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Abstract

The automotive industry in the European Union (EU) and Germany faces major challenges including decarbonisation, digitalisation and global competition. While the automotive industry has a significant economic role in terms of income and employment, it has immense ecological damages. The green and digital transition make certain occupations redundant, causing job losses, while it generates new occupations in new economic activities. These put the industry in the center of socio-ecological transformation debate in Germany and the EU. The vertical industrial policy with a focus on energy and technology-intensive areas has become important in the EU and Germany due to these challenges. The industrial policy in the EU and Germany follows an ecological modernisation approach with a "sustainable competitiveness" motto, whereby electromobility transformation is perceived as the ultimate route on the way to decarbonisation, digitalisation and global competitiveness. Alternative approaches see this differently. The democratic conversion approach and the degrowth approach, while having differences, both perceive electromobility as only one part of a comprehensive mobility system transformation needed; they view a decline in private automobility and a more democratic transformation with labour and environmental stakeholders as essential in the face of climate crisis.

Key words: Automotive industry, electromobility, climate crisis, industrial policy, Germany, European Union

JEL codes: L50, L62, Q50

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1. Introduction

Today three major challenges of the automotive industry[1] in the European Union (EU) are labeled as decarbonisation, digitalisation and global competition (European Commission (EC) 2021a). The remedies of these challenges are not necessarily compatible. Eco-friendly technological advancements may not necessarily be green enough to mitigate the climate crisis, while radical climate measures may obstruct new technologies. Due to the automotive industry's key economic role historically and currently, "Germany was and is a car-country"[2] (Blöcker 2015: 534). The German automotive industry is also crucial for the EU economy (Table 1). Yet, the industry's "golden decade" ended shortly before the Covid-19 pandemic, as shown by the global sales drop and challenges of electromobility transformation. The ecological effects of the industry and the question of labour in the face of transformation are further big issues. According to BMWK (2019a), between 130 thousand to 300 thousand jobs out of 920 thousand direct manufacturing jobs in 2017 are expected to be lost in the German automotive industry by 2040. These economic, social and ecological challenges place the automotive industry in the center of socio-ecological transformation debate in the EU and Germany.

Climate targets are the biggest force pushing the automotive industry towards electromobility transformation today (Brunnengräber/Haas 2020). Automotive industry and road transport cause significant ecological damage due to greenhouse gas (GHG) emissions, raw materials extraction and consumption of non-renewable resources, water pollution and land use (Böhm et al. 2006). As companies must maintain their competitiveness in the face of climate targets, transformation to electromobility is generally perceived as the climate-friendly solution. However, road transport in the EU has so far failed in decreasing GHG emissions relative to 1990 levels (EEA 2022). This failure can be partly attributed to rebound effects[3] (Haas 2021).

Nevertheless, the climate crisis induces not only changes in legal frameworks, but also influences consumer preferences away from private cars and towards more eco-friendly alternative mobility

[1] The automotive industry consists of manufacturing and non-manufacturing activities, whereby manufacturing is categorized in two: direct and indirect manufacturing. The direct manufacturing consists of manufacturing of motor vehicles, manufacturing of bodies (coachwork), trailers and semi-trailers and manufacturing of parts and accessories. The indirect manufacturing consists of manufacturing of various items including rubber tyres and tubes, retreading and rebuilding of rubber tyres, computers and peripheral equipment, electric motors, generators and transformers, bearings, gears, gearing and driving elements, cooling and ventilation equipment. The non-manufacturing categories are related to automobile use (sale of motor vehicles, maintenance and repair of motor vehicles, etc.), transport (other passenger land transport and freight transport by road) and construction (roads and motorways, bridges and tunnels) (acea 2022).

[2] Original: "Deutschland war und ist ein Autoland" (Blöcker 2015: 534).

[3] Rebound effect of efficiency in this context can result in, for instance, when fuel use of cars pro-kilometer decreases due to technological advancements, but then more kilometers are driven due to lower pro-kilometer fuel costs. As a result, emission reductions via efficiency gains would be neutralized or even counteracted.

options like car-sharing, car-pooling, e-bikes and e-scooters. This shift in consumer preferences must be considered as another driver of transformation (Haas 2021).

A third driver is digitalisation which implies increasing use of software technologies in automobile production but also new and alternative forms of mobility such as autonomous driving, car sharing applications, etc. (Brunnengräber/Haas 2020; Urry 2004). Digitalisation, electromobility transformation and shifting consumer preferences bring increased competition and challenges - especially for small and medium-sized enterprises (SMEs) - as new companies focused on electromobility and artificial intelligence (AI) competencies are entering the industry. New mobility concepts require new services, therefore new service providers are entering the market (BMWK 2020; Haas 2021). This puts a significant competitive pressure on traditional car manufacturers and their suppliers, whose competitiveness has been dependent on the combustion engine.

A fourth driver is urbanisation and urban congestion (see Haas 2021; Brunnengräber/Haas 2020; Böhm et al. 2006). The urban population is expected to increase relative to the rural population in the upcoming decades. Automotive industry growth, and the production growth of larger cars with larger engines, like sport utility vehicles (SUVs) (see for Germany, KBA 2023) corresponds to more urban congestion and pollution. This pushes the mobility system towards more intermodal and shared mobility options.

Other notable drivers of transformation discussed in the literature are state austerity, oil dependency and geopolitical conflicts as well as normalisation of the death toll by car accidents. With the growth of the automotive industry, infrastructure expands with new highways, roads and parking spaces. State austerity can be a challenge for the maintenance and modernisation of this infrastructure expansion (Haas 2021). Another driver is the fossil fuel dependency of the internal combustion engine cars, which exposes the industry to oil price fluctuations and geopolitical conflicts (Böhm et al. 2006; Urry 2004). However, transformation to electromobility is no solution to raw materials dependency as it also requires extraction of raw materials, especially some rare earths, and new technologies would require new types of raw materials, which is a factor of environmental degradation, but also a strategic tool for countries to gain dominance in world market of mobility technologies (Brunnengräber/Haas 2020). China, for example, is a major source of rare earths and therefore has a major economic influence on the global electroauto market. Lastly, the normalisation of death toll from car accidents, a long-lasting issue, is an important reason for change in today's automobility (Böhm et al. 2006).

The purpose of this paper is to critically evaluate the industrial policy for transformation in the automotive industry in the EU and Germany. The paper elaborates on the key characteristics of the German automotive industry in the next section. The third section introduces the debate on

transformation conceptually. The fourth section presents the industrial policy for the automotive industry in the EU and Germany, by the top-down instruments and the bottom-up initiatives aiming at shaping the industry. A discussion of critical points follows and the last section concludes.

2. Key characteristics of the German automotive industry

With the recovery after World War II and acceleration of economic growth, the German automotive industry gained momentum with increased production and expansion of road infrastructure, while fiscal policies supported this development (Haas 2020). The automotive industry is the pivotal industry for Germany because of its large contribution to gross domestic product (GDP), employment, tax revenues for the state, research and innovation, global market share as well as its connectedness to other industries including the metal, rubber and plastic industries, manufacturing of electric equipment, machinery, information and communication technology, textiles and construction, mobility-related services, among others. The German automotive industry follows a "high-road-model" meaning a good social dialogue, high value-added processes and products in global competition, highly skilled workforce and a focus on qualifications (Blöcker 2015: 534). The industry is integrated in the global value chains (GVCs) in two ways: a "globalisation strategy" of producing lower-price cars overseas with large markets and/or low costs, particularly in the United States (US) and China; and a "premium strategy" of keeping the premium, higher-price, higher-profit car manufacturing in Germany (Puls/Fritsch 2020). In fact, due to the semiconductor shortage during the Covid-19 pandemic, car manufacturers in Germany and other countries, like Toyota, Volkswagen, Mercedes-Benz, BMW and Tesla gave priority to this premium segment, enabling their record high profitability (Industrie.de 2022). This shows that the Covid-19 pandemic did not hamper the high profits of the big car manufacturers; on the contrary, it allowed them to generate vast profits.

After China[4], Europe[5] has the second largest share of vehicle production in units with 20.5% of total production in the world as of 2021 (acea 2022: 17) (Table 1). Germany has by far the largest share of vehicle production in units (cars, vans, trucks, busses) in the EU with its share of 27% as of 2021 (acea 2022: 23). Since the mid-2000s Europe's share in world vehicle production has been decreasing and China's rising significantly. Germany's share in the EU vehicle production has also decreased in the same period, which also indicates Germany's declining share in world vehicle production.

The automotive industry enterprises and employment are concentrated in West and South-West Germany. The largest number of enterprises are located in Baden-Württemberg and Bavaria, followed

[4] Including Hong Kong and Taiwan
[5] Including Turkey and CIS countries

by North Rhine-Westphalia, Lower Saxony and Saxony, but there are also a number of them in Thuringia, Hesse, Rhineland-Palatinate and a few in other German states. Correspondingly, Baden-Württemberg and Bavaria have the highest automotive industry employment, followed by Lower Saxony, North Rhine-Westphalia and Hesse (Schäfer 2020).

The Covid-19 pandemic in 2020 was a big shock to the industry due to declining sales, while supply shortages brought a halt to some car factories. Car production in units dropped by 17.1% in the world and 23.5% in the EU in 2020 (acea 2022: 19, 25). Production of German automobile manufacturers across the world dropped by 16.9%, domestic production being more significantly affected than the production abroad and their total sales (foreign and domestic) in terms of million Euros decreased by 13.3% from 2019 to 2020 (VDA 2022). Germany's export of passenger cars decreased by 24% from 2019 to 2020 (VDA 2022). However, the reduction of sales of German manufacturers across the world during the Covid-19 crisis was lesser than many of its competitors in Europe, such as French, Italian, Spanish and British manufacturers. This was attributed to the strategic integration of the German industry to GVCs (globalisation strategy and premium strategy) (Puls/Fritsch 2020).

The decade after the 2008-2009 global financial crisis was labeled a "golden decade" for the German automotive industry due to industrial growth and large profits of enterprises (Puls/Fritsch 2020: 5; Krpata 2021: 16). The share of manufacturing of motor vehicles and motors vehicle parts (direct manufacturing) in GDP increased from around 3.2% in 2008 to 4.5% of GDP in 2018 (Eurostat 2022a). Nevertheless, the industry had begun to be strongly confronted by the green and digital transition, the so-called twin transition, shortly before the Covid-19 pandemic. Two trends put an end to the golden decade and initiated an industrial downturn: the shrinkage of automobile sales in the global market particularly in China and the challenges of technological transformation, particularly for the small-and medium sized suppliers which are highly specialized in internal combustion engine components (Puls/Fritsch 2020).

The automotive industry is also highly significant due to its employment share. In 2019, the total automotive industry employment in the EU including manufacturing and non-manufacturing activities was 12.7 million people (6.6% of EU total employment). Direct and indirect automotive manufacturing employment was 3.5 million people (11.5% of EU total manufacturing employment), and the direct automotive manufacturing employment was around 2.6 million people (8.5% of EU total manufacturing employment) (acea 2022: 13). In Germany, from 2008 to 2018, employment in direct automotive manufacturing increased by 15.2% (Eurostat 2022b). Direct manufacturing employment of the automotive industry was 919,002 people in 2018, referring to 11.3% of total manufacturing employment, which decreased to 916,159 people in 2019, referring to 11.1% of total manufacturing employment in Germany (Eurostat 2022b; acea 2022: 14). Employment in direct

manufacturing was hit hard by the Covid-19 crisis in Germany, significantly decreasing in 2020 to 896,210 people, by 19,949 people (Eurostat 2022).

Table 1: German automotive industry

	2008	**2018**	**Latest available**
Share of direct automotive manufacturing value added in GDP, Germany, %	3.2	4.5	3.8 (2020, p)
Share of direct automotive manufacturing value added in manufacturing total, Germany, %	12.9	16.7	16.3 (2019)
Share of direct automotive manufacturing employment in manufacturing total, Germany, %	11.2	11.3	11.4 (2020, p)
Direct automotive manufacturing, persons employed, Germany	797,871	919,002	896,209 (2020, p)
Germany‘s share in EU motor vehicle production in units, %	34.2 (2009)	29.4	27 (2021)
Germany‘s share in EU direct automotive manufacturing employment, %	33	33.7	n.a.
Share of Europe[1] in world motor vehicle production in units, %	31 (China[2]: 14)	23 (China[2]: 29)	20.5 (2021) (China[2]: 32)

[1] Includes Turkey and CIS countries
[2] Includes Hong Kong and Taiwan
p: provisional
Source: Eurostat (2022a; 2022b); acea (2010, 2019, 2022); own calculations

While the economic significance of the automotive industry is big for the EU and Germany, the industry generates immense ecological damages. The subject of energy transition dates back to the 1980s in Germany, yet the twin transition is relatively new (Haas 2020). The Dieselgate scandal in September 2015 revealed the fraud of huge discrepancy between the emission test results and real-world emissions of the Volkswagen Group diesel engine cars in the US, and later in other models like Audi, Seat and Skoda. The environmental and consumer protection movements reacted strongly and the scandal raised more awareness about the environmental degradation caused by the automotive industry. This led to new regulations like restrictions on highly polluting cars in certain cities or new emission testing procedures along with hundreds of lawsuits against the car companies (Müller 2021).

The general transport sector constitutes 25% of all GHG emissions in the EU (EEA 2022: 240). Out of this, the share of road transport is by far the largest with 71% (European Council 2022a). Passenger cars contribute 12% of all CO2 emissions in the EU (EC 2022a). In fact, road transport is marked as one of the two source categories of GHG emissions in the EU - the other one is refrigeration and air

conditioning - whose 2020 emissions increased relative to 1990 levels (EEA 2022). Between 1990 and 2020, the CO2 emissions from road transport increased by 7% in the EU, with Germany, France, Italy, Spain and the United Kingdom contributing 62.3% of all road transport emissions (EEA 2022: 240). Industrial policy for the automotive industry has always been important for Germany since the 1970s, yet it needs to be reconsidered, what kind of industrial policy is needed to face these ecological, economic and social challenges (Blöcker 2015).

3. Transformation approaches

For the context of the US (Reese 2016) and Germany (Haas 2020) alternative scenarios for the future of mobility are projected as follows: 1) The technological progress scenario: persisting private car dominance in everyday life, but with less emissions thanks to technical advances in auto-engineering, like electromobility, 2) Moderation scenario: reduced private automobility combined with intermodal mobility, more livable, designed green urban spaces and less traffic, 3) A radical transformation scenario: a catastrophic climate change is understood as inevitable without radically altering the consumption and production patterns of today; private automobility is largely doomed to fade and alternative mobility options are to become the common practice. In the face of energy scarcity and an accelerating climate crisis, this third scenario involves scaling down transport infrastructure and socialisation of the transport system.

The conceptual backgrounds regarding these alternative scenarios above can be categorized as follows: The first scenario is rooted in the ecological modernisation approach, while the second one, with its moderate measures, can be associated with the democratic conversion approach. The third scenario, by its radical turn from today's car dominance, is closely associated with the degrowth approach (Table 2).

Table 2: Automotive industry transformation approaches

Ecological modernisation	Democratic conversion	Degrowth
- Primacy: growth, competitiveness - Internalisation of externalities, i.e. emissions trading system; efficiency; techno-fix, i.e. electomobility with remaining dominance of private automobility - Renewable energies - Industrial policy: Climate targets, research and innovation funding, incentives for electroautos, industrial alliances - Just Transition - Political program in practice: EU Green Deal	- Primacy: democracy at workplace - Internalisation of externalities - Techno-fix, i.e. electromobility but reduced private automobility - Renewable energies - Industrial policy: Climate targets, mobility as a service, conversion to socially and ecologically meaningful products - Just Transition with labour-nature alliance; extensive codetermination - Political program in practice: no	- Primacy: climate crisis - Absolute reduction of emissions - Minimized or phased-out private automobility; convivial forms of e-mobility - Renewable energies - Industrial policy: Explicit measures to phase out of unsustainable practices, scaling down of production, transport and infrastructure - Labour-nature alliance; massive redistribution; social policy measures - Political program in practice: no

Source: Own depiction based on the literature

3.1. Ecological modernisation approach

The 2008 economic crisis along with the ever-deepening climate crisis gave a momentum to a shift away from business-as-usual growth strategies and replaced them with the green growth discourse in the EU (European Green Deal), in the US (Green New Deal program), by the United Nations Environment Programme and in many other advanced economies (Mastini et al. 2021). Green growth discourse perceives economic growth as a precondition for increasing human well-being. It is a selective growth approach which stands for a shift to environmentally friendly technologies, production methods and strategies to cope with the climate crisis and sustain economic growth. It is discussed under alternative names including “ecological transition”, “green transition”, “technological fix” or “ecological modernisation” (EC 2019a; Felli 2014; Mastini et al. 2021).

For the ecological modernisation approach, anthropogenic environmental degradation is an “externality” to be internalized, such as by carbon taxes or carbon pricing. Resource efficiency by technological advancements, a gradual shift from fossil fuel to renewable energy resources, shift to low-emission products as well as circular economy and experimental technologies to absorb GHG emissions from the atmosphere are at the center of the climate strategy. A green industrial policy with carbon taxes, emissions trading system and subsidies for renewable energies and electromobility transformation, emission targets and carrot-and-stick mechanisms are recommended for enabling a green growth strategy (Rodrik 2014; EC 2019a). In this regard, this approach does not fundamentally

differ from any industrial policy approach aimed at developing infant industries and new technologies.

In the context of the automotive industry, electromobility is central. When emissions in terms of the entire life cycle of a car are considered, from the manufacturing supply chain of the vehicle to its use, both battery electric vehicles and internal combustion engine vehicles have almost the same amount of CO2-eq emissions per vehicle during the manufacturing phase, but the use-phase makes the difference. The combustion engine vehicles emit over 40 tCO2-eq per vehicle during lifetime, while the electroautos generate emissions of around 20 tCO2-eq per vehicle related to manufacturing, batteries and minerals, batteries assembly and electricity use in its lifetime (Greenpeace 2021: 9). Green industrial policy for the automotive industry implies funding for research and innovation as well as subsidies for electromobility transformation of companies, transfers to consumers for e-auto consumption, carbon emission targets and regulations, quotas for minimum biofuel, new vehicle taxes, etc.

As an example, a study on behalf of the Federal Ministry for Economic Affairs and Climate Action in Germany recommends the following actions for the automotive industry transformation (BMWK 2019a). First, battery loading infrastructure should be built and various technologies of electromobility must be supported. Innovations should be facilitated by "Reallabore" where they can be tested. Requalifications and new competences in the labour market must be supported, such as for battery technologies or the use of AI. Support for SMEs and start-ups is crucial as they have lesser financial capabilities for innovation.

The ecological modernisation approach for the automotive industry transformation does not involve a radical change in production and consumption patterns, rather techno-fixation and eco-friendly consumption practices are believed to be the remedies to deal with the climate crisis. Ecological modernisation is also considered as a “reindustrialisation” as the green transition requires new types of economic activities and new skills. It is expected to create jobs. However, significant job losses are also inevitable as certain occupations and skills will become idle. Transformation to electromobility and changing mobility preferences of households, are argued to cause multidimensional employment effects (see for these BMWK 2019a; IG Metall 2021). First, as a direct effect, the transformation to electromobility and new mobility concepts (will) lead to job losses as transformation means new production processes and require new qualifications. Second, changing the global competitiveness of the German automotive industry - as it primarily relies on internal combustion engine cars - may lead to job losses. Third, new mobility concepts like car sharing or autonomous driving may also exacerbate negative employment effects in the transport sector. Yet, the demographic changes in Germany with the decreasing labour force participation and positive

employment effects of new technologies like battery production and infrastructure investments for electromobility, like charging stations, would partly counteract job losses.

3.2. Democratic conversion approach

The central focus of the democratic conversion view[6] is industrial conversion by questioning "what, for whom and how" to produce, with workers' democratic participation in the workplace a central concern and area for improvement (Röttger 2010; Urban 2018; Blöcker 2021; Pichler et al. 2021a). Economic growth and competitiveness are not the most important goals of this view, although the labour movement has traditionally had an industrial growth and competitiveness orientation to increase employment and wages. In this view, private car hegemony should be reduced and the industry should be converted to socially and ecologically meaningful alternative products, which is also considered as a solution to prevent job losses in the twin transition (Röttger 2010; Henriksson 2015). In this regard, the moderate transformation scenario of the automotive industry described above can be associated with the democratic conversion view due to its support for reduced private cars and new products, intermodal mobility, mobility as a service and more democratic use of public space.

In a democratic conversion, the automotive industry transformation is understood as a comprehensive mobility system change, rather than just a drive system techno-fixation, with more stakeholder participation including labour and environmental movements (Blöcker 2021: 143; Pichler et al. 2021a). Transformation to electromobility and alternative fuels are not the ultimate solutions. Electromobility requires electricity which is mainly generated by fossil fuels today and battery production is not emission-free. Biofuels and agro fuels require land use and do not generate sufficient energy for compensating fossil fuels (Henriksson 2015). The technology of electromobility also requires extraction of rare earths which causes land and water pollution as well as iron and steel inputs just as conventional autos, which are among the most polluting industries (Greenpeace 2021). Electromobility would still use a great amount of land for road infrastructure, loading stations and parking, which has adverse ecological effects and is controversial in terms of democratic public space use.

The democratic conversion view perceives electromobility not as the ultimate solution, rather just a part of a comprehensive mobility system change. It suggests that mobility must become a service via public transport, public shuttle and public taxi services, car sharing and car-pooling, etc. Reduction in passenger car production, expansion of railways and e-bus production and their components, expansion of public transport and its accessibility, cycling and walking routes, replacement of

[6] "Demokratische Form der Konversion" (Blöcker 2021: 143).

automobile production by new products are among many proposals in this approach (Blöcker 2021). New products can be, for instance, renewable energy equipment, trams, trains, other vehicles and equipment for a sustainable transport system and household use (Henriksson 2015; Blöcker 2021). The automotive industry is argued to be highly flexible for conversion to new products and processes as production engineering, design, quality control, and workers' skills are continuously updated (Henriksson 2015). A quick conversion of the automotive industry to produce military equipment during World War II in the US and Britain are examples. In the post-war labour movement history, there are also examples of worker participation in industrial conversion plans in the UK (Lucas Aerospace Plan) and Germany (Arbeitskreise Alternative Produktion) (Röttger 2010).

3.3. Degrowth approach

For the degrowth approach, ecological modernisation is an insufficient or even a counterproductive approach to deal with the climate crisis, due to the rebound effects of economic growth. The degrowth approach rather suggests industrial downscaling and shares many commonalities with the democratic conversion approach, yet it perceives a more radical turn from today's mobility system.

The degrowth approach is an interdisciplinary critique of the economic growth imperative - first argued by the Club of Rome in 1972 - fed by ecology, economics, sociology, political science and anthropology (Demaria et al. 2013). Degrowth is a social movement as well as an emerging social science field suggesting voluntary downscaling of resource use and ultimately reduction of output coupled with economic and social reorganisation to tackle the climate emergency, environmental degradation as well as social inequalities (Demaria et al. 2013). This alternative is mainly discussed for the context of advanced industrialized countries. It is based on the perception that a complete decoupling of resource use and economic growth is not possible with today's technology and circular economy, thus a voluntary downscaling of resource use and ultimately output is the only way to tackle the climate crisis. This should be complemented with extensive redistribution policies, reorganisation of production and social organisation.

For the automotive industry, the degrowth approach opposes the expansion of transport infrastructure in general and opposes private motorized mobility in particular due to its high social and environmental costs relative to private benefits. Among the motorized mobility options, shared /pooled mobility options and public transport are relatively preferable; convivial mobility options such as (e-)bikes and (e-)scooters are most desirable (Cattaneo et al. 2022). Pichler et al. (2021b) argue for a transformative industrial policy for the automotive industry along the following lines: it should aim beyond growth and competitiveness; at absolute reduction of maximum emissions (rather than pro-car emission targets), the phase-out of certain unsustainable practices by explicit instruments, employment protection, for example via work time reduction (see also Dörre et al. 2020)

or job guarantees. The transformation must also be democratic by participation of relevant stakeholders like environmental and labour movements. Nevertheless, the power and willingness of a state to become such an "environmental state", prioritizing the climate crisis against economic gains is controversial in the literature (Duit et al. 2016; Koch 2020).

4. Industrial policy for the automotive industry in the EU and Germany

Among the conceptual approaches discussed above, the industrial policy for the automotive industry in the EU and Germany is clearly rooted in the ecological modernisation approach. This is shown by the four facets of industrial policy below: climate regulations, budgetary programs, stakeholder coordination and bottom-up initiatives.

4.1. Climate regulations

Proposals for the automotive industry is one of the major areas in the Fit-for-55 package of the European Green Deal as 14.5% of total CO2 emissions in the EU is related to personal cars and vans (EC 2022a). Pichler et al. (2021b: 142) call emission targets "implicit industrial policy" as their fundamental goal is transforming the industrial structure. For the road transportation of passenger cars and vans, emission targets for the period of 2020-2024 are 95g CO2/km for passenger cars and 147g CO2/km for vans, which are to be updated for the period of 2025-2030 (EC 2022a). The target by the package is 100% emission reductions as of 2035, meaning phasing-out of internal combustion engine cars (European Council 2022b). Additionally, an incentive mechanism for zero or low emission vehicles was introduced. If a car manufacturer produces more zero- or low-emission cars, his total car production would be subject to more relaxed conditions in terms of CO2 emissions per kilometer (EC 2022a). This implies that the car manufacturer can increase its e-auto production to a certain extent without decreasing the amount of manufactured combustion engine autos. This policy is primarily a promotion of automobile industry growth rather than a policy tool to seriously mitigate the climate crisis. The updated industrial policy strategy of the EU in 2021 by the Covid-19 crisis reveals that the goal of industrial growth and competitiveness is a priority even in the context of green transition, which is indicated by the "competitive sustainability" motto (EC 2021b: 5).

4.2. Budgetary programs

The industrial strategy of the EU (EC 2021b) stresses the industrial dependency challenge especially in energy and technology intensive areas. Pichler et al. (2021b) argue that until the Great Financial Crisis of 2008-2009, EU industrial policy has been a horizontal type, supporting general economic development. This is perceived as insufficient for ecological transformation and strategic autonomy after the crisis. The EU has begun to put emphasis on vertical industrial policy supporting strategic industrial activities in technology and energy intensive areas. The breakdown of GVCs during the

Covid-19 pandemic has once again highlighted this industrial dependency issue. For the twin transition, the EU aims at a short-term recovery of the automotive industry after the Covid-19 crisis as well as developing its long-term innovative capability and competitiveness. Several funding and budgetary programs had been implemented before the Covid-19 crisis and have been implemented since then (see EC 2021a) (see Table 3).

Long before the Covid-19 crisis, in 2012, the European Commission initiated the action plan of CARS 2020 with the aim of supporting innovation and access to credit of companies, especially the SMEs in the twin transition of Europe's automotive industry, aiming at competitiveness and sustainability (EC 2012). Later, in 2018, the Commission launched an initiative of the EU, funded by France, Germany, Italy and the United Kingdom with 1.75 billion euros and expected to generate 6 billion euros private investment, for research and innovation in the area of microelectronics which are used in a number of everyday devices but also important for electromobility (EC 2018). In December 2019, shortly before the Covid-19 crisis, the Commission initiated the Important Projects of Common European Interest (IPCEI) in battery value chain, which gives funding to the Battery Alliance aimed at research and innovation for establishing an entire battery value chain in the EU. The first round was funded by Belgium, Finland, France, Germany, Italy, Poland and Sweden with an amount of 3.2 billion euros of public funds for research and innovation and had 5 billion euros private investment potential (EC 2019b).

By the Covid-19 crisis, further funding programs have been introduced with the aim of mitigating the effects of the crisis as well as promoting competitiveness. As part of the long-term budget, the EU adopted at the end-2020 a budgetary program, the Next Generation EU Program, which is fully financed by borrowing of the Commission from the capital markets for the first time. A big part of this program is the Recovery and Resilience Facility (RRF) which consists of loans and grants to be allocated to Member States to recover from the crisis and support long-term investment projects. In regards to the automotive industry, RRF offers funding for research and innovation, loading infrastructure and many more dimensions of digital technologies for electromobility (EC 2021c). The second round of funding for the Battery Alliance was launched in 2021 with finance of 2.9 billion euros from Austria, Belgium, Croatia, Finland, France, Germany, Greece, Italy, Poland, Slovakia, Spain and Sweden. This is expected to generate around 9 billion euros private investment in the battery value chain (EC 2021d). Within IPCEI, support for the hydrogen value chain was initiated in 2021 by public funding of 5.4 billion Euro for research and innovation as well as industrial infrastructure (EC 2022b).

Further funding programs of the EU are Connecting Europe Facility for Transport for investment in transport infrastructure, modernisation of the existing infrastructure and its digitalisation such as by

5G technology for connected and automated mobility. Horizon Europe is funding research and development in clean technology innovations such as battery and hydrogen technologies in mobility or innovations in autonomous driving. The Digital Europe Programme aims at facilitating high-tech applications in supply chain coordination, autonomous driving and mobility management. InvestEU is funding similar types of projects but at a smaller scale (EC 2021a).

On the national level, Germany adopted in 2021 a large-scale fiscal program which is to be supported by the EU grants of 25.6 billion Euro (Table 3). The German Recovery and Resilience Plan (GRRP) was a response to the Covid-19 crisis in the long-term. One of the components of the GRRP is climate-friendly mobility constituting 19.4% of all components of the program. Various types of investments and reforms are planned, such as investments for battery loading stations infrastructure and extending the time of tax exemptions on electroautos. 2.5 billion Euros is to be allocated as a financial help measure for citizens to facilitate their shift to electric cars (Bundesministerium der Finanzen 2021).

Germany has further funding programmes for the automotive industry which aims at facilitating twin transition while maintaining industrial competitiveness. BMWK (2020) addresses the need to invest in a range of alternative technologies, the so-called "technology openness"[7] for long-term competitiveness, rather than specializing in a few technologies. Enabling new technologies for electromobility transformation, like batteries, hydrogen or synthetic sources of energy and promoting digitalisation in mobility such as autonomous driving technology are the major goals of industrial strategy. The steps to be achieved are investments in innovations, facilitating legal frameworks, easing cooperations between companies, introducing norms and standards and enabling testing of new technologies in real labs (BMWK 2019b). For these steps, several funding programs have been introduced. We can group these current budgetary programs of Germany targeting the automotive industry in the following way (see for this part BMWK 2022):

The first group is the funding programs for the future investments of companies.[8] As part of the "Konjunkturpaket" to counteract the negative consequences of the Covid-19 crisis, the German government has introduced a funding program of one billion Euro targeted at the automobile manufacturers and suppliers to support modernisation, innovativeness and productivity of the industry and facilitating the establishment of innovation clusters.

The second group is the funding program of one billion euros addressing the medium to long-term challenges of the industry at the federal level with strategic structural policies which then can be transferred to the regional level.[9] Around 340 million euros is to be directed to development of

[7] Original: "Technologieoffenheit" (BMWK 2020: 9)
[8] Zukunftsinvestitionen für Fahrzeughersteller und Zulieferindustrie
[9] Zukunftsfonds Automobilindustrie und Expertenausschuss

regional transformation strategies and value chains of the automotive industry, especially addressing SMEs. Another 340 million euros is planned for digitalisation focusing on operating systems and e-architectures, software and systems engineering as well as protection/validation, digital twins and virtualisation. The final amount of 320 million euros is planned for the sustainability of the value chains, especially of the SMEs and their capability of electric vehicle production, drive systems and fuel cells.

Overall, these funding programs are targeting three areas of automotive industry transformation which are closely connected: transition to electroautos, carbon emission reductions and new forms of mobility.

In the first area, electromobility, the target is 15 million personal electric cars by 2030 in Germany. The objectives are innovations in vehicles, drives and components and integration of these vehicles into the electricity and transport networks; optimizing the new value chains and developing new drive technologies via research and especially battery research. The second area of transformation is carbon emission reduction. Emission reduction targets based on Climate Law of Germany and the EU Commission's Fit-for-55 package. Certain ecological innovations are also foreseen to support emission reductions, such as solar roofs which feed electricity generated from solar energy into the car battery, or measures to convert engine heat into electrical energy. The third area is new forms of transportation, such as automatised and networked driving. For this, digital infrastructure and other conditions like legal requirements especially for autonomous driving are still required in the entire EU. Further issues are the modernisation of the type approval process, data access and data use, research and testing support, strengthening of social acceptance and promotion of real operation on the road.

Table 3 Budgetary programs in the EU and Germany

Programs - EU	**Amount (Euro)**	**Aim**
CARS 2020, 2012	n.a.	Supporting innovation and access to credit of companies, especially the SMEs in twin transition of Europe's automotive industry
Microelectronics, 2018	- Public funds: 1.75 billion - Expected private investment: 6 billion	Research and innovation in the area of microelectronics
Important Projects of Common European Interest (IPCEI), battery value chain, 2019, 2021	- First round of public funds: 3.2 billion - Expected private investment: 5 billion - Second round of public funds: 2.9 billion - Expected private investment: 9 billion	Research and innovation for establishing an entire battery value chain in the EU
IPCEI, hydrogen value chain, 2021	- Public funds: 5.4 billion - Expected private investment: 8.8 billion	Research and innovation, and industrial infrastructure in hydrogen value chain
Recovery and Resilience Facility (RRF), 2020	n.a.	Research and innovation, loading infrastructure and many more dimensions of digital technologies for electromobility
Connecting Europe Facility (CEF) Transport	23.7 billion	Investment in transport infrastructure, modernisation of the existing one and digitalisation of transport infrastructure such as 5G technology for connected and automated mobility
Horizon Europe	n.a.	Research and development in clean technologies, such as battery and hydrogen technologies in mobility, innovations in autonomous driving
Digital Europe Programme	n.a.	Facilitating high-tech applications in supply chain coordination, autonomous driving and mobility management
InvestEU	n.a.	Funding similar type of projects but at a smaller scale
Programs - Germany		
Deutsche Aufbau und Resilienzplan (DARP): climate-friendly mobility component, 2021	ca. 0.5 billion	Battery loading stations infrastructure, extending the time of tax exemptions on electroautos, financial help measures for citizens to facilitate their shift to electric cars, etc.
Zukunftsinvestitionen für Fahrzeughersteller und Zulieferindustrie, 2020	1 billion	Modernisation, innovativeness and productivity of the industry and facilitating establishment of innovation clusters
Zukunftsfonds Automobilindustrie und Expertenausschuss, 2021	1 billion	Development of regional transformation strategies and value chains, digitalisation, support for SMEs

Source: Own depiction based on the sources in the text

4.3. Stakeholder coordination

In the EU, certain industrial alliances aim at shaping the automotive industry for more industrial independence and more competitiveness. In Germany, platforms including various stakeholders discuss, plan and influence industrial policy for the automotive industry.

Alliances in the European Union

The electroauto manufacturing in the EU has high external input dependency. The EU is searching for solutions to decrease such dependencies via strategic alliances or partnerships and support substitution strategies for inputs. The battery value chain in the world is dominated by the oligopoly of a few East Asian companies, whereby the biggest German e-auto manufacturers like BMW, Daimler and VW import all of their batteries (Krpata 2021). The EU aims at gaining autonomy in its investments in China and preventing China's subsidies to maintain the EU's competitiveness by the EU-China Comprehensive Agreement (Krpata 2021). With the aim of reducing industrial dependency, the European Commission initiated the European Battery Alliance in 2017 including 750 stakeholders from the manufacturing sector, academia and the financial sector. This aims at building an entire battery value chain in Europe which is particularly relevant for electromobility transformation (EC 2019b; EIT InnoEnergy 2022) and is expected both to minimize external dependency on third countries and to secure competitiveness of the EU in the industries involving such technology via innovations (EC 2021d). The alliance is funded by the Member State contributions.

Another industrial alliance, the European Raw Materials Alliance, was initiated in 2020 aiming at diversifying the EU's value chain of raw materials and magnets, decreasing its dependency, particularly on China which currently supplies 90% of Europe's needs in these inputs. For the electromobility transformation and energy storage needs, greater autonomy in the supply of these materials is considered crucial (ERMA 2023). Similarly, the Clean Hydrogen Alliance was established in 2020 aiming at innovation in clean hydrogen technologies via collaborations from industry, finance, civil society and academia (EC 2022b). In 2021, the EU further initiated an alliance on processors and semiconductor technologies, which aims at collaborations of various actors from manufacturing to academia to develop innovativeness and capacity of production of the EU (EC 2021b; 2022c).

Platforms in Germany

There are platforms for dialogue and planning industrial policy strategies for the socio-ecological transformation in Germany. A major one at the national level is the Alliance Future of Industry[10]

[10] Bündnis Zukunft der Industrie

founded in 2015 as a dialogue platform. Its members are trade unions, industry organisations, employers' associations, the Association of German Chambers of Industry and Commerce, and the Federal Ministry of Economic Affairs and Climate Action. Its declared aim is to improve the innovativeness, working conditions and competitiveness of the industry. Climate targets are not mentioned in this declaration, and no environmental organisations are members.

The National Platform Future of Mobility is the key forum for mobility transformation including politicians from a number of ministries, researchers, industry actors, trade unions and non-governmental organisations. Here the strategies of industrial transformation are discussed and developed. Although a few environmental organisations are members of the platform, none of them is a head or co-head of any thematic working group, not even the working group of Transport and Climate Change - which is solely headed by an e-mobility consulting firm.

4.4. Bottom-up initiatives

Trade unions in the automotive industry in Germany had big demonstrations in 2019 in Baden-Württemberg against the restructuring of employment, which was then estimated to cause 30 thousand to 45 thousand job losses by 2030 (IndustriAll 2019). Trade unions increasingly voiced a "just transition", whereby job losses have to be prevented, companies must invest in future technologies and workers must be reskilled for new occupations. An ILO publication writes: "the question of the position of labour and the labour movement towards the climate crisis and its role in solving it becomes more urgent than ever" and "[t]rade unions are social actors aiming to change the social conditions of production, and thus their contribution to challenge the threats to nature is crucial." (Räthzel/Uzzell 2019: 146). Besides, by generating a decisive and feasible climate crisis agenda, trade unions can empower themselves in the political arena, and similarly, the environmental movement would be strengthened by the supportive power of the labour movement (Brand 2020; Dörre et al. 2020).

IG Metall is the dominant trade union in the automotive industry in Germany. It has traditionally the leading position in German industrial relations. It has been a long advocate of industrial modernisation calling for investments in infrastructure and employee qualification, whereby the codetermination actors have been pushing for investments in innovations and climate-friendly products, technologies and production processes and developing new enterprise models (IG Metall 2021).

There are initiatives and involvement of the IG Metall in Just Transition in the automotive industry at the EU level, federal level, regional level, company level and plant level (see for these Strötzel/Brunkhorst 2019). At the EU level, IG Metall has an advisory role in the committees of the

European Parliament. At the federal level, it is a member of and the head of a working group of National Platform Future of Mobility. Moreover, it advocates an education policy more in line with the transformation needs as well as new labour market instruments for the employees which are in training for new skills, such as a payment scheme of “short-time transformation allowance”. It supports a 4-day work week scheme which has ecological and social benefits. At the regional level, partnerships were introduced for improving worker participation in new products, production processes and company decisions, such as the “Transformation Advisory Council” in Baden-Württemberg. The state, employers’ representatives and works councils of companies (including Bosch Bamberg, MAN Truck & Bus, Schaeffler Technologies and Continental) in Bavaria signed an agreement (“Vertrag for Future") in 2020 committing to investments of companies in future technologies in mobility like fuel cells, employment protection and employee qualifications as well as state support for future driving systems (IG Metall 2020). A cooperative project of industry actors and IG Metall Bavaria has been initiated in 2022 mainly with the aim of employee qualification in the face of transformation in the automotive industry (IG Metall 2022). At the company level, works councils have engaged in agreements with companies for securing employment for a specific period and guaranteeing investments in new products and technologies, such as in the case of Daimler and Volkswagen. At the plant level, training initiatives were implemented to facilitate employee’s understanding of the transformation process and its consequences for the world of work.

Nevertheless, these initiatives do not necessarily involve the stakeholders of the environmental movement. A “working-class environmentalism” that is an “environmental activism that aims to radically transform ‘the economy’, based on principles of mutual interdependency between production, reproduction, and ecology” (Barca/Leonardi 2018: 491) is missing. Yet, there are a few recent examples of labour-nature alliances in Germany, which are relevant for the automotive industry. The first one is the alliance between IG Metall and German Federation for the Environment and Nature Conservation (BUND) aimed at shaping the socio-ecological transformation together. This particularly considers the companies which get Konjunkturpaket benefits from the German government. The aims are to achieve more codetermination rights of workers and transforming business models to 1.5 degrees Celcius climate targets. Another recent example is the alliance between Verdi and Fridays for Future. The alliance demands expansion of public transport as an alternative to private automobility, which would create more jobs requiring qualifications, while also contributing to emission targets (Barthe 2021).

5. Critical points

"Sustainable competitiveness"

EU and German industrial policy in the face of twin transition aims at competitiveness and sustainability at the same time, which can be controversial. Industrial policy primarily promotes industrial growth and competitiveness, and efficiency via techno-fixation - even in unsustainable industrial practices (Pichler et al. 2021b; Urban 2022). However, the automotive industry has failed so far in reducing emissions due to the rebound effects generated by industrial growth and the production of larger vehicles with stronger engines (Schwedes 2017 in Brunnengräber/Haas 2020). Nevertheless, a radical industrial transformation with phasing-out ecologically unsustainable industrial practices, absolute reduction of maximum GHG emissions (rather than per car emissions) or halting expansion of transport infrastructure are not in the political agenda of the EU or Germany. Despite the intensification of the climate crisis in the Global North and the catastrophic effects of climate crisis on the Global South, industrial practices are resistant to a radical transformation (Pichler et al 2021b).

Drive system transformation

The mainstream thinking about the automotive industry transformation today is the drive system transformation, from internal combustion engine to electric cars. Electroautos are more "eco-friendly" than combustion engine autos, however, their life cycle is not emissions-free. From the extraction of raw materials to the disposition as well as the infrastructure and electricity production, electroautos would continue to generate emissions and ecological damages. The most carbon intensive raw materials for both combustion engine cars and e-cars are iron and steel. Apart from these, electro auto manufacturing requires rare earths: Lithium, cobalt and nickel are among the most crucial raw materials; however their extraction causes ecological damages and is subject to very low labour standards in the Global South (Greenpeace 2021). Transformation to electromobility also does not question the hegemony of private automobility in the public sphere (Dowling/Simpson 2013). Therefore e-mobility is not a solution for many questions of sustainability today: Air, water and land pollution in production, emissions due to battery production, urban congestion, extraction of raw materials from the Global South as well as hegemony of private automobility (see the literature in Manderscheid 2020, p. 58).

Reconfiguration in automotive industry GVCs

The automotive industry GVCs had been subject to reconfiguration already before the Covid-19 crisis. The production in the Global North has been decreasing and in countries like Brazil, China, India increasing. For the sake of employment, this requires the German automotive industry to

develop new, high quality products with highly skilled workforce, especially in the middle class and upper class product segments which are mainly domestically produced (Blöcker 2015: 535). With the intensification of competition in e-auto production and energy technologies by new players entering the market, climate targets and the rare earths supply advantages of a few East Asian companies, the EU industrial policy has the challenge of establishing autonomy in electromobility and gaining competitiveness for the technologies of the future, such as hydrogen. The loss of EU automotive industry's global leadership and challenges of electromobility transformation as well as input dependency on third countries in electromobility risks domestic production and employment.

On the one hand, the EU has initiatives to establish industrial autonomy by regionalizing its automotive industry supply chain and diversification of suppliers. On the other hand, factors including stricter climate targets in the EU, raw materials availability abroad, such as in China, Vietnam and Brazil, the energy crisis in the EU, large car market size and the increased production quality in China might be the push factors for shifting some premium segment of car manufacturing from Germany to China or elsewhere in the Global South. This would hamper the success model of Germany, shrink domestic industry and employment, and jeopardize the dynamism of innovation (Puls/Fritsch 2020; Krpata 2021). To prevent the shift of production abroad and level the playing field, the EU introduced the Carbon Border Adjustment Mechanism for selected sectors which aims at avoiding carbon leakage. Yet, costs of imported products do not necessarily reflect the environmental costs of transportation emissions.

Limited "just transition"

The Just Transition initiatives are mainly focused on electromobility transformation, rather than aiming at a comprehensive mobility system change. Rethinking of "what, how and for whom" to produce is usually not at stake. Participation of the environmental movement is weak in Just Transition initiatives of trade unions and stakeholder platforms for planning industrial policy - at least in the context of Germany. Despite inclusion of environmental concerns in trade unions' rhetoric since the 1970s and several examples of alliances between the labour and environmental movements in history and today (Räthzel/Uzzell 2013), a strong, widespread and effective alliance of trade unions with the environmental movement in the socio-ecological transformation politics is still missing. A "working-class environmentalism" (Barca/Leonardi 2018: 491) is urgently needed. Alliances between trade unions and environmental organisations are essential in developing a truly just transition strategy (Urban 2022).

6. Conclusion

To conclude, the industrial policy in the EU and Germany on the automotive industry has a focus primarily on growth and competitiveness goals today. The climate crisis is subordinated to these. A comprehensive mobility system transformation must be operationalized with involvement of all stakeholders, especially the labour and environmental movements. The democratic conversion approach and the degrowth approach should be taken into account for a comprehensive, ecological and social transformation of the automotive industry today.

As the climate crisis is a global issue, global cooperation in industrial policy and climate politics is essential. Further shifts of production overseas must be prevented by industrial policy instruments. Conversion of the industry with reduced private car manufacturing and ecologically and socially meaningful new products must be facilitated by industrial policy. In addition to electromobility transformation, widespread and improved public transportation, intermodal mobility and shared mobility solutions are also crucial. A labour-nature alliance must complement this process by more codetermination rights and participation of environmental stakeholders in the industrial policy making and codetermination system.

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