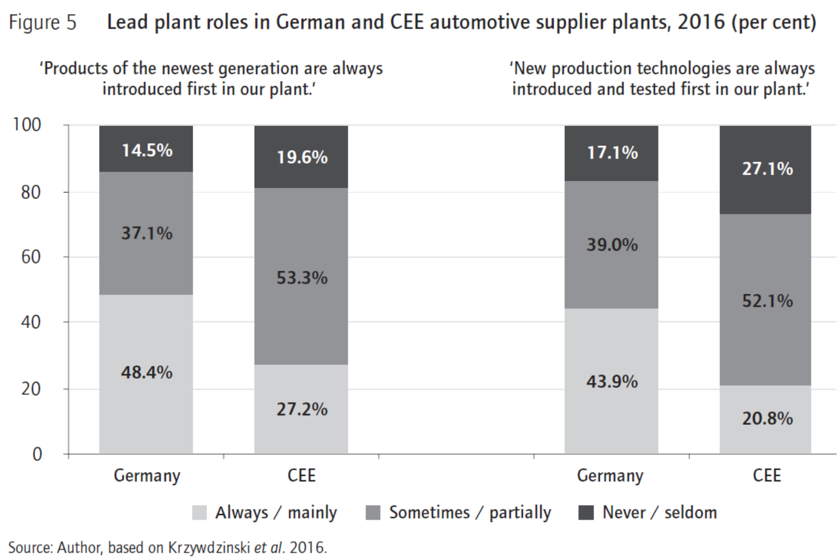


Figure 2: Focal vs periphery plants. Source, Krzywdzinski, 2019

labour share (Figure 3). Figure 4 shows the rate of change between 2012 and 2020s of internal production of parts and components in the European automotive industry. The change is negative/slightly negative in core countries, due to relocation to foreign automotive suppliers, while it is positive in Poland, Czech and Slovakia.

Heterogeneity in innovation activity across periphery and core countries reflects on the skills distribution of the workforce in the sector. The percentage of automotive supplier plants with high automation degree in the automotive industry in Germany have a higher share of jobs requiring multiyear vocational training than CEE (Krzywdzinski, 2019). Such difference is also due to asymmetries in the institutional skill formation regimes (Krzywdzinski, 2017). Therefore, plants with a higher share of workers with vocational training are more likely to be able to face new challenges of the automation and digitalization process and in particular, the possibility to upskill/reskill workers can offset the risk of technological unemployment for those occupations most likely to be automated.

Of course, a strong bargaining power of trade unions, unionisation and representation of working councils are crucial to put pressure on keeping high vocational training to avoid technological unemployment and labour expulsion. Again, asymmetries are present with respect to unionisation across Northern, Southern and Eastern Europe, where bargaining

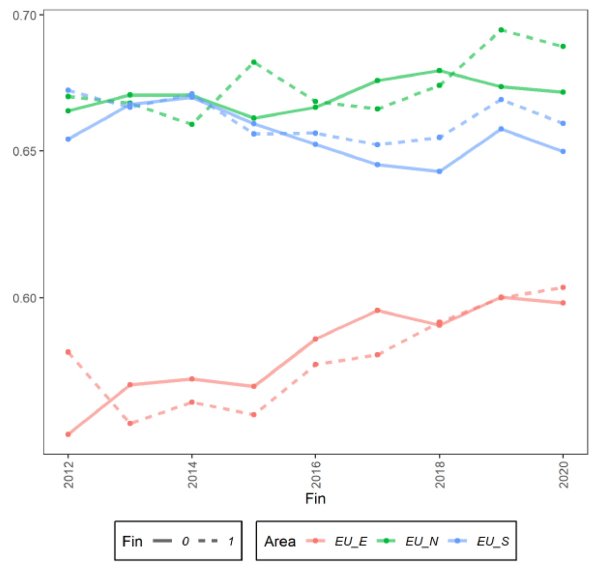


Figure 3: Wage share in core vs periphery countries. Source: Collodoro and Virgillito (2023) [18]

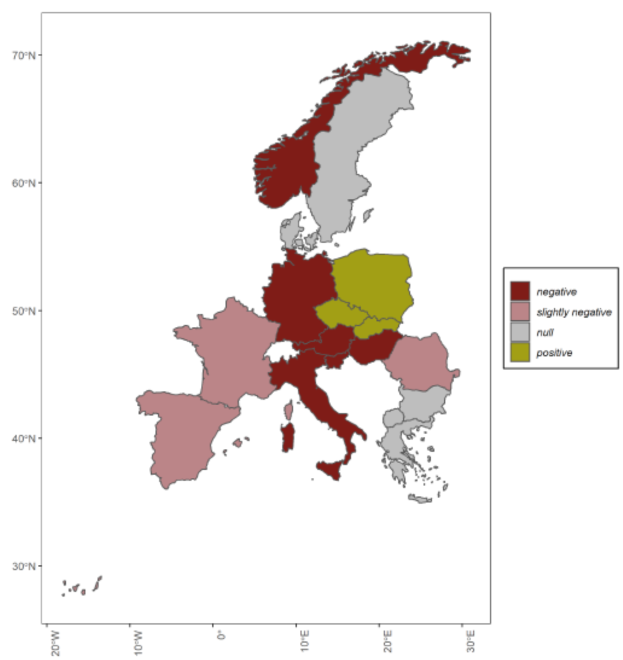


Figure 4: Component-producers differential between 2012 and 2020. Source: Collodoro and Virgillito (2023)

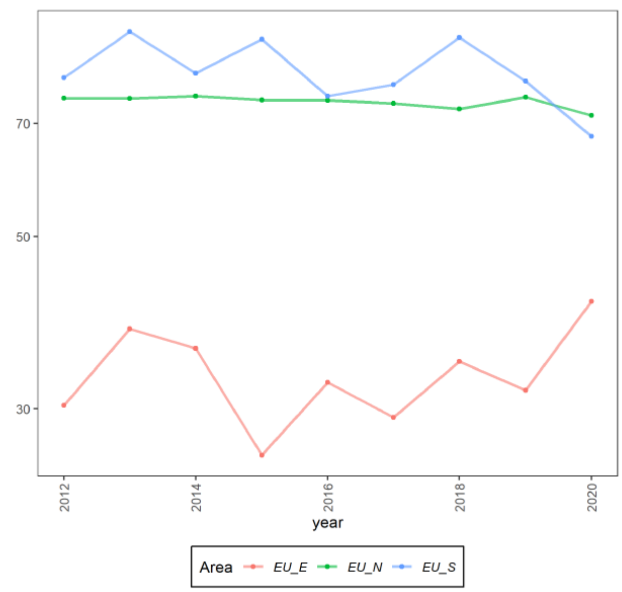
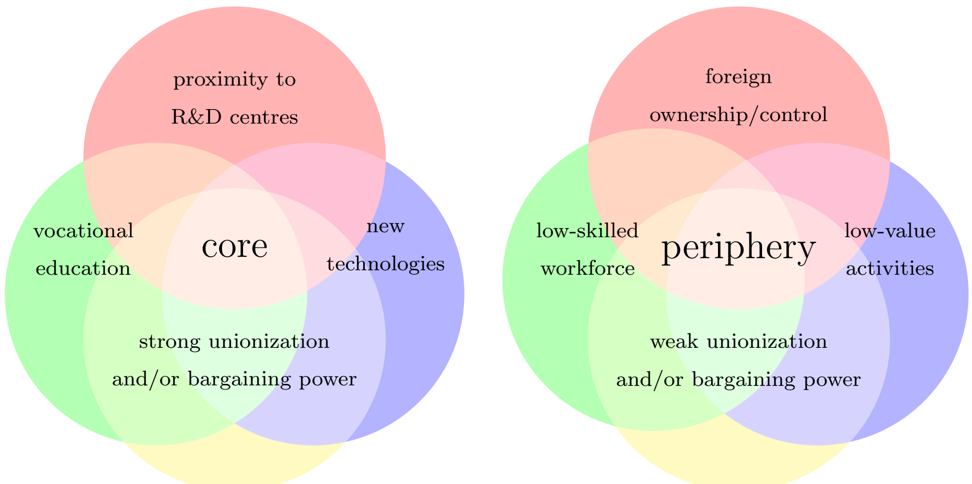


Figure 5: Bargaining coverage in core vs peripheral European areas. Source: Collodoro and Virgillito (2023)

coverage oscillates between 25%-30% and 40% (Figure 5). Workers and their representatives should push bargaining towards investments in organizational capabilities (in the sense of high level tasks, Dosi and Nelson, 2010) proposing new corporate strategies, divergent from low cost relocation strategies and which could lead to new and successful organizational structures (Krzywdzinski, 2017). Trade unions indeed have proven to be effective in shaping directions of investments and product upgrading in the automotive sector (Cirillo et al., 2023) [15].

Last but not least, institutional factors are the common thread of corporate strategies, organizational structures, level of wages and labour costs, vocational education systems, possibility of relocation and bargaining power shaping the differences between core and periphery. In the next section, we describe the attributes of the decarbonization process, sharing these factors with the automation and digitalization ones.

In the following diagram, we summarise the relation between the factors shaping core vs periphery positioning and effects in the automation and digitalization process. A second map is provided at the end of the next section adding the decarbonization process, highlighting the common aspects of the trends under analysis.



(a) Factors shaping core plants and countries **(b)** Factors behind core-periphery dualisms

Figure 6: Factors behind core-periphery dualisms

3 Decarbonization trends and scenarios for the automotive industry

The transport sector alone is responsible for a level of emissions ranging from 10 to beyond 20 percent of overall annual CO_2 emissions. The urgency to tackle climate change has pushed the European Commission to propose a 100% cut in CO_2 emissions by 2035. Other countries have declared strategies of phasing-out fossil fuel vehicles by 2040 during the COP 26 in Glasgow. In particular, the resulting Climate Path includes a Declaration on Accelerating the Transition to 100% Zero Emission Cars and Vans ratified by 35 countries and 6 major carmakers, with the notable absence of some big players as Toyota not signing the agreement. As a consequence, vehicles with combustion engines will not circulate any more by 2035, thus the production has to stop and shift to manufacturing electric vehicles. Such transition is expected to have employment effects and values chain disruptions. Particularly, as automation and technological change, the decarbonization process is characterized by the duality of creation and destruction of jobs. This dichotomy is evident in two archetypal sectors: the energy and automotive sector.

On the one hand, the energy sector is expected to foster employment in the development, installation and maintenance of green technologies for the renewable energy sources, the production and supply of green hydrogen in particular, and in the manufacturing of batteries for electric vehicles (BEVs). According to the IEA, 0.21 million jobs will be created in critical mineral sectors, 0.29 million in offshore wind, 0.30 million in hydrogen production, 0.61 in bioenergy and 0.29 in carbon dioxide capture and utilization and storage[4]. On the other hand, job losses are expected in the automotive industry, given value chain disruptions due to the shift to electric vehicles. In particular, losses are targeted towards blue collars on the assembly lines, given that an internal combustion engine is composed by 200 components while the electrical one only by 20 of them (Brown, 2022)[11], and on second and third tier suppliers of parts and components related to the internal combustion engine.

Nevertheless, in a best case scenario, losses in the automotive industry are expected to be offset by the production of BEVs, together with the improvement in the demand for ICT and engineering occupations, and increase in indirect jobs (eg., related services). However, the reallocation of dismissed workers into BEVs manufacturing depends on:

- the decision taken at the OEMs headquarters about the production vis-à-vis the import of batteries. In the case of import of batteries (mostly from Asian countries), the possibility to reallocate blue-collars into the battery manufacturing industry fails;
- in the case of internal production of batteries, the decision of the OEMs in which plants to produce and the investments in training the workforce;
- eventual regulations and policy interventions promoting investments and re-skilling and up-skilling of the workforce reforms (Pirie et al., 2022) [67]

Such uncertainty largely characterises the automotive industry in central and eastern European countries, where several plants of foreign OEMs are located and they are not

[4] IEA

independent in the decision making process: the foreign ownership and control via FDI in CEE exceeds 90% in the most relevant countries part of the automotive supply chain, thus they have no independent decision making process (Pavlinek, 2022) [64]. Foreign companies could decide to import or to produce batteries in high-wage countries, where the required skills are available. For instance, Northvolt, a Swedish Gigafactory company, has based its gigafactories in Sweden, Northern Germany, but also and Poland, countries where wages where not necessarily so competitive and skilled workforce was available.

At the same time, a high degree of firm-specific innovation activity cumulated over time gives an absolute advantage on the market, and alternative company-level innovation strategies in addressing the shift to electrification of the automotive industry are expected across different OEMs as well. According to Mazzei et al. (2022) [56], technological leaders in the internal combustion engine trajectory are also leaders on the hybrid, electric and fuel cell vehicles one (Toyota), thanks to past knowledge accumulated (Figure 9). At same time, some specific players as Tesla, with a strategy only on the green segment, are not targeting high-volume markets, but rather high-price products. As we shall see, such heterogeneity across countries and car producers also reflects the existence of conflicting interests emerged during the definition of CO_2 emissions targets and regulations by European authorities.

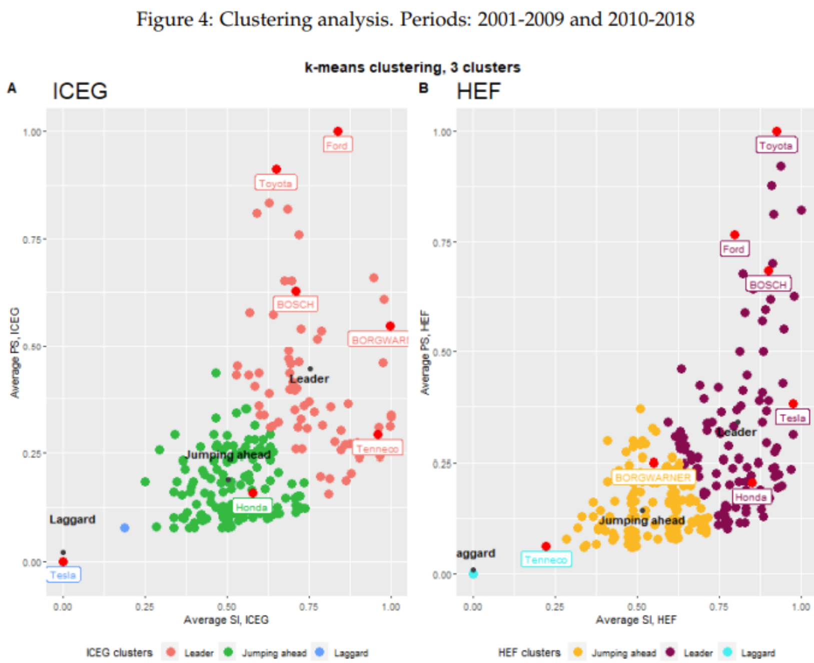


Figure 7: Firms' position in the technological landscape of eco-innovations, measured by average patent share (PS) and average specialization index (SI), over 2001-2009 and 2010-2018 in the internal combustion engine trajectory (ICEG) and in the hybrid, electric and fuel cell vehicles (HEF). Source: Mazzei et al, (2022)

In order to give an account of the extent to which the transition toward electrification is ongoing in the automotive industry, in Table 3, we report some cases of OEMs shifting the production to the electric vehicle engine, together with other automotive suppliers and Gigafactories (from Automotive Manufacturer Solutions and secondary data). To take some examples, Audi has declared that by 2025, 9,500 jobs will be lost, by early retirement programs and through employee turnover, and 2,000 jobs will be created as a consequence of the electrification and digitalization of the production in the two plants in Ingolstadt and Neckarsulm. On the contrary, Seat is shifting the production to the electric engine in Martorell and El Prat where 2,400 and 1,000 jobs are at risk respectively, while no reallocation has been declared yet. Job losses are expected also for automotive supplier manufacturers, as Marelli in Italy. Together, a high number of traineeships for students will be provided. All examples of Gigafactories are expected to create new jobs.

Table 3: Selected OEMs shifting to production of electric vehicles and gigafactory plants. Table 3. Source Nelli et al., 2022 [61]

OEM	Country	Shift to electric engine	Expected job impact	Jobs reallocation	Policy intervention	Advancement status
Germany	Audi	YES	-9,500, +2,000 by 2025	NO	YES	Low
Slovakia, Bratislava	Volkswagen	YES	-3,000	NO	NO	Advanced
Slovakia, Kechnec	Magna	NO (Manufacturing of EV's assistance components)	+100 by the 4th quarter 2022, +600 by 2027	/	NO	Medium
Spain, Martorell	SEAT	YES	-2,400 direct jobs (Martorell) -1,000 (El Prat)	NA	YES	Advanced
Spain, Sagunto	Volkswagen	NO, Gigafactory	+3,000	/	YES	Low
Italy, Bari	Bosch	YES	NA	NA	YES	Low
Italy, Bari	Marelli	YES	-550	NA	NA	Low
Italy, Grugliasco	Stellantis (Maserati)	YES	-1.100	YES	NO	Medium
Italy, Scarmagno	Italvolt	NO, Gigafactory	+13,000	/	YES	Medium
Italy, Termoli	Stellantis	NO, Gigafactory	+2,400	NA	YES	Low
Sweden, Trollhättan	NEVS	YES	+Thousands (since 2019)	NA	NO	Advanced
Sweden, Göteborg	Northvolt	NO, Gigafactory	+3,000	NO	YES	Medium
Sweden, Skellefteå	Northvolt	NO, Gigafactory	+3,000	NO	YES	Medium
Sweden, Borlänge	Northvolt	NO, Gigafactory	+1,000	NO	YES	Medium

As a result, we expect a deepening of the asymmetries between core and peripheral countries and plants as observed for the automation and digitalization process. To sustain the cost of electrification, OEMs and automotive suppliers will relocate low-value added activities towards low-cost countries, leading to a further loss in employment (Pardi, 2022), while R&D activities remain and keep developing in high-wage countries as Western Europe, the United States, Japan and South Korea (Pavlinek, 2022). Indeed, Asian BEVs manufacturers are investing in Europe and especially in CEE, but only in assembly lines manufacturing (Pardi, 2022). Again, the role of bargaining coverage and strength of trade unions in contracting with the main OEMs is crucial to assure reallocation of dismissed workers.

Policy regulations are pivotal to address the decarbonization process in the right direction, both in peripheral countries to break the persistent asymmetry with core ones, and in peripheral plants in core countries. Policies should be managed at the European level considering the peculiarities and specific needs, otherwise asymmetries will keep reverberating: "virtuous" countries will put in place "virtuous" policies, but non-virtuous countries would not. For instance, on the one hand, in a multi-targets policy package, the German government by means of the sustainable battery cells production measure allocated 3 billion euros for the manufacturing of battery cells and research projects in 2021[5]. Producing climate friendly, efficient batteries in Germany is crucial to preserve jobs and for the development of new value chains. On the other hand, Slovakia mainly provides tax exemption and purchase bonuses translating past EU regulations of charging infrastructures[6], but no ad-hoc plans are devoted to preserve and create new jobs within the automotive and batteries manufacturing.

Figure 10 summarizes the causes and consequences of two alternative scenarios, a positive vis-à-vis a negative one, of the automation, digitalization and decarbonization trends in the automotive industry outlined so far.

[5] https://www.bmwk.de/Redaktion/DE/Dossier/batteriezellfertigung.html

[6] https://www.iea.org/policies/6776-registration-tax-benefits-ev ; https://www.iea.org/policies/6697-local-incentives-ev

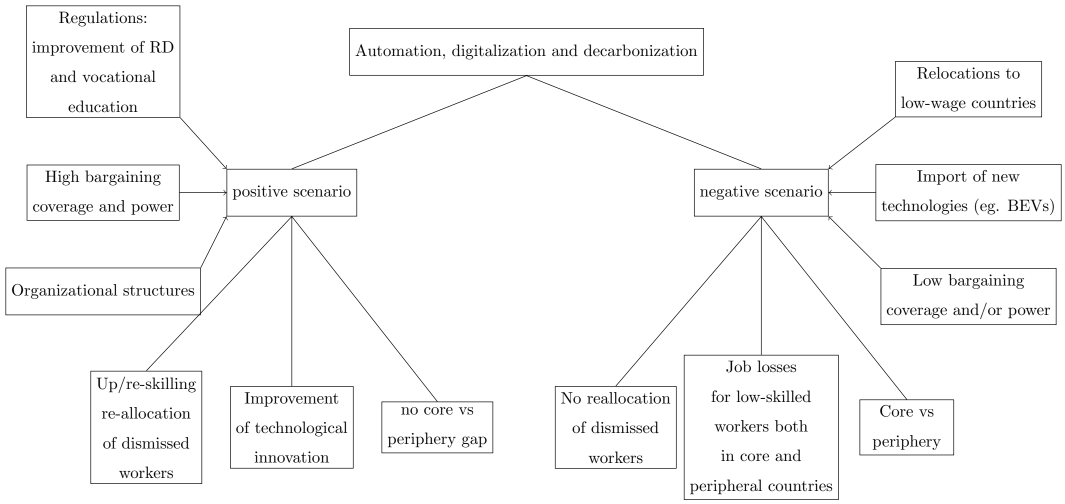


Figure 8: Positive and negative scenarios, causes and consequences

Inside such potential scenarios, heterogeneity of car producers is also fuelled by non-neutral regulatory actions. Because of the divide between premium and mass cars producers, combined to asymmetries in country production capabilities, European CO_2 regulations have so far acted in determining a purported ex-ante external push, which however turned out favouring some actors, while disfavouring some others. Since the EU CO_2 regulation has shown different impacts on countries and car producers competitiveness, on the one hand, and on the efficacy to reach sustainable and efficient targets, on the other, the evolution of the EU CO_2 regulation and the response of the car industry are analysed in the next section.

4 A brief history of European regulations on CO_2 emissions: the non-neutrality of the regulatory push

To assess whether and how the European regulation on CO_2 emissions shaped the productive choices of automotive companies and affected their competitiveness, it is necessary to look at its evolution over time. What is more, it is crucial to account for the presence of heterogeneous actors - both countries and car producers - whose conflicting interests emerged in the process of refining and strengthening targets on CO_2 emissions. If compared to the experience in the US, where already in 1970 the first regulation over air pollutants - the

Clean Air Act - was introduced, the European Union arrived quite late with the Euro Norm 1 in 1992, then followed by the Euro Norm 2 in 1996 (which also granted lower NO_x limits for diesel engines with respect to petrol ones).

Not only these norms were much less challenging for car producers with respect to the American ones, but they were also based on the principle of self-regulation since no institutional mechanism of control over car production was envisaged by European authorities at the beginning.

This purported cooperative approach was further pursued in 1998, when the EU made an important agreement with the European Automobile Manufacturers Association (ACEA) on reaching the voluntary target of 140 CO_2 gr/km by 2008, then turned in 2007 into a mandatory target equal to 120 CO_2 gr/km by 2012.

Despite presented as "one size fits for all" measure, the ways through which automotive producers could reach these goals were different and highly dependent on the type (and weight) of cars produced and, on the technology adopted to reduce CO_2 emissions.

As explained by Pardi (2022), when these rules came into force, the European landscape of car production was far from being homogeneous as two main models were on stage. From the one hand, producers of premium (luxury and larger) cars mainly located in Sweden and Germany, on the other hand, producers of mass cars (smaller and lighter) located mainly in Italy and France. While the former were pushing for more complex technological solutions and in particular for the use of diesel, the latter on the contrary, preferred cheaper solutions based on the improvement of fuel quality through lead traps and were opening up the possibility of institutional constraints such as the introduction of speed limits. Among these actors, Germany, Italy and France represented and still constitute the core of the European automotive sector, but their positions have dramatically diverged over the last decades (Pavlínek, 2022). The evolution of the EU regulation over CO_2 emissions, that turned to favor an "upward shift" of the automotive sector, might have contributed to this process of core reconfiguration with Germany increasing its market share while France and Italy weakening their position (Pardi, 2022).

The definition in 1998 of the voluntary target of 140 CO_2 gr/km by 2008 turned quite early to be not sustainable, in particular for what concerned the premium car manufacturers that were struggling more to reduce their emissions. Keeping a cooperative approach, the European Commission created in 2005 CARS21, a task force on the Competitive Automotive

Regulatory System for the 21st century, that involved several stakeholders in order to define policies able to ensure both employment and competitiveness of the automotive sector in the face of climate justice challenges.

However, a comprehensive European perspective failed to be pursued. On the contrary, a crucial role was played by the German association of cars (VDA) that bypassed ACEA. The VDA was able to influence the final decision of the European Commission in 2007 to: (i) move the target from 120 to 130 gr/km, postponing the limit to 2015 (from 2012), (ii) introduce CO_2 credits related to the production of eco-innovations (that at that moment were all in Germany), (iii) adopt a weighted target and make a distinction between cars and vans (Haas and Sander, 2019 [36]; Pardi, 2022).

In particular, the introduction of a weighted measure of CO_2 emission was highly criticized by environmental organizations such as T&E (Transport and Environment) that denounced the promotion of a vicious circle. In fact, while producers of premium cars, heavier polluters, were getting a relative discount with respect to their CO_2 emission target, generalist producers that were (successfully) reducing cars' weights with a positive overall impact on pollution were going to face even stricter requirements.

Concerning premium cars, the tradeoff was nevertheless clear. Even if the producers were developing advanced technologies, such as the catalytic converter, able to filter the pollutants, the net reduction of CO_2 emissions due to fuel consumption was hampered by the increasing weight and power of the engine of these cars. As reported by Pardi (2022, p.19), a 10% rise in the weight of the car was implying up to 7% in fuel consumption, while a 10% increase in the power of the engine was causing up to 5% increase in fuel consumption.

In this sense, the introduction of diesel engines that allowed for a reduction in the consumption of fuels represented a solution to the inherent contradiction between the expansion of the premium car market and the tightening of environmental constraints. At the same time, this also implied the emergence of new issues related to the necessity of keeping up not only with the exacerbation of these contradictory processes, but also with the large NO_x emissions caused by diesel and the high costs of these engines that, even if being more powerful, turned to be significantly more expensive than petrol ones (between 9% and 21% according to Pardi, 2022, p.19).

The development of diesel engines and eco-innovations determined an increase in the costs of production (and car prices) not only for premium, but also for generalist producers, which tried to increase their competitiveness, offering more powerful and technologically advanced cars. However, the former were clearly experiencing a comparative advantage, as shown by their market expansion contrasted with the crisis faced by generalist producers. This paved the way to a more radical process of productive restructuring and delocalization of French and Italian companies to reduce costs (Pavlínek, 2020 [63]).

New targets both related to the emissions of CO_2 and NO_x were defined in 2009 with the introduction of Euro Norm 5 and in 2015 with the updated Euro Norm 6. These two new regulations, despite being based on weighted targets, were still quite challenging for both premium car producers and generalist producers which were facing more difficulties in integrating the diesel technology into the lower segments of the car production.

In fact, the huge reduction in CO_2 emissions reported by car producers was mainly related to the adoption of tests optimization practices, as partially allowed by the UNECE (United Nations Economic Commission for Europe) R101 procedure and the NEDC (New European Driving Cycle). Specific strategies were adopted to obtain significantly lower CO_2 emissions (i.e., driving techniques, short cycle of tests, no contemporaneous use of other devices such as air conditioning). However, the conditions under which laboratory tests were implemented were far from being realistic, such that the average distance between the CO_2 emissions detected through optimization tests and the real drive data increased from 9% in 2001 to 42% in 2015 (Tiedge et al. 2019).

Concerning the emission of other toxic air pollutants, a similar strategy was adopted. As discovered by the International Council on Clean Transportation (ICCT) and the EPA during the Diesel Gate in 2015, the insertion of software engines able to dynamically ensure emissions minimization in case of detection of test conditions proved even more clearly that car producers were systematically adopting cheating strategies to comply with environmental standards, that in the case of US were even stricter than the European ones. Given the widespread occurrence of these practices, the EU introduced in 2017 a stricter procedure on car test - the Worldwide Harmonised Light Vehicles Test Procedure (WLTP). It also imposed huge penalties for car producers in case of lack of compliance, keeping at the same time the target of 95gr/km of CO_2 emissions for the average car (with a threshold equal to 95% of total sales in 2020 and 100% of sales in 2021), while maintaining both weighted targets and premia for eco-innovations.

Clearly, as underlined by Pardi (2022), the only possibility to comply to the new rules was

to radically shift towards the production of electric cars - both BEVs and PHEVs - which until that moment were still marginal in the European car market.
It is interesting to underline that BEVs initially produced by companies such as Nissan and Renault were light and compact models, more in line with the tradition of generalist car producers, while PHEVs were from the very beginning closer to the model of premium cars, since they were heavier and more expensive to produce (Pardi, 2022). However, also given the prompt reaction of premium car producers, the entire production of BEVs and PHEVs moved towards an upward shift shown by the rapid increase in their average weight and price, as previously experienced with diesel cars.

While the non-neutrality of the regulatory push clearly emerged in favour of new production models favouring heavy, multipurpose, luxury cars, major open issues remain in terms of their sustainability. In particular:

- still scarce attention is devoted to the pollution generated by the extraction of materials needed for the batteries, notwithstanding all the geo-political problems concerning the provision of raw materials, the energy required to produce batteries and the management of their disposals.
- The price and affordability of these cars keep targeting an ascendant luxury consumer segment. They are still too expensive for the average European consumer, who have been experiencing a decline in purchasing power in the last decades, due to wage stagnation and inflation spike, especially after the Covid-19 pandemic and the Ukrainian war.
- The lack of infrastructure building, in order to ensure that electric vehicles do not remain a luxury choice for city inhabitants, but become a viable solution also for more remote areas.

Such contradictions are also revealed by the different country positions in their productive capabilities toward electric vehicles. Indeed, the very last interventions of the EU - the European Green Deal launched in 2019 and the Fit for 55 Package in 2021 (recently revised) - seem to further reinforce and accelerate this unbalanced process of electrification without accounting for the real sustainability of producing heavier, larger and more powerful electric cars. Signals of tensions have unequivocally emerged in February 2023, during the last round of approval of the final resolution setting a 100% reduction of CO_2 by 2035 for new cars and vans, when Germany, Italy and Poland explicitly opposed to it, fearing the necessity of leaving the door opened to some alternative solutions to electric cars. The regulation has been finally adopted by the European Council in March 2023 - with the abstention of Italy, Bulgaria, Romania, the vote against of Poland and the vote in favor of Germany - granting the possibility of producing ICE cars that function exclusively with CO_2 neutral e-fuels, stimulating new debates among European countries and environmental actors on their alleged climate neutrality and effectiveness (Transport & Environment, 2021 [27]).

As a result, specific forms of regulations accounting for the heterogeneity of actors and conflicting interests at stake need to be identified to achieve efficient and sustainable targets. Among the actors involved, trade unions, workers' representatives and institutions play a crucial role to balance the risks and opportunities which the twin transition of the automotive industry entails for employment and working conditions. Collective bargaining on new technologies should be supported by ad-hoc regulations as well, given the asymmetries of industrial dynamics across countries, the reinforcement of structural asymmetries between employers and workers by the twin transition, and core and periphery dualism of protection of the workforce along the value chain. We discuss the impact of the twin transition on the industrial relations system in what follows.

5 The role of trade unions in the digital and ecological transitions

Either at the sectoral or company level, the twin digital and ecological transition in the automotive industry invests crucial dimensions concerning employment and working conditions, presenting risks (e.g., reconfiguration of value chains, technological substitution of the workforce, deskilling, work intensification, digital control of performance) and opportunities (e.g., increasing professionalism and qualification due to the interface with new technologies, ergonomic improvements, greater opportunities for employee participation). However, the balance between risks and opportunities is neither a direct function of technological implementation *per sè*, nor it will depend exclusively on economic constraints, business strategies or the role of macro institutional factors (such as labour market institutions, welfare systems, technological innovation regimes, etc.).

The lack of a deterministic impact of technological innovations on the world of work has been pointed out by a large tradition of studies, recognizing the role of various forms of institutional arrangements, shaped by social structures and political decision-making (Landes, 1969 [50]; Noble, 1977 [1]; Mackenzie and Waijcman (eds.), 1985 [53]; Howcroft and Taylor, 2022 [39]). Among these forms, the institutions and systems of norms, formal or informal, which regulate employment and industrial relations play a major role, setting both limits to the employers' scope for action and defining the space of power relations (Lazonick, 1979 [51], Hyman and Streeck (eds.), 1988 [2]). Although with a more limited and constrained capacity, workers too can assess the direct and indirect consequences of new technologies on their working conditions, and in that potentially decide whether to embrace or resist them, building alternative paths to managerial top-down adoption (Edwards and Ramirez, 2016) [26]. To understand the relationship between workers and technologies, from a labour power perspective, it is crucial to examine the possibilities for action open up to trade unions and workers' representative bodies (Martinez Lucio et al., 2021)[55], (Cirillo et al., 2023)[15], providing an analytical framework to study the role they play (or not) in transition processes in terms of (i) levels and spaces of intervention, and (ii) structures of interactions with other actors.

5.1 Variety of industrial relations inside a convergence trend toward neoliberalism

European countries are characterised by a variety of industrial relations systems, dependent on their different historical paths as well as the prevailing variety of capitalism at work, which can nevertheless be grouped into coherent clusters ordered according to a limited number of variables, mainly, the power of trade unions and the relationships between capital (employers) and labour (workers) organisations (Crouch, 1993)[19]. This variety translates into the existence of "models" of industrial relations that diverge not only with respect to the mode of relations between the social actors (e.g., pluralist vs. corporatist models) but also with respect to the predominant level of regulation and the ensuing space of actions (sectoral vs. firm level) (Traxler et al., 2001 [78]). Since the variety of capitalisms approach has taken place, sociology and comparative political economy have considered the possibilities for action and strategic choices of trade unions as mainly dependent on the structural dimensions of the industrial relations models, the historical embeddedness of union movements within national institutions, and the values and identities developed within the country's specific capitalist structure (Kelly and Frege (eds.), 2004) [29]. Similarly, the activity and scope of collective bargaining were considered to be closely related to the mode of organization of trade unions on a national basis, and to the existing national types of industrial relations institutions (Clegg, 1976) [17].

The variety of capitalisms approach has been put under question by theories of neoliberal convergence, according to which national institutions and power relations are progressively showing common traits of labour disembedding. Globalisation and the rise of neoliberalism over the last three decades have ignited a convergence dynamic across all levels of the productive fabric, characterised by the progressive dismantling of social dialogue and the liberalisation of collective bargaining, through the weakening of national/sectoral level agreements and the strengthening of the local/firm ones (Howell and Baccaro, 2017) [5]. Above all, MCNs have had an increasing impact on industrial relations systems, both through the influence they have exerted on national governments to liberalise the labour market and collective bargaining, and through the strategies they have implemented to circumvent these constraints (Marginson and Meardi, 2009)[54].

The convergence debate does not only concern the national level of industrial relations, but increasingly the level of single industry. In addition to theoretical reasons, stemming especially from the capability-based theory of the firm, institutional labour economics and labour process theory, technological, market and product factors have more recently reinforced the idea that currently divergence in EU industrial relations regimes is determined more by sectoral specificity rather than country locations (Bachter et al., 2012)[8]. According to these authors, while the existence of a 'national model' still appears to be relevant for a limited number of countries (the Scandinavian countries plus France), in the remaining European states variations across sectors appear to be more significant than variations across countries. Consequently, homogeneity in industrial relations can be expected on a sectoral basis, especially in those sectors that are highly internationalised, dominated by large multinationals and subject to strong regulation at EU level. In these sectors, which are labelled "organized corporatist", industrial relations are expected to be 'dense', "in the sense of involving strong and numerous actors, at many levels" in the process of negotiation (ibid., p. 11).

5.2 The decline of trade unions power in the automotive industry

The automotive industry, the critical sector of the second phase of industrialisation since the early post-war period (Kurth, 1979)[49], represents one of the industries in which collective bargaining has been most developed – especially in OEMs and larger suppliers in the industry – and in which industrial relations have shown to be resilient but also highly dependent on national historical paths (Jacobi et al. (eds.), 1986)[41]. The continental European model of industrial relations, associated in particular with countries such as Germany or Sweden, with their legal framework regulating the conflict between capital and labour, seemed at the time to be able to guarantee a structuring of interest representation suited both to corporatist forms of collective bargaining and to the maintenance of internal cohesion within the labour movement, thus protecting trade unions from the risk of incorporation (Turner, 1991) [79].

However, since the second half of the 1980s, the automotive sector has been hit by strong convergence trends with respect to the organisation of production, due in particular to the dominance of the Japanese lean production model (Womack et al, 1990 [82]; MacDuffie and Pil, 1996 [66]). Although strong country-to-country variations persist, the shift of the balance of power in the direction of employers seems everywhere to strengthen managerial prerogatives at the expense of the influence of trade unions in decision-making processes, which remains quite low overall and this despite their concessionary bargaining cooperation to improve firm performances (Deutsch, 1986 [20]; Kochan and Lansbury, 1997[44]). The lean production system, in fact, is globally oriented towards marginalising trade unions or shaping their subordinate participation, preferring to directly manage relations with workers through involvement devices or to give rise to forms of company or factory unions that implement a cooperative trade unionism dependent on managerial power (Rinehart et al. 1997 [71]; Huxley, 2015[40]). Even in countries such as Germany or Sweden, trade unions have suffered from the reconstruction of managerial hegemony in the workplace and from reforms that have liberalised the labour market and favoured decentralisation of collective bargaining. In this scenario, increasing employment insecurity has made trade unions less resilient to the impact of lean production and they have undergone marginalisation processes that have thwarted their adaptation strategies, making them increasingly deferential to managerial competitiveness prerogatives (Rutherford and Frangi, 2021[73]). While these trends have weakened the strength of national regimes with respect to corporate production systems (Jurgens and Krzywdzinski, 2016) [43], at the same time, workplace regimes continue to be an active force of divergence, conditioning at a micro level the politics of production (Rutherford, 2004)[72].

5.3 The role of delocalisation and transnational managerial strategies

The automotive industry has also been deeply affected by the intensification of international competition which has led to the creation of global production networks headed by Original Equipment Manufacturers (OEMs) and multinational component corporations that make up the first tier of suppliers (Banyuls and Haipeter, 2010) [6]. The quest for competitiveness has led these actors to adopt a strategy of reterritorialisation of production implemented also by exploiting the differences between industrial relations systems in terms of employment protection and institutionalisation of collective bargaining, competing among themselves on cost-compression and labour-disempowering strategies. In this sense, both OEMs and component multinationals have resorted to the delocalisation of production facilities to countries or regions with lower labour costs and less union protection, activating forms of intra-firm competition in terms of plant productivity and efficiency. This process ended up into the creation of global value chains in which second and third tier suppliers are induced to compete fiercely on price (Greer, 2008)[34]. This dynamic of social dumping has been an active force exerting pressure on industrial relations systems in the industry, pushing for their further liberalisation and lowering of labour standards (Banyuls and Haipeter, 2010). Trade unions have tried to respond to this pressure either through the instruments of the European social dialogue (ex. EWC), or by activating forms of bargaining and mobilisation along value chains (Whittal et al., 2017) [81]. However, the effectiveness of these strategies in terms of regaining bargaining power is still a matter of debate (Greer and Hauptmeier, 2008) [35].

More recently, the automotive sector in Europe has been particularly affected by the economic crisis of 2008 and the recession that followed, in which demand for motor vehicles collapsed, especially in the medium-high segments. As a consequence, the collective bargaining system within the sector was subjected to acute stress for several years, in which, by threatening site closures, downsizing and new relocations, large companies managed to impose a concessionary bargaining framework on the trade unions, especially in terms of intensification and worsening of working conditions, increased flexibility of work performance, and renewed recourse to precarious work arrangements (Pedersini, 2010)[65]. This bargaining stress was also echoed along the value chains, often accentuating forms of dualisation of the workforce, between a core that was able to defend its employment, and a periphery that was less protected and more exposed to the risk of collective redundancies (ibid.). Alongside this, we have witnessed both attempts by OEMs to circumvent the institutions of industrial relations (exemplary is the case of FCA in Italy, which from 2009 onwards left the employers' organisation, thus breaking away from the national contract of the metalworking sector, Meardi, 2014 [57]), and, on the other hand, government interventions aimed at weakening national collective bargaining, increasingly allowing decentralised bargaining to derogate both from the terms agreed by national industry agreements and from the labour protections provided by law (see the French case of the instrument of 'competitiveness agreements', Reaney and Cullinane, 2017 [68], 2021 [69]).

5.4 Trade unions and Industry 4.0

Given the path done so far, trade unions do not appear to be in a strong position in order to orient the twin transition. So far, the literature has not identified a unique path toward a low-end or, at the opposite, a high-end scenario.

Starting with evidence on the role of trade unions in shaping the digital transition, the so-called Industry 4.0 technologies, results from a diverse number of production sectors demonstrate the relative importance of labour market institutional factors in shaping technology implementation. A revival of the variety of capitalisms approach has emerged, with the old divide between coordinated and liberal economies again proving to be relevant (Doellgast and Wagner, 2022)[22]. In coordinated market economies, institutions support firms in the adoption of new technologies through the development of specific workers skills or social partnerships, while at the same time trying to use technological change as a means to circumvent national and industrial arrangements. At the opposite, in countries with liberal or embedded neoliberal market economies (such as the Visegrad countries, Bohle, 2017 [9]) the absence of these institutions ignites firms to formulate strategies based on short-term investments and reliance on cheap, unskilled labour (Krzywdzinski, 2017; Lloyd and Payne, 2021 [52], Diessner et al., 2022 [21]).

In assessing how industrial relations can face the twin transition within the automotive sector, it is important on the one hand to distinguish the specific forms of regulation that can help support collective bargaining on new technologies, and on the other hand to assess the centrality of the industry within national economic systems and how these forms of regulation are concretely applied therein. While specific industry level studies on such matter are still missing, insights can be drawn from studies on the involvement of trade unions and works councils in the implementation of Industry 4.0 in the metalworking sector in Germany and in Italy.

With respect to the German case, the industrial relations system is dual: works councils are entrusted with the representation of workers at company or plant level with strong co-determination rights, while the trade union negotiates collective agreements at industry level with employers' organisations (Muller-Jentsch, 2008)[60]. Although it has not been exempt from processes of erosion of representation and labour standards (Greer, 2008), the metal industry represents a core sector of industrial relations in Germany with respect to other sectors (Vandaele, 2018) [80] and also one in which, by international comparison, works councils and unions have quite extensive bargaining and consultation rights (Jager et al., 2022)[42].

Given the institutional entrenchment of German trade unions and works councils within the organisational structure of the metalworking sector, the introduction of new technologies is an important subject of negotiations between management and labour, both at industry and company level. However, even in this institutional environment, the involvement of trade unions and works councils in technological innovation processes linked to Industry 4.0 has not been straightforward. On the one hand, IG Metall, arguably the most powerful trade union in the world, only recently decided to abandon the defensive position in which it had been placed by restructuring plans linked to the economic crisis and to try to take a proactive role in shaping technological change, by engaging in the promotion of social partnership kind of framework agreements on digitalisation at company and plant level (Bosch and Schmitz-KieBler, 2020) [10]. On the other hand, the aim to raise the work councils' awareness of the impact of digitalisation required substantial investments on the part of the trade unions (e.g. through the provision of union officers and external experts) and in any case was successful mainly in those cases where a tradition of cooperative industrial relations already existed at factory or company level (Haipeter, 2020)[37]. Nevertheless, discussions of Industry 4.0 together with the Covid-19 crisis contributed to a more general resurgence of corporatist coordination between state and corporate actors. This resurgence manifested itself especially in the development of the German government's strategy on artificial intelligence (AI), which includes a commitment to strengthen social dialogue in this area. Conversely, although the trade unions failed to obtain a general right of co-determination in the digitalisation process, the Works Council Modernisation Act, enacted in June 2021, reinforced the consultation, information and co-determination rights of works councils in the field of AI (Krzywdzinski et al., 2023) [48].

With reference to the Italian case, regulated by a mandated industry-level collective bargaining plus an optional firm-level one, in some respects recalling the dual German model, Cirillo et al., 2023 [15] show that the introduction of I4.0 technology opens up a new space of action for the role of TUs in influencing firms' technological adoption decisions. However, this new scope of action can have ambiguous effects, depending on how the process is governed. On the one hand, TUs' involvement in said decisions might end up fostering corporatist tendencies, favouring the alignment of workers' and managers' objectives. On the other hand, such a major involvement can help both recompose old forms of dualism and revitalising workers' role in the crucial issue of work organisation. The results are however limited to a niche region, highly innovative and largely dependent from German FDI and ownership control, Emilia Romagna. In addition, the companies analysed are entirely under FIOM representation, an organization mixing both forms of corporatism (to a larger extent) and conflictual practices (to a minor extent).

5.5 A theoretical framework to map trade unions capacity in the twin transition

The German and Italian cases of Industry 4.0 allow thus to move away from a narrow view of the study of negotiation over technology and to frame the issue according to a broader perspective of "politics of production" (Burawoy, 1985) [12], of which negotiation of technology constitutes only a sub-field. Focusing on the politics and regimes of production opens up the possibility of understanding negotiation over technology as it takes place within and across different 'arenas' (Schaupp, 2022) [74].

- The arena of regulation involving the state, trade unions and employers confederation, giving rise to the regulatory framework, acting at the macro-institutional level.
- The arena of implementation, wherein at the company and also workplace level, the process of technological adoption takes place.
- The arena of the space of actions undertaken in response to technological innovations, in terms of appropriation of the use, but also misuse, of such instruments. The space of actions also includes forms of resistance, but also perimeters of representation in the capital-labour relation, occurring at all levels, from macro to micro.

These arenas do not correspond to the various levels of collective bargaining (country, sectoral, company/plant), but rather to negotiation processes that may take place at different levels, depending on the industrial relations system under consideration. In that, the framework is apt to analyse institutionally different national environments. Besides, the concept of negotiation "encompasses both cooperation and confrontational interactions" (Schaupp, 2022 [74], p. 75), dealing not only with formal collective bargaining, but also with informal negotiation processes, for instance through collective or individual practices of resistance and organisational misbehaviour enacted in reaction to the implementation of new technological artefacts (Hodson, 1995) [38]. Finally, using this analytical framework makes it possible to include in the analysis those actors external to industrial relations institutions but who can influence the negotiation outputs by exerting political, social or economic pressure (e.g. public institutions of a local or national character, social movements - especially those linked to the struggle against climate change - experts, etc.).
How the power of actors involved in these arenas can be measured and confronted? Power

resource analysis offers a suitable approach for this purpose, as it allows for the assessment of different power spaces, relations, and configurations between workers and employers at different analytical levels (Wright, 2000 [83]; Schmalz et al., 2018 [75]; Refslund and Arnholtz, 2022 [70]). Although the starting point of power resource theory is the recognition of the structural asymmetry of power between workers and employers, the aim of the theory is to focus on how workers' mobilisation and organisation can counteract this asymmetry, by changing the desired outcome of employers' strategies, but also by influencing public policy or creating institutions that govern the compromise between capital and labour. In particular, in a context in which, albeit in a differentiated manner from country to country, we are witnessing a reduction in both associational power (steady decline in union density, weakening of corporatist structures) and structural power (dictated in particular by the fragmentation of the workforce and weakening of employment conditions), in order to influence the digital and ecological transition, trade unions could try to resort alternatively to:

- their capabilities in exercising *institutional power*, i.e. the power to foster workers interests or constraining employers action through the use of institutional mechanisms or legal frameworks;
- their capabilities in exercising *societal or coalition power*, i.e. the power to forge alliances and coalitions with other actors of society;
- their capabilities in exercising *symbolic power*, putting forward political agendas able to re-orient the public discourse on matters as working rights, unfair working and contractual conditions, decent salaries, intermittence of working times and contracts, i.e., the world of work in a nutshell.

5.6 The case of the just transition as symbolic and societal powers' reconstruction

A case to the point is the inclusion of the notion of 'Just Transition' at the top of the international political agenda, since the UNFCCC COP held in 2010, which is partly the result of the efforts of the international trade union movement (Clarke and Lipsig-Mummé, 2020) [16]. The concept of just transition was in fact an early union demand whose origins date back to the 1960s and which signalled from the outset the need to reconcile labour security with environmental protection (Galgóczi, 2020)[33]. Embedded in various institutional frameworks, such as the preamble of the Paris agreements and the ILO guidelines, the concept of just transition concerns not only outcomes of the decarbonisation process, but also the management of the transition itself, which must involve significant forms of social dialogue at all levels, concerning both the distributional effects of climate policies and the management of the employment transition (Galgóczi, 2018) [32]. A successful discursive representation of societal problems, able to mobilise external support, the concept of just transition has developed into a policy framework that orients social dialogue at different levels, from workplace to national and supranational, institutionalising both the role of trade unions in the process of change and the ecological transition as an object of collective bargaining (Galgóczi, 2020; Tomasetti, 2020[77]). However, its transformative impact on economic structures has been variously interpreted by trade unions, depending on the country or sector of production as well as on their own approach to the fight against climate change, which has varied according to histories and identities (Clarke and Lipsig-Mummé, 2020).

Alongside the institutional strategy, and not necessarily as an alternative to it, trade unions could resort to mobilising their societal resources, promoting alliances with climate justice movements and rediscovering their social-environmentalist roots in a working class ecology perspective (Barca and Leonardi, 2018 [7], Feltrin and Sacchetto, 2021 [28]). This strategy can be particularly valuable in those cases where grassroots unions are not able to obtain sufficient institutional support, as in the recent case of the GKN factory in Florence, whose mobilisation gained international recognition thanks to the convergence with environmental activists and the elaboration from below of a plan for the ecological reconversion of the plant (Cini et al., 2022)[13]. In both cases, mobilising symbolic power, i.e., the capability to put forwards new ideologies and practices in addressing societal needs and challenges, is proving to be an effective way to regaining lost power for trade unions.

If, in one way or another, collective bargaining and trade unions will play a central role in influencing the twin digital and ecological transitions, it is important to note that their action in this field has great potential to radically alter current industrial relations systems by shifting their power relations. Indeed, the stability of current industrial relations systems is linked to the reproduction of existing negotiation practices, which currently seem to limit the role of workers and trade unions in the processes of technological change. By redefining the actors, the logic of action and the boundaries, both internal and external, of collective bargaining to adapt it to the challenges of the twin transitions, trade unions have a historic opportunity to change the balance of power in the automotive industry and beyond. Conversely, especially with regard to digitisation and electrification, the growing influence of transnational dynamics, linked both to supranational regulation of the automotive market and the competitive logic inherent in automotive value chains, may further challenge the effectiveness of collective bargaining institutions, without necessarily creating new ones, thus continuing the trend of marginalisation of labour and trade unions.

6 Conclusions

Automation and digitalization have a dual effect on employment, observed in the automotive industry as well. The increase in complexity of technological innovations implies a decreasing share of manual work in plants, however it is fostering new skills and occupations in development, installation and maintenance of machineries, robots and software systems. The very same duality defines the employment effects of the decarbonization process. Because of the shift to the production of the electric engine and vehicles, value chain disruptions are expected together with consequent job losses. The manufacturing of BEVs is expected to offset such job losses, together with ICT, engineering and indirect jobs.

However the relation is all but straightforward. Asymmetries across core and peripheral countries, and plants, characterise all the trends at stake: relocation towards low wage countries, proximity to R&D centres, institutional factors as differences in vocational training programs and bargaining coverage are the main sources enhancing such asymmetries.

The direct effects of the above mentioned asymmetries are reflected in the ability to manage and govern the automation, digitalization and decarbonization challenges, especially in limiting massive unemployment and workplace inequalities. To manage the process of transformation brought about new technologies and decarbonization efforts in the automotive industry, we have outlined the importance of different factors at stake, with particular reference to the role exerted by the regulatory push as a non-neutral institutional stratification of rules, and trade unions actions in affecting the end results of such transformations. A framework of mobilization of trade unions actions and social dialogue is spelled out, with reference to three parallel directions of power reconstruction, namely, institutional, societal and symbolic.

Policy proposals pushing an alignment across countries in R&D investments for technological innovation and ensuing programs for vocational training, labour market regulations to increase wages and labour rights, and limitations to relocation of production activities should be addressed by a multi-level social dialogue framework. The social dialogue approach is deeply needed in order to conceive and imagine paths to make the twin transition a just one, addressing the negative distributional effects of climate policies, and reorienting the state interventions from being only supportive of managerial and employers interests, to fostering a new path able to restore and support labour power.

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BARMETAL

Digitalization, Automatization and Decarbonization: Opportunity for Strengthening Collective Bargaining in the Metal Sector

Conceptual and methodologicl toolkit for national analysis

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Co-funded by the European Union

This project has received funding from the European Union's Social Prerogative and Specific Competencies Lines (SOCPL) programme under grant agreement N. 101052331.

Introduction

Automotive and metal industries across EU countries have been under severe pressure in recent years, due to emerging and intensifying automatization, digitalization and decarbonization (DAD) of production. Shifting to the next stage of the BARMETAL project, the aim of WP3 is to analyse how the key challenges related to changing workplaces and working conditions due to digitalization, automatization and decarbonization are addressed in collective bargaining both at the workplace and sector levels across 11 EU Member States and 1 Candidate Country.

The aim of this document is to elaborate a framework for country case studies, guiding the observation of bargaining processes, outcomes, and proposed adaptations in response to technological change. The document covers a) conceptualizing collective bargaining, with emphasis on variety of IR systems in the EU; b) mapping of the main risks and opportunities that DAD poses for work, employment and IR on various levels of social partner operation, b) highlighting additional factors deriving from structure and character of the industry that may have an impact on collective bargaining and finally d) outlining the structure for country policy papers, focusing on the general overview regarding DAD and collective bargaining and the specific situation in the metal sector from the bargaining perspective.

Key starting points

- The BARMETAL project deals with *dual transformation* that is on one hand boosted by automation and digitalization technologies emerging from business interest to increase productivity and competitiveness on the market, but on the other intensified by current decarbonization goals introduced by the EU and affecting both metal and automotive industries across EU Member States (Brown, et al. 2021). Such dual change brings broad implications for labour, namely for employment and labour market, but also for work organisation, working conditions and job quality.
- Technology-related implications vary from country to country (or sector to sector[1]) based on country specific characteristics. In the analysis of collective bargaining processes, there can be substantial variations in terms of whether job loss or job creation dominates, whether the lack of (skilled) labour or other employment developments affect the same countries, regions, sectors, occupations and demographic groups, and whether they take place in parallel or at different points in time, depending on the specific technologies (or combination of them), their operational deployment in the economy and nature and degree of regulation.
- In comparison to regulations, the collective bargaining is a flexible process and thus hold potential to address DAD-related changes on workplace and sectoral level. *Trade unions and managers are gradually playing role in addressing effects of technological change*. According to Eurofound (2021), the effects of technological transformation at company and workplace levels are being addressed step by step through collective bargaining, particularly by implementing risks – mitigating working time and skills measures. The identification of main risks and opportunities on work organisation, employment/labour market and IR in country case studies is thus particularly important in country analysis.

[1] In line with critique of methodological nationalism, some scholars believe that countries and their industrial relations vary across sectors as deeply as they do across countries (see: Bechter et al., 2012)

Furthermore, we highlight *institutional/agential, structural and contextual aspects* that have impact on range and influence of collective bargaining to address changes related to technological transformation, namely bargaining channels and legitimacy of actors to negotiate changes in these channels, as well as external influences deriving from structural organization and character of the (automotive) industry (GPNs, core-periphery & OEM-supplier dynamics). In WP3, the project overlooks the technological change in automotive/metal industry through the lenses of collective bargaining, which emerges on multiple levels of IR, i.e. *macro, meso and micro* (Kochan et al., 1986; Katz, Batt and Keefe, 2003). In order to keep CB-related analysis[2] coherent throughout the whole project, the analytical approach should take into consideration a multi-level governance perspective (Keune and Marginson, 2013). This approach captures the activities of social partners on different levels of decision-making process, while allowing for substantial diversity in IR models, diverse challenges in the same sectors across the EU and responsively diverse preferences of sectoral and company level actors presented in collective bargaining.

[2] In WP 5 the project deals with EU level social dialogue.

Collective bargaining in context of technological change: a conceptualization

In this project, we deal with the company and sectoral dimension of collective bargaining in country case studies (WP3), and bargaining transformations in EU-level social dialogue deriving from automation, digitalisation and decarbonisation (WP5). Based on high variety of countries involved in BARMETAL project regarding the IR system, we acknowledge the diversity of contexts in which collective bargaining operates, focusing on industrial relations systems across EU member states with regards to national diversity and multilevel nature of such system. Such acknowledgement resembles a diversity in actors' structures, institutional resources, practices and culture of dialogue and the legitimacy assigned to collective bargaining and participating actors.

While social dialogue is a term used in Europe to denote all instances of negotiation and wider activities between employers' and workers' representatives, collective bargaining evolves around the specific collective negotiation between employers and workers and their representatives on remuneration and working conditions, for a given sector, company or workplace. We refer to collective bargaining in line with EC as "*the process of negotiation between trade unions and employers regarding the terms and conditions of the employment of employees, and the rights and responsibilities of trade unions; it is a process of rule-making, leading to joint regulation*"[3].

Process of collective bargaining typically results in a bargained agreement. However, the activities can lead to further joint working or even simple exchange of views between employers' and workers' representatives. The conceptual framework guiding country case studies thus distinguishes between **binding and non-binding outcomes of collective bargaining process**. Differentiation between binding and non-binding outcomes can indicate, if not addressed and regulated by agreement, whether and in what ways technological change is penetrating bargaining agendas.

Multilevel system of collective bargaining/Collective bargaining processes

Collective bargaining in the EU Member States takes place in different national and institutional settings[4] that vary in terms of the respective roles of collective bargaining and legislation in regulating the labour market, in the levels at which bargaining is conducted (cross-sectoral, sectoral, company and workplace, regional, occupational), and in the way in which negotiations at different levels may interrelate (articulation). Most EU countries have a multilevel collective bargaining system that is characterised by a hierarchical or functional interaction between the different bargaining levels (Eurofound, 2015). The key aspects of national collective bargaining systems and practices are the degree of centralisation and decentralisation, bargaining coordination/articulation, as well as extension mechanisms.

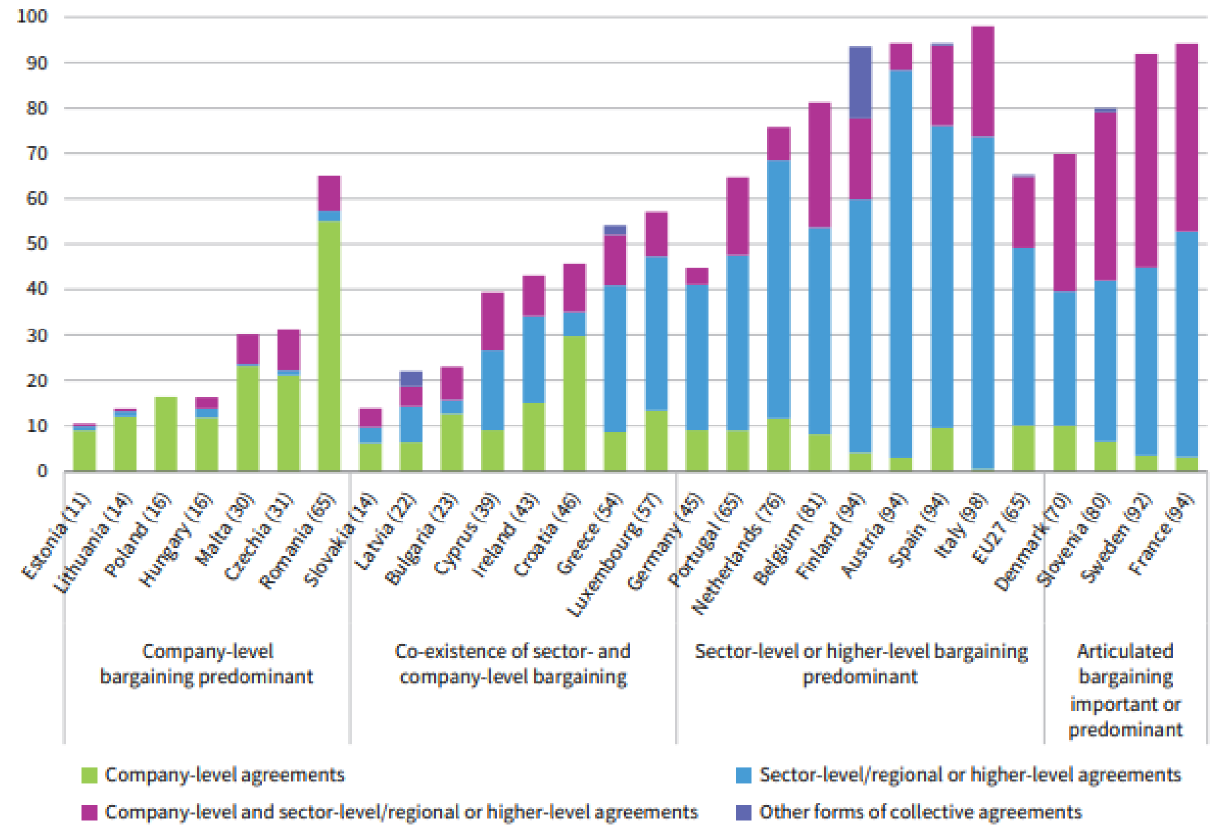
There has been persisting decline in number of employees covered by collective agreements in the EU. According to EC, the collective bargaining coverage, based on the ICTWSS database, fell from an estimated EU average of about 66% in 2000 to around 56% in 2018, with particularly strong declines in Central and Eastern Europe. [5] The reasons for such decline are declining coverage rates and regulatory changes in a number of collective bargaining practices and processes, particularly with regard to the extension of collective agreements, shifting functional hierarchies and the growing importance of company-based bargaining processes.

To assess to what extent collective bargaining processes may be able to address work-related changes in various countries and on various levels, we draw on the existing literature to categorize the EU member states

[3]https://www.eurofound.europa.eu/topic/collective-bargaining
[4]Ibid.
[5]https://www.eurofound.europa.eu/observatories/eurwork/industrial-relations-dictionary/collective-bargaining-coverage

into several clusters according to predominant bargaining level. In line with Eurofound (2022) and 2019 European Company Survey, we distinguish between four clusters of countries, namely those with a) decentralised, predominantly company-based bargaining, b) those in which company- and sector-level bargaining coexist with neither dominating, c) those with predominantly sector-level bargaining and finally d) those in which articulated bargaining (between sector and company levels) is the predominant form and there is also a high degree of sector-level bargaining.

Figure 1: Estimated collective bargaining coverage (%) and predominant level of agreements, EU27, 2019



The project covers bargaining systems in 10 MS (Table below) and one candidate country.

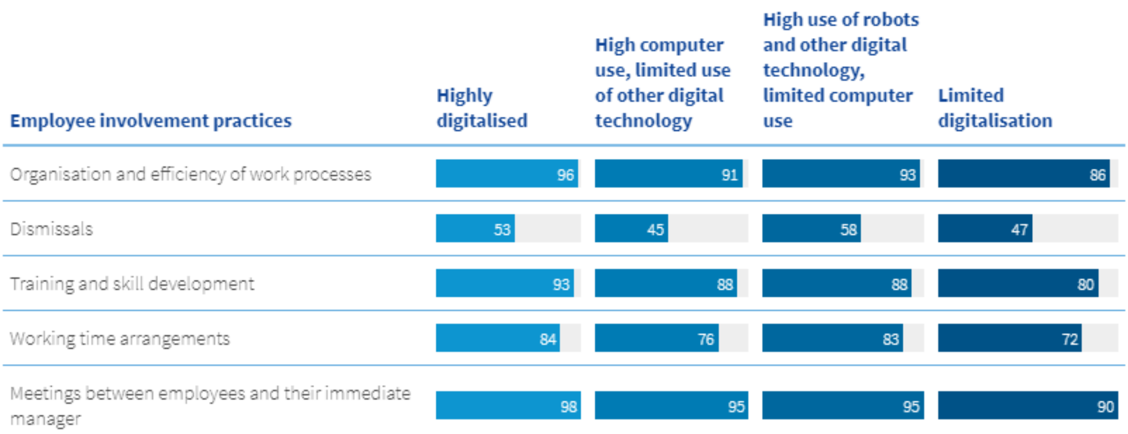
Predominant level of bargaining	**Collective bargaining system**
Company	Poland, Czechia, Hungary, Romania
Co-existence of company and sector levels	Slovakia
Sector or higher level	Germany, Netherlands, Belgium, Italy
Articulated (sector and company levels)	Sweden

Technological change and collective bargaining

Involvement of IR in addressing technological changes comes from the theoretical grounding that transformation does not happen in isolation but it is a process mediated by IR. The relationship between technological change and IR is, however, twofold. DAD bring significant implications for working conditions and thus also for workplace and employment relations. The more disruptive is the technology, the greater impact it has on working conditions, and thus on collective bargaining. But at the same time, industrial relations actors contribute to shaping the deployment of new technologies through addressing the effects of the technological on labour market.

There is already an evidence on industrial relations participation on anticipation and management of the effects of technological change. For instance, in 2020, EU-level social partners (BusinessEurope, ETUC, CEEP and SMEunited) have signed a joint agreement on digitalisation, highlighting need to create specific approach towards transition. Furthermore, social partners have been involved in development of the Industry 4.0 strategy on the national level, such as in Austria, Germany, Italy, Sweden and several other EU Member States. While tendencies aimed at navigating the digital transition through joint statements and social dialogue are present, the effects of technological change are still only slowly penetrating collective bargaining agendas. Following the accounts reported by Eurofound, (2021), when the effects of technological transformation at company and workplace levels are being addressed through collective bargaining,

Figure 3: Employee involvement in management decisions by digitalisation intensity of establishments, EU27 and the UK, 2019 (%)



Source: ECS 2019 management questionnaire

implementing risks-mitigating working time and skills measures seem to be priority on negotiating agenda. Depending on how digitalized is the company, the involvement of employees and their representatives in management decisions vary (Figure above). There is a slightly higher share of managers in highly digitalised establishments than involve staff in the decisions. The highest differences are in area of training and skills development and working time arrangements (more than 10 %).

In the automotive sector, the impacts of automation have led to adaptations to work organisation, working time (shifts), employment (apprenticeships), skills programmes and working conditions (health and safety) in some workplaces. In terms of managing the effects of automation, among the leaders are carmakers in Germany such as Daimler, Volkswagen, BMW, Audi and Bosch, and automotive parts manufacturers such as Continental, which have introduced ambitious remote working programmes for hundreds of thousands of employees (in which, for instance, robots can be managed remotely). Similarly, SAP's 22,000 employees in Germany have been granted the right to work wherever they want in the country.

Mapping potential responses in collective bargaining

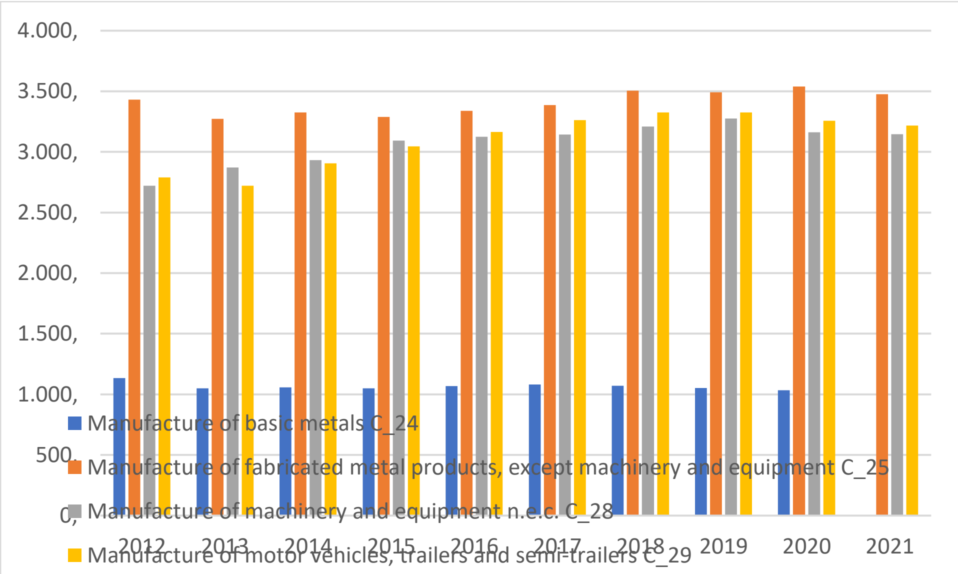
Categorisation of challenges driven by DAD is difficult as the effects vary from workplace to workplace. Each type of change (digitalisation, automation and decarbonization) is specific in nature and has diverse implications for workers across sectors and countries. Thus, available evidence is often also inconclusive; for instance the labour-replacing effects of automation may be considerable (McKinsey, 2017), and only partly compensated by positive macroeconomic effects arising from more efficient use of technology and, as a consequence, from stronger demand for new products, services, and labour (Arntz et al., 2016).

In line with Eurofound (2021) we categories challenges deriving from DAD related to *macro aspects of employment* (for example new occupational needs) and the *micro aspects* (for example, related to work organisation, working conditions or job quality). There correlate with areas of IR actions and channels of intervention. While the employment-related themes refer to discussions on industrial policies, labour market reforms, skills policies, social protection and pensions, and tax reforms. The latter concerns the reorganisation of work, the impact on jobs and working conditions, labour and social costs resulting from restructuring at company level, and the negotiation of productivity gains, if these occur.

Levels	Sphere of action	Main areas of issues	Forms of IR intervention
Macro-level	(Trans-)national / political / macro-societal	Public policies; definition & administration of state-enforced rules governing ER (eg labour law, minimum wage)	Social dialogue / concertation; lobbying; campaigning; contestation (e.g. general strikes)
Meso-level	Sectoral / industry level	Pay levels & pay increases for different professional / skills profiles; common ground rules for competition & work organisation within a sector	Sectoral collective bargaining; campaigning; recruitment; contestation (e.g. sector-wide strikes)
Micro-level	Workplace / firm or local / territorial level	Work organisation, working time, control / autonomy, internal labour markets / promotions, remuneration, bonuses / benefits…	Firm-level bargaining or work councils; recruitment/organising; contestation / strikes; informal resistance

The responses of industrial relations actors at the macro level may stem from the general challenges that technological change brings for employment and labour market. The automotive industry employs a high share of workers across Europe, around ten millions among direct (2 millions) and indirect (8 millions) workers (Gaddi and Garbellini, 2021). The highest share of jobs in the automotive sector with respect to employment in the manufacturing sector is in Slovakia, where in 2020 more than 15% of jobs in manufacturing were in the manufacture of vehicles, trailers and semi-trailers. Sweden has employed a share between 10 and 14 % between 2005 and 2020, while Germany around 10% and 12%, the share for Spain is similar to the European average close to 7.5%, while for Italy is below 5%. Moreover, the statistics refer to direct jobs without counting on number of "hidden" employees working in dense supplier hubs.

Figure 1 Employment in selected sectors, EU27, (1000)



Source: Authors' compilation based on Eurostat data, LFSA_EGAN22D.

Existing evidence shows that countries specializing in manufacturing are particularly vulnerable to the job challenge caused by new technology (ETUI contributors, 2020). The biggest thread is that workers exposed to a routine task that can be highly automated could be replaced by new technology. Moreover, the higher productivity achieved through automation and digitalisation is likely to generate demand for untraditional skills profiles, particularly in labour in non-automated tasks (Pfeiffer et al. 2016). New technologies might widen the gaps between low and high skill tasks leading to skill polarization[6]. The detriment of middle skilled jobs might therefore lead to challenges in wage as well as retraining policies (Goos et al. 2014). These macro effects could affect prevailing employment forms on the country labour market, which could push for further action by trade unions addressing the gaps in social protection and welfare systems. In this regard, the current most salient political issue for actors of industrial relation is the governance of job-related effects of industry 4.0 (Gaspari and Tassinari, 2020) including the secondary effects in the area of social protection.

- Plus new forms of work contracts , especially after covid- smart working etc.

[6] https://www.adb.org/sites/default/files/publication/623036/covid-19-technology-polarizing-jobs.pdf

Meso level

At the sectoral level social partners of automotive IR are exposed to the ever-growing restructuring pressure due to new technologies (1)[7]. Including the highly exposed manufacturing, various sectors face the need to adapt to the new challenges imposed by international competition due to transformation. The new technologies as well as e-mobility affect the workplaces too, giving rise to resturturalization pressures. As a result, flexible, atypical and unstable (precarious) job vacancies may be re-introduced as a consistent feature of industries affected by digitalization (Gumbrell-McCormick, 2011; EUTI, [8]).

The challenges that industrial relations face, are therefore aligned with the sectoral reconfiguration. As mentioned by Gaspari and Tassinari (2020) the literature elaborating highly digitalized sectors in 1990s and early 2000s had shed light on the role of institutions, and particularly the erosion of institutions of collective bargaining, in determining potential and constrains for actors in industrial relations. The effects that digitalization represents therefore puts restrictions on trade union actions in ensuring the uniformity of working conditions across the sectors (Visser, 2019). The main challenge ahead is for actors to use existing institutional structures (particularly the sectoral collective bargaining channel) at their disposal to manage the reconfiguration changes connected to diverging standards due to new working conditions, job polarisation overall fragmentation of the employment regime.

Micro level

At the micro level, apart from number of jobs, the impact of new technologies might modify work content leading to either deskilling or upskilling effect (Bonekamp and Sure 2015). Destructing the work of complex tasks into simple steps on one hand leads to facilitation of a work performed, but also lowers the skills level requirements for workers. On the other hand, new technologically-fostered production techniques can lead to an increasing task complexity resulting in upskilling of workers. The general logic behind this organization process is that the more difficult and complex tasks will be performed by workers while new technologies as for instance industrial robots will handle repetitive or physically difficult tasks (Kergroach, 2017; ETUI contributors, 2020). Several authors suggest that so-called multitasking and the related requirements for better educated workers are an inevitable part of the technological revolution (Bonekamp and Sure 2015; Porter and Heppelmann 2014). On the other hand, workers' upskilling requires comprehensive retraining policies which are usually always provided in the workplace.

Moreover, various studies highlight that the novel management in work-organization processes contribute to increased levels of stress of employees. The claim is that so-called 'algorithmic management' methods lead to more standardization of work practices with less worker autonomy and control (Moore et al., 2017). For instance, as recognised by Crouch (2018) with digitalization, the threat of increased control within the labour process through the implementation of sensors, chips or wearables – various devices attached to one's clothing or body, serving to monitor movements and improve performance is higher, which contribute to losses in workers' autonomy and an increase in the level of control to which they are subject to. In this regard, trade unionist at the workplace might find themselves in difficult interactions towards management practices in securing the decent working conditions due to changed job opportunities but possibility also of modified job intensity and content (Bonekamp and Sure, 2015).

[7] https://www.etui.org/publications/books/employment-relations-in-an-era-of-change
[8] https://pmb.cereq.fr/doc_num.php?explnum_id=3681

Underlying factors behind social partners responses

In comparison to statutory regulation, the flexibility of collective bargaining allows trade unions and managers to be proactive in facing the challenges stemming from the dual (green and digital) transformation (Eurofound, 2022). However, the extent to which it is able to adapt to these challenges relates to the priorities of the negotiating agenda and to the structural and contextual factors affecting capacity to innovate. We elaborate additional factors to be taken into account in country case analysis, focusing on structural factors related to the industry´s structure, policy factors related to the EU level policy making related to the decarbonization and regional level factors which actually determine how the transformation is addressed at the ground.

Structural Factors

As first we highlight *hierarchical nature of automotive sector* and particularly, position of studied companies within it. Such uneven relation can mirror the course and result of collective bargaining. The automotive industry in Europe is characterized by hierarchical structure in which multinational corporations (MNCs) play a major role. Final producers develop final products, assemble vehicles and organise supplier relations in the production network. Moreover, these carmakers now rely on a relatively small number of large supplier firms that dominate tier one supply operations and with which they have thus forged close relationships based on interdependence. They share some research and development functions and are closely interlinked through the just-in-time, lean production model. In this regard, the new technology facilitates horizontal integration along the value chain, allowing OEMs, or upper-tier operators, to monitor and directly control production processes in supplier firms to the level of the specific tasks conducted by individual workers (Gaddi, 2021). Such superiority of OEMs in OEM-supplier dynamics might have significant effects on collective bargaining agenda in lower tier production sites.

EU level policies

The role of national, European and international regulations which speed up or hamper the transition
To fight climate change, in 2021, the European Commission released its "Fit for 55" legislation package, which contains important guidelines for the future of the automotive industry according to which all new cars sold in the EU must be zero-emission vehicles from 2035.

Despite the fact that the proactive participation and the importance of the involvement of social partners (Garvey et al., 2022) are emphasized in connection with the green transformation in the EU, the process as such often takes the form of political measures introduced from above, which can even deepen the work and employment effects in various regions (Sovacool et al., 2021).

The EU level policy making became an arena of contested interests of national and EU level stakeholders as the decarbonization efforts will impact workplaces in several EU countries. Social partners at the EU level have different positions when it comes to the limits imposed on the automotive industry. Social partners advocate for the preservation of the workplaces and at the same time realizing the acute need to decarbonize. The impacts of the EU level policies on the industry and company level realities creates social partners responses which is worth to explore in the project. The report will address the following questions:

What is the impacts of social partners at the EU level on the policy regulation? How the agenda is articulated from the national to the EU level? What discussions are there within trade union and employers organizations and how is this transferred to their agenda? What are the national social partners responses to the EU level policies? What are their actions?

Fair green transformation in the EU is usually understood in connection with territorial industrial impact of climate policies, i.e. of regions economically dependent on coal mining and processing. Others, often more important sectors for the economy, such as e.g. automotive industry are left out from the policies (Galgoczi, 2019). Various instruments, such as the EU cohesion policy offers support for the regions lagging behind, but now the transition in the automotive industry is affecting many of the richest regions, take for example Barcelona, the north of Italy, of Germany´s Bavaria which are very important areas for the automotive sector and there mights be a lack of recourse for these regions.

Regional dimension

Regional dimension may arise as an important factor in country analysis as collective bargaining/social dialogue processes may concentrate in companies located in regions eligible to national and EU funds allocated for green transition, such as Just Transition Fund. On one hand, available resources may speed up restructuring and implementation of new technologies in certain companies located in affected regions, but on the other, open doors for more generous and thorough collective bargaining.

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