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In search of the twin transition
The limited performativity of the « green and digital » transitions in the European automotive industry

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Carbonell, J. S.

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Contact information
Name: Juan Sebastian Carbonell
Email: sebastian.carbonell@gmail.com

EU Science Hub
https://joint-research-centre.ec.europa.eu

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In search of the twin transition

The limited performativity of the « green and digital » transitions in the European automotive industry

Juan Sebastian Carbonell, Gerpisa, Ecole Normale Supérieure Paris-Saclay, IDHES

Abstract

This paper examines the concept of « twin transition » using the core/periphery structure of the European automotive industry as a case study. This term has emerged in recent years as a new leitmotif in international organisations and industrial companies. The idea is that the digital and green transitions can fuel each other in a virtuous economic circle of « smart growth ». This paper defends that this concept is part of the automotive industry's long history of socio-technical paradigms. Using the theories on the performativity of economic concepts, we deconstruct the idea of a « twin transition ». We show that it is necessary to dissociate the production process from the output in order to understand the possible interactions between the two transitions. For this, we describe the regional structure of the European automotive industry in terms of core and periphery, we show then the forms taken by digitalisation and electrification in the value chain of the European automotive industry in processes and products. Finally, we show that the concept of « twin transition » has little empirical basis, but rather aims to attract resources in the context of significant economic uncertainty and the lack of coherent industrial policy.

Keywords: twin transition, automotive industry, digitalisation, green transition, electro-mobility

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Executive summary

This paper examines the concept of the "twin transition" in the European automotive industry, focusing in particular on its effects on work and employment. The paper analyses the "digital and green" transitions and the interplay between them in one the most labour-intensive sectors in the European Union. While the idea of these transitions mutually reinforcing each other to achieve "smart growth" is gaining traction, this paper argues that the concept is more of a political construct than a reality.

The term "twin transition" was first introduced in the strategic priorities of the European Commission in 2019, and it has been incorporated into various EU strategies and documents, including the Green Deal and the Industrial Strategy. The concept is presented as a reality, an opportunity, and as something to be made happen, highlighting the need for investment to achieve its full potential. International organisations such as the World Economic Forum have also adopted the term, promoting the idea that digitalisation enhances sustainability and the green transition drives further digitalisation through investments.

In the European automotive sector, the adoption and impact of both transitions are significantly influenced by the existing core/periphery structure of the industry. The core (Germany, France, Italy) focuses on high-value activities such as research and development (R&D) and the production of mid-range and premium vehicles, while the integrated periphery (Central and Eastern European countries, Turkey and Maghreb) specialises in labour-intensive assembly and the production of low-cost vehicles.

While digitalisation is typically associated with production processes, in the case of the automotive industry it also extends to the product itself. Vehicles are increasingly incorporating digital technologies and becoming connected objects, leading to increased complexity and reliance on software. As far as work processes are concerned, the impact of digitalisation differs between core and peripheral countries. In core countries, digitalisation leads to "lean augmentation", further optimising work processes and increasing control over the workforce. Peripheral countries experience "strategic upgrading", with the adoption of new technologies being driven by transnational firms, often leading to a division in the workforce.

The green transition in the automotive industry primarily takes the form of electrification. While the EU aims for a 100% reduction in emissions from passenger cars by 2035, the transition presents both challenges and opportunities. Electrification could lead to job losses in vehicle production but create new opportunities in battery production and charging infrastructure. However, the transition is also influenced by the core/periphery dynamic, with core countries leading in electrification efforts and seeking to establish battery production facilities.

The "twin transition" concept, while lacking strong empirical foundations, serves a performative function. It helps to structure investment and foster collaboration between industry stakeholders and policymakers. This is especially relevant in the context of uncertainties surrounding electrification and increasing global competition. The term creates the perception of a technological revolution, attracting investment and reinforcing the belief in its potential. This is similar to the performativity observed with Industry 4.0, where the hype surrounding the concept contributed to its adoption and the allocation of resources, even in the absence of significant technological breakthroughs.

The "twin transition" concept highlights the interconnectedness of digitalisation and the green transition in the European automotive industry. While the extent of their interaction is debatable, we can distinguish a pragmatic interaction between the two transitions in the production process, from an organic interaction in the product (the vehicle), where digitalisation is effectively reinforced

by the introduction of the battery management system. At the same time, the concept mobilises resources and shapes policy decisions. However, it is crucial to acknowledge the limited empirical basis for the “twin transition” and critically assess its potential impact on employment and the regional distribution of economic activities. The current focus on innovation-driven industrial policy may exacerbate existing inequalities between core and peripheral countries, raising concerns about a race to the bottom and the continued exploitation of low-cost labour.

1 Introduction

The European automotive industry is currently facing two structural challenges: the introduction of new technologies inspired by « digital manufacturing », also referred to as Industry 4.0, and the sector's fast-track transition from internal combustion engine vehicles (ICEVs) to battery-electric vehicles (BEVs) (Nelli and Virgillito, 2023). On the one hand, vehicle manufacturing is undergoing a process of digitalisation. Over and above the multitude of technologies associated with the digitalisation of production, this corresponds to the establishment of cyber-physical networks, the optimisation of industrial processes and product quality through the use of mass-produced digital data collected from machines and tools (Anzolin, 2021).

On the other hand, the automotive industry is also going through a green transition towards electromobility. The electrification of motor vehicles seems today to be the only way for the automotive sector to achieve the standards imposed by the EU in July 2021 in its « Fit for 55 » package. The aim is to achieve a 55% reduction of 1990 level emissions by 2030 in all sectors. For passenger cars, the target is a 100% reduction by 2035. The consequences for work and employment are major since in ten years, the whole internal combustion powertrain industry, which employs tens of thousands of workers in Europe, will be phased out (Pardi, 2022).

This dual challenge, digitalisation and electrification, and their interaction is more and more referred to as the « twin transition ». The origins of this notion are still obscure, however it has gradually made its way from European institutions and international organizations to firms and market actors in the automotive sector. The aim of this paper is to analyse the concept of « twin transition » using the European automotive industry as a case study, by drawing on the literature on the performativity of economic concepts (Muniesa et al., 2007). We aim to establish whether there is a « twin transition » and to find out why certain economic players believe that there is one. Our main argument is that this concept is a political construct that has has been incorporated as a new techno-organisational paradigms in the automotive industry. It is part of the long history of paradigms that have structured the industry. This history dates back to the success of lean production as a new production model in the 1980s, intended to replace mass production (Pardi, 2021), and continues with Industry 4.0 (Pardi et al., 2021) and the CASE (connected, autonomous, shared, electric) paradigm in the 2010s, and continues today with the « twin transition ». Each of these concepts has played a role in meeting the specific needs or the interests of certain actors at pivotal moments in history of the automotive industry.

Our main argument is that the « twin transition » in the European automotive industry is a political construct and a concept with a performative purpose, whose main objective is to create economic and political alliances between public and private actors in the uncertain context of electrification and international competition. However, despite empirical limitations of the « twin transition », we will see that it achieves one of its main objective, that of securing investment – particularly through the emergence of a European battery industry – and of major international competition from new entrants, such as Chinese and American brands in the European market. We will also demonstrate that the « twin transition » performs poorly in reality (Brisset, 2016) when it comes to real changes in the production process. That is because the discourse on digitalisation and the green transition does not take into account the distinction between process (vehicle manufacturing) and output (the vehicle as product). In order to address this, we distinguish a « pragmatic interaction » from an « organic interaction » between digitalisation and electrification regarding the process and the output. Finally, we will show that what remains decisive is not so much technological change, whether digital or green, as pre-existing trends in the automotive industry, namely the problem of production costs, which is taking the form of the increased deployment of lean organisations and the structuring of regional value chains. Digitalisation and electrification are therefore highly dependent on the core/periphery structure of the European automotive industry.

This paper is structured as follows. We will start with the description of the institutional origins of the « twin transition » (2.). We will then describe core/periphery structure of the European automotive industry, since it is the most important defining change of the last twenty-five years, and also because this structure largely determines the deployment of new technologies and the allocation of new vehicles (3.). We will then look at digitalisation in core and peripheral country by illustrating it using different cases corresponding to core and peripheral countries (4.). We will then analyse the challenges of electrification for the European automotive industry value chain (5.). Finally, we will draw discuss the interactions between digitalisation and electrification (6.).

2 The institutional origins of the « twin transition »

One of the very first occurrences of the notion was on the 27th of 2019 in the speech by Ursula von der Leyen to the European Parliament on assuming the presidency of the European Commission, and on the occasion of the presentation of her programme and her College of Commissioners. During this occasion, von der Leyen introduced into the Commission's vocabulary the notion of « twin transition » – in reference to green transition and digitalisation. According to von der Layen, « we should harness this transformative power of the twin digital and climate transition to strengthen our own industrial base and innovation potential. This can only be done through investment » . As we can see, here these transitions are presented simultaneously as a reality, a challenge and an economic opportunity for the European Union, in other words, both as a fact, an opportunity, and as something to be brought into existence by addressing the question of the resources needed to achieve it.

Later that year, the concept was indirectly mentioned in the Commission's « Green Deal » of December 2019, which includes a roadmap and « key policies » needed to achieve sustainability. Here, digitalisation is described as a « critical enabler » for attaining sustainability, as it can « help improve the availability of information on the characteristics of products sold in the EU », or « energy efficiency », among others . On March 2020, the term was directly incorporated into the EU's Industrial Strategy. The aim of this strategy is for the EU to put in place a system of industrial policy, two of the major challenges of which are the EU's competitiveness and strategic autonomy . This industrial strategy was updated in May 2021, incorporating the effects of the Covid-19 pandemic and focusing efforts on economic recovery. According to this later document, Covid-19 has accelerated the « twin transition », making it unavoidable insofar as « companies pursuing sustainability and digitalisation are more likely to succeed than others » . At the same time, it is also a question of acting on this transition by « accelerating » it in certain sectors, including the automotive industry. This is also the aim of the Staff Working Paper « For a resilient, innovative, sustainable and digital mobility ecosystem », published in January 2022, which is designed to strengthen the « sustainable competitiveness » of the European automotive industry in the face of new entrants such as China .

Finally, the term is being invoked in a context of increasing international competition and geopolitical tensions, where the challenge is to ensure Europe's technological autonomy and sovereignty. In June 2021, the European Commission identified several sectors corresponding to « strategic dependencies » involving « products, services or technologies key to the twin transition, such as renewables or energy storage ». These technologies include several that are key to the automotive industry today, such as raw materials, Li-ion batteries, semiconductors and cloud computing . Similarly, in its 2022 Strategic Foresight Report, the « twin transition" is raised to the « top of the EU's political agenda », given « their interplay will have massive consequences for the future », particularly in a new geopolitical context .

One of the main institutional forms taken by this « twin transition » approach in the EU is a common policy of investment in innovation. For example, the « General introduction » to the Horizon Europe Work Programme 2023-2024 of April 2024 mentions the ambition to « support the green and digital transitions and target global challenges while supporting European industrial competitiveness », through research and innovation instruments. The idea is that research and innovation activities will enable the development of « smart and sustainable » transport, while maintaining industrial competitiveness, through key technologies . However, as we will see later in section 6, this innovation-based approach is primarily a response to the lack of a common industrial policy, dans la mesure où (Klebaner, Ramírez Pérez, 2022).

On the private sector, the notion was quickly adopted by actors in the automotive industry when employer's associations responded favorably to the Commission's vision of the future of the sector, calling for a more concrete and coherent approach to industrial investment (VDA, 2023a). This can be seen in the document produced by the European Association of Automotive Suppliers (CLEPA), the European Automobile Manufacturers' Association (ACEA), the European Council for Motor Trades and Repairs (CECRA) and the European Tyre and Rubber Manufacturers' Association (ETRMA) calling for a « resilient, innovative, sustainable, and digital ecosystem » .

More generally, the expression has become increasingly popular as a result of its use by international organisations with the goal to drive and shape industrial, energy and employment policies (Leterme, 2019, Muench et al., 2022, Verdolini, 2023). In most of the grey literature, the aim of the « twin transition » is to achieve « smart green growth » (Fouquet and Hippe, 2022). According to the World Economic Forum – another organisation that has adopted the term – digitisation enhances the sustainability of industries, while the green transition would enable further digitisation through new investments .

Despite the growing hype for this notion, the literature on the two transitions appears to be « parallel » and « separate », insofar as there is almost « no systematic assessment of the linkages, potential synergies and trade-offs between the digital and the ecological transitions » (Verdolini, 2023, p. 5). This would be because digital technologies correspond to a very vast and heterogeneous collection of innovations and applications, so their influence on the green transition is difficult to assess. We shall see in the following sections that digitalisation and electrification are having concrete effects on the organisation of work and products in the automotive sector, but that their interactions are not as straightforward as the institutional discourse would lead us to believe. But, to understand this, we need first to describe the core/periphery structure of the European automotive industry.

3 Core and periphery in the European automotive industry

One of the very first occurrences of the notion was on the 27th of 2019 in the speech by Ursula von der Leyen to the European Parliament on assuming the presidency of the European Commission, and on the occasion of the presentation of her programme and her College of Commissioners. During this occasion, von der Leyen introduced into the Commission's vocabulary the notion of « twin transition » – in reference to green transition and digitalisation. According to von der Layen, « we should harness this transformative power of the twin digital and climate transition to strengthen our own industrial base and innovation potential. This can only be done through investment » . As we can see, here these transitions are presented simultaneously as a reality, a challenge and an economic opportunity for the European Union, in other words, both as a fact, an opportunity, and as something to be brought into existence by addressing the question of the resources needed to achieve it.

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4 Digitalisation in the automotive industry: products or processes?

4.1 Digitalisation in products

After describing how the European automotive industry is structured, between core and periphery, and following on from what we outlined earlier, we will look now at how digital technologies are being deployed throughout the European automotive value chain. As mentioned in the introduction, it is important to distinguish between the product and the process when analysing the effects of technological change in the automotive industry.

Digitalisation usually refers to the vehicle production process. However, digitalisation also applies to the product, as the vehicle incorporates more and more electronics and IT components, as well as services. As a result, the vehicle has become a connected object with a digitally layered architecture. For example, a vehicle has a telephone communication system, an integrated services system (navigation, information, safety, assistance, maintenance, etc.), an infotainment system, etc. (Bosler, 2021). This increase in vehicle complexity is partly linked to the « upmarket drift » described above, in other words the tendency for private vehicles to become increasingly powerful, heavy and expensive, without this necessarily reflecting consumer preference or technological progress. As Pardi (2022) says, this is mainly a result of the dominant profit strategy in the European car industry, which favours this type of vehicles.

This digitalisation of the vehicle is visible in the case of the use of artificial intelligence (AI) in the automotive industry. According to industry stakeholders, application of AI not only concerns production or assembly, but mostly the vehicle design and usage (ACEA, 2020, VDAb, 2023). The best-known application of AI in the automotive industry is autonomous driving, but other applications are already taking place, such as safety and comfort functions, driver assistance systems and infotainment systems. This is the case in braking systems, based on the recognition of objects and obstacles, such as pedestrians, or in driving, based on the detection of other vehicles in the vicinity, in signage identification, in driver facial recognition, etc. This leads employer associations like CLEPA to claim that « the major challenge for AI in our sector is safety » (CLEPA, 2020, p. 6), and not only work processes. What’s more, studies show that the automotive industry has become one of the main customers worldwide of micro-work services for AI training, with hidden labour present in the production of the AI needed to optimise driving systems in the form of invisible online micro-work (Tubaro and Casilli, 2019).

These changes in product architecture led to claim that automotive firms are moving ever closer to the business model of digital firms, particularly under the influence of « tech » firms like Tesla (Daum, 2022). The latter are firms that produce or capture digital data and then exploit it, like digital platforms. In the case of the automotive industry, the idea is that consumers not only buy a high-tech product, but also services attached to the vehicle, while at the same time producing data which is then exploited by automotive firms. Nonetheless, the idea that automotive industry are becoming more and more digital like firms, with a « software-centered approach » (Daum, 2022) is exaggerated. Despite the incorporation of digital technologies into the product, the automotive industry's basic business model remains the manufacture, assembly and sale of commodities (MacDuffie, Fujimoto, 2010).

4.2 Between lean augmentation and strategic upgrading: digitalisation in core and peripheral countries

Without going into the details of the technological changes in automotive production, it can be said that these are not a radical break with past automation, but rather a continuation of it. More specifically, the robots used in industry today are improved versions of the robots used in the previous generation, and they are still used mainly for physical tasks (Fernández-Macías et al., 2020). What is new is the installation of captors, the use of the data collected to optimise the production process, and the connectivity between physical and digital domains through cyber-physical networks (Pardi et al., 2021).

There is now a series of studies (Krzywdzinski, 2021, Butollo, Jürgens, Krzywdzinski, 2019, Moro and Virgillito, 2022, Cirillo et al., 2021, Carbonell, 2021, Szalavetz, 2020) that illustrate how digitalisation is intensifying work and worsening working conditions. However, it must be said that the effects of digital technologies are not unequivocal. As we shall see in this section, they vary according to the country's place in the core-periphery structure of the European automotive industry.

When it comes to assembly work in core countries, we observe a case of « lean augmentation » through digitalisation in production sites (Mokudai et. al, 2021). For example, different case studies show the introduction of pick-to-light or pick-to-voice systems, which are picking systems where employees select parts based on lights that light up, or a voice that dictates instructions, before placing them on an automated guided vehicles (AGVs), which will then transport the parts kits to the assembly stations (Carbonell, 2021). The aim is to reduce errors and cut part-picking time. More marginally, we are also seeing the development of pick-by-vision systems, using connected glasses. These make it possible to identify which products are needed, where they are located in the workshop, and in what order they should be picked (Butollo, et al., 2019).

In the Italian and French cases, these technologies encourage the standardisation of workflows and the use of digital data to optimise work processes. This makes it possible to meet more demanding requirements in terms of product quality, time-to-market and supply chain responsiveness. In Italy, for example, Moro and Virgillito (2022) note that lean is reinforced by digital technologies in the various assembly plants, aiming to reduce costs, rationalise and synchronise production with the market, in order to achieve « tight » production flow. There is also evidence of a saturation of work rhythms with the introduction of kitting, pick-to-light and AGVs for component supply (Gaddi, 2021). Digitalisation is also increasing machine connectivity and control over the work process. This is the case with connected or digital wrenches, which enable data to be collected, stored and analysed. For instance, if the screwdriving is not strong enough, the operator sees a red light on the screen. Management has access to a range of informations on individual performances, errors, stoppages, breakdowns, etc., strengthening control over the work process and workers (Cirillo et al., 2021).

We see similar developments in French vehicle assembly plants, where the main aim of digitalisation is to cut costs, which has the effect of reducing employee autonomy, tightening control over the work process and intensifying work (Carbonell, 2021). We have also seen the introduction of full-kitting, with pick-to-light as a support system in PSA plants (now Stellantis), and the use of AGVs to automate the delivery of parts to assembly stations. As a result, employees are less able to move around workstations, and have to keep up with the pace of work imposed by AGVs. From the company's point of view, downtime is eliminated and employees can concentrate more on value-added tasks in assembly.

The picture is a little different in Germany, where the share of manual workers in the automotive industry has declined from 70% at the end of the 1990s to 60% in 2018 (Krzywdzinski, 2021b) while remaining rather stable in absolute numbers. In this country, there is a growing proportion of engineers and technicians on the one hand and computer scientists on the other in the German auto sector. This reflects the country’s relationship with digitalisation and automation, where the share of blue-collar workers in total employment is declining, with a higher share of engineers and computer scientists (Krzywdzinski, 2021b).

As a growing literature shows (Krzywdzinski, 2017, Szalavetz, 2020), digitalisation and robotisation ((Fernández-Macías et al., 2020) in peripheral countries is a reality. In the 1990s, the automotive industries in Poland, Slovakia, the Czech Republic and Hungary remained « simple », limited to labour-intensive assembly. But, as described in section 3, there has been a gradual upgrading (without necessarily the establishment of certain R&D units of OEMs, with the exception of Renault in Romania) in the « integrated periphery » of firms belonging to large international groups, which are the first to incorporate new technologies.

We find technologies and work organisation similar to those described for the core countries, with the presence of AGVs in certain plants, as well as the capture and use of digital data through a Manufacturing Execution System. There is also real-time production tracking and production monitoring and planning systems. Generally speaking, these technologies are found mainly in the most recent plants: « the newer the production site, the more digitally mature it is » (Szalavetz, 2020, p. 54). However, when it comes to high-volume, low-cost product assembly sites belonging to transnational firms, the technologies implemented are context-specific and with little autonomy for local actors. As Szalavetz (2020) reports, production planning and the flow of parts is decided at higher, more central levels, while the factories simply implement this plan.

From the point of view of peripheral countries, the fact that a factory belongs to a domestic or international firm, or that it is an assembly plant or a component manufacturer, has a major influence on the way in which digital technologies are incorporated into the work process. « Some of the more highly traditional parts of automobile production, and the oldest machines, are found in component production, at the same time increasingly alongside some of the newest and most automated due to the production of electric cars » (Meil, 2020, p. 28). For example, domestic component manufacturers in Poland still have very old, labour-intensive processes. They find it difficult to implement new digital technologies (due to a lack of skills and financial resources), but also implement them partially, step by step (Gwosdz et al. 2020). But, at the same time, digitalisation of subsidiaries can be pushed forward OEMs, specially by German companies, who have a « technology-driven » approach to automation (Olejniczak et al., 2020). This means that the workforce in the sector is divided in two. On the one hand, between workers – generally employed in subsidiaries, or suppliers working for global OEMs – who benefit from upgrading, through the possibility of requalification and better wages. On the other hand, workers who work for low wages, generally in domestic firms and component manufacturers.

In this section we have described how digitalisation is developed in products and throughout the European automotive value chain. While a growing proportion of production has been relocated to peripheral countries in the last twenty years, this has gradually been accompanied by technological upgrading. In terms of the production process, we see little direct interaction with the electrification of the automotive industry, insofar as vehicle assembly remains more or less the same between ICEVs and BEVs, as we will detail later. However, we can talk of a pragmatic interaction, insofar as the leading plants – where there is strong cooperation between R&D and manufacturing – or the greenfield plants to which electric vehicles have been allocated are also those with a higher degree of digitalisation (Krzywdzinski, 2021b). In the next section, we will show that there is a more organic interaction when it comes to the product. However, we will also show how the electrification of the automotive industry is also taking place according to the core/periphery structure.

5 Electrification: more complex vehicles and more fragmentation of value chains

5.1 A transition determined by the core/periphery structure of the industry

The other major challenge facing the European automotive industry is the green transition that takes the form of the electrification of motor vehicles. As mentioned in the introduction, the « fit for 55 » package imposed by the EU implies a 100% reduction in emissions from passenger cars by 2035. In this respect, there is no longer a discussion on the « if », but only on the « how » and « how fast » the electrification of the European automotive industry is going to happen.

The effects of electrification on employment are still the subject of competing estimates (Strategy&, 2021). Not only must the technical dimension of the phenomenon be taken into account to assess labour requirements according to product type, but also issues such as access to natural resources, production volumes, purchasing power, industrial relations, mobility needs, etc., as well as the scale of analysis relevant to understanding this development (the automotive industry, services, infrastructure, energy production, etc.). However, there is a general agreement in literature that electrification will mean a reduction in labour requirements in automotive production, with new labour needs in battery production and in the construction of the charging infrastructure.

Like the digital transition, the transition to electric vehicles in the European automotive industry is strongly determined by its regional structure and its division between core and periphery. In the case of France, the auto industry industry is suffering a significant decline in production volumes and employment numbers, as well as a negative trade balance, with a dynamic of deindustrialisation that has only accelerated in recent years, despite significant state aid (Pardi, 2020, Lechowski et al., 2023). More recently, President Emmanuel Macron announced that he wanted to transform north-eastern France, a centre of the country's automotive industry, into a « battery valley », with the installation of several gigafactories, reversing this downward trajectory[1]. In general, the trend towards decline is far from being reversed: France is lagging far behind in the electrification of its plants, with only 14% of them producing electric vehicles exclusively in 2022 (Schulze-Marmeling and Palliet, 2023). Everything seems to indicate that electrification will have a negative impact on employment in France, as it is part of the ongoing restructuring of the sector over the last fifteen years.

The German auto industry is an inverted mirror image of the French car industry, since it relies on a strong industrial base, on its hegemony in the premium segment, and on substantial state aid to rapidly begin the transition to electric vehicles. All German manufacturers have embarked on ambitious plans to electrify their vehicles and train their employees. Daimler, for example, plans to train 20,000 of its employees in electromobility by 2020. However, there are also vulnerabilities: the Covid-19 crisis has been accompanied by job cuts on an unprecedented scale in the German automotive industry (Krzywdzinski et al., 2023). It should be added that German trade unions in the automotive sector were not all on the same wavelength when it came to electrification. The Works Councils of the equipment manufacturers (whose companies would be most affected by the transition to the electric vehicle) were opposed to the union taking a position in favour of the electric vehicle, while IG Metall was in favour if this transition meant maintaining jobs in Germany, among other things. However, the transition to the electric vehicle means that companies have to negotiate agreements to preserve jobs, with concessions from the unions, which is something that is also happening in France. Like its French neighbour, the German government has taken advantage of Covid-19 to restructure the sector, with subsidies for the purchase of electric vehicles, investment in technological upgrading of the industry, and funding for the development of a charging infrastructure and R&D in electromobility and batteries (Lechowski et al., 2023).

[1] https://www.lemonde.fr/economie-francaise/article/2023/05/12/emmanuel-macron-officialise-l-implantation-d-une-mega-usine-de-batteries-du-taiwanais-prologium-a-dunkerque_6173117_1656968.html

The challenge of electrification for CEECs is different, because of their export-oriented economic model and their dependence on FDI. According to Pavlinek (2023), four factors need to be taken into account in the integrated periphery transition to electromobility. First, because there are few R&D skills in CEECs automotive firms, the region will have few skills for the transition to EVs. Added to this is the fact that the trade unions themselves sometimes lack the skills and expertise to position themselves in the debate on the transition to EVs (Gažo, Martišková, Smith, 2022). Second, the transition to EV production in in the region will be slower than in Western Europe. This is because plants in CEECs will continue to produce internal combustion engine vehicles (ICEVs) for extra-European markets. Third, the production of ICEVs will continue longer in in the region because of low labour costs. Finally, the fact that the auto industry in the « integrated periphery » is dominated by transnational firms means that its local subsidiaries have little room for manoeuvre in this transition, and that the negative effects will fall entirely on local economies and workers.

The European automotive industry is facing new challenges in the context of electrification, notably the arrival of new entrants such as Tesla, and particularly the rise of the Chinese automotive industry and Chinese products in the European market. The latter has a head start on the electrification of its industry and controls a large part of the battery value chain, and could call into question the « traditional balance of the global automotive industry » (Alochet, 2023). Furthermore, the announcement of the creation of a BYD factory in Hungary is a step in the same direction, potentially heralding a wave of FDI in the region. As we shall see in the next section, it is in this context of structural fragility that the concept of « twin transition » aims to act defensively on the automotive industry.

Here too, there is little direct interaction between digitalisation and electrification. The launch of electric models in factories can be an opportunity for further digitalisation, but this is more a question of modernising old industrial plants or opening new ones. Research has shown that the automotive industry, having a high degree of modularity, can produce diesel or petrol, manual or automatic vehicles, etc. on the same assembly line, and that finally many OEMs have opted for « mixed production », that is to say producing BEVs and ICEVs on the same assembly line (Alochet et al., 2023). This is because the assembly of an electric vehicle is ultimately quite similar to that of an ICEV, despite the existence of specific operations. As we will see in the next subsection, organic interactions between digitalisation and electrification exist nonetheless within the vehicle, but mostly due to the incorporation of the electric battery, which requires a complex management system both inside and outside the vehicle.

5.2 The emergence of an European battery industry

The challenge of electrification is closely linked to that of manufacturing electric batteries, as an increase in demand for electric vehicles will also means an increase in demand for batteries. By 2022, 25 battery plants were in operation or have been announced in Europe. It is estimated that by 2030 this will mean 52,000 employees will work in the battery industry (Shade et al., 2022). To this must be added indirect jobs in logistics, recycling, and the manufacture of battery components. We should also note that European carmakers are adopting different strategies regarding the sourcing of batteries. Some, like BMW and Volvo, have opted for a low-control strategy, which involves suppliers the manufacture of the entire battery. Stellantis, Renault and Daimler have a partial control strategy, which involves participating in joint ventures. Finally, BYD, Tesla and VW have opted for a strong control strategy, which includes the manufacture of the cell, the module and the pack (Idem).

The EU is seeking to catch up quickly with its competitors in the USA and especially China, though for example, the European Battery Alliance2. For the moment, Germany and Norway have the most battery production capacity, followed by Italy and France. At the same time, although the development of the battery industry in CEECs is limited compared with Western Europe, some

[2] https://www.eba250.com/

countries such as Hungary and Poland have begun to develop a specialisation in this sector. Conversely, while the Czech Republic and Slovakia have higher vehicle production volumes, other countries have not yet emerged as battery producers, due to a lack of public policies to attract new investment (Heimes, 2022).

Notably, we observe that battery production closely follows the logic of dependence on economic investment and the absence of R&D centres, which is found in vehicle production. For example, in 2021, Hungary was the largest producer of batteries in Europe, accounting for 4% of world production (Czirfusz, 2023). The entire value chain is present in the country, with the exception of mineral extraction and refining, which is mainly dominated by Asian and German companies. In 2021, there was an estimated 14,000 jobs in the battery industry in the country, and it is estimated that more than 30,000 workers will be employed by the entire sector in 2025. In battery production, 72.5% of employees are manual workers, and up to 80-90% in battery pack production. Most shifts are 12 hours a day, with little protection. Wages are also low, as workers rely on bonuses and overtime. However, the sector is facing a labour shortage. At the same time, there is no R&D in the battery industry in Hungary, even though there are some very modern, high-tech facilities alongside a blue-collar workforce.

These dynamics limit the scope for interaction between digitalisation and electrification. CEECs find themselves in the same « familiar position » (Drahokoupil, 2019) in the value chain despite electrification and the emergence of a battery industry in Europe, that of factory economies with limited and selective upgrading. The issue of production cost remains central to electrification, which suggests that the trend towards cost reduction in core countries will continue at the same time as the trend towards offshoring. This is likely to happen despite some efforts to structure national battery industries, aiming for sovereignty in the supply of electric batteries, as the French case shows. The production of ICEVs will continue or even increase in CEECs as manufacturers relocate production to low-cost countries, as core countries will tend to specialise in EVs. At the same time, EVs are also beginning to be produced in the integrated periphery, particularly small and low-cost models.

As mentioned earlier, it is in the electric vehicle, and more specifically in the on-board battery, that we find an organic interaction between digitalisation and electrification. This is because the battery requires a highly sophisticated digital management, the Battery Management System, a complex electronic system for managing and controlling the battery. It monitors the state of charge, battery condition, temperature, battery cells, etc. in real time, collecting data on all these parameters. Added to this is the car's need to connect bi-directionally to the smart grid, which requires an extra degree of connectivity to provide information about the availability of the recharging network. Finally, the fast-charging process also requires an additional software layer for the Battery Management System (Pardi, 2024).

In this section we have described how the electrification of the European automotive industry is developing. We have shown that electrification is highly dependent on the core/periphery structure of the industry, that electrification does not in itself lead to more digitalisation (insofar as the BEV has a production process similar to that of the ICEV), but that the battery is a factor in the increased digitalisation of the vehicle.

6 Discussion: innovation policies in the absence of an industrial policy

We have shown how digitalisation and electrification are structured by the core/periphery relationship in the European automotive industry, and the importance of dissociating the process from the product when it comes to studying the possible interactions between digitalisation and electrification. On the one hand, there are marginal interactions between the two phenomena in terms of the vehicle manufacturing process. In this sense, we can speak of a pragmatic interaction in the case of new factories for BEVs, or the launch of new electric models in existing factories. On the other hand, there are organic interactions in the product itself, as the vehicle becomes an increasingly complex object, particularly because of the electric battery, which requires an advanced digital management system. In this respect, it is difficult to talk about an ongoing « twin transition », insofar as there is nothing intrinsically digital about electrification, just as there is nothing particularly green about digital manufacturing. There are only pragmatic or organic interactions between the two phenomena.

If the « twin transition » has limited empirical foundations, why are some actors adopting this concept? As shown in section 2, the « twin transition » has become become a leitmotif of the European Commission and has been adopted by private actors. It can be argued that this concept has a performative function, aimed as much at describing a phenomenon as at acting on it (McKenzie et al., 2007, Muniesa, 2014, Brisset, 2019). According to the literature on the performativity of economic concepts, their role is to act on the world, rather than describing it. However, this action is far from direct, insofar as it is an action of persuasion or conversion of points of view on the economy that requires multiple mediations in the form of socio-technical mechanisms (for example, in the manner of managerial instruments or investment policies). Moreover, this action is not always successful, and the failures of performance are just as important to analyse as the successes (Brisset, 2017). According to Brisset (2019), in order for a concept to perform with success, 1/ there needs to be a minimum empirical basis that supports the beliefs of economic actors in the usefulness of the concept, 2/ there needs to be a shared belief in the effectiveness of the concept in markets, and 3/ the economic concept needs to be considered as a coherent convention, shared and recognised by the economic actors in a field.

A performativity approach has already been applied to technological change in the automotive industry. This is the case with the « Fourth Industrial Revolution » and Industry 4.0. According to this research, « technological revolutions » can be thought of « political projects that aim at shaping improbable futures » (Pardi et al., 2020). For example, the concept of Industry 4.0 appeared long before any technological change took shape in production sites, because it is a concept that aims above all to create technological expectations and secure investment. Enthusiastic statements about new technologies contribute to their acceptance and to attract investment, regardless of their social or political consequences. This becomes a self-fulfilling prophecy: the belief in a technological revolution encourages the allocation of additional resources for the development of these technologies and the introduction of these technologies into the workplace, in turn reinforcing the idea of a technological revolution. Here, the notion of performativity makes it possible to understand and deconstruct the deterministic premises of I4.0 and digital manufacturing, and to understand why actors believe in concepts with little empirical basis.

The same can be said regarding the « twin transition »: this concept contributes to the belief that « digital technologies provide functions that can catalyse the green transition » (Muench et al., 2022), or that « smart green growth » is not only possible, but desirable. This can be seen in the profusion of this term, first in a large number of documents internal to the European Commission, second in the same international organisations that have promoted the idea of a « Fourth Industrial Revolution » (Leterme, 2019), such as the OECD (Muench et al., 2022), the World Economic Forum, and third in its use by government organisations in the form of reports or roadmaps (French Government, 2021, GIZ, Adelphi, 2022). Finally, fourth, we see it being appropriated by professional organisations of OEMs (ACEA, 2024, VDA, 2023a).

European actors of the automotive value chain need this concept in order to structure industrial policies. Once the concept is institutionalised, it can become an instrument of funding and investment. However, the notion of « twin transition » is facing two problems. First, as a category for policy in the auto industry, the concept has very little empirical basis and doesn't « perform » well in reality (Brisset, 2016). In this respect, it can be compared with the Connected, Autonomous, Shared and Electric (CASE) paradigm, which has been presented as a new dominant paradigm in which new players from the digital economy would reconfigure the balance of power within the automotive value chain (Daum, 2022). At the same time, the structure of the European automotive industry remained the same, while OEMs maintain their hegemony over automotive products and markets, and while the new entrants remain in subordinate positions, whether in mobility services (Uber, Lyft, etc.) or digital services (Google, Amazon), or are going through a major crisis, as in the case of autonomous vehicles (Waymo, Tesla). Only electrification stands out as a transformation with major implications in the CASE paradigm.

Since the Covid-19 pandemic, the concept of « twin transition » seems to be gradually taking over as a paradigm that can bring together the interests of different players in the automotive sector. However, the concept of « twin transition » assumes that digitalisation and electrification are equivalent in terms of importance for work and employment. Without wishing to play down the effects of digitalisation on working conditions, electrification has far more reaching repercussions for work, employment and the regional structure of the European automotive industry than the digital transition, mainly in the creation, destruction, location and quality of jobs. The concept of « twin transition » also assumes that these two phenomena interact, or that one amplifies the other. However, if this is the case, it is mainly in an indirect and pragmatic way. The promoters of these technologies see new investment as a means of increasing digitalisation, but the players closer to the ground also see new technologies as a cost with uncertain or overly long-term benefits.

The modernisation of vehicle assembly lines to produce EVs or the construction of new gigafactories, whether in the core countries or in the integrated periphery, does involve technological investments in new machines and equipment. However, this is a by-product of the green transition, rather than the heart of it. Moreover, while the production of batteries for EVs is announced as a capital-intensive process, with a high degree of automation (Schade et al., 2022), this is perfectly compatible with the use of a vast workforce in poor working conditions. This is particularly true of the battery industry in Hungary (Czirfusz, 2023).

Secondly, for Klebaner and Ramírez Pérez (2022), current EU industrial policy is mainly an innovation policy, because the EU is an economic area, but without a common industrial policy. As far as the automotive industry is concerned, there was no common industrial policy in the 1990s and 2000s, and the policy of the 2010s and 2020s is mainly a policy to support innovation and competition within the Union. More specifically, when it comes to electrification and digitalisation, as we already mentioned, we are talking about policies for innovation, investment and economic support. On the one hand, with an R&D policy for digital manufacturing. On the other, with subsidies on the demand side for electric vehicles, and the development of skills in the battery industry

At a time when the European automotive industry is facing up to the challenges of electrification and international competition, concepts such as « twin transition » are helping to give a semblance of coherence to an industrial policy to support innovation, despite weak empirical foundations. In that sense, the « twin transition » cannot only be analyzed on the basis of its capacity to perform or on the basis of its « disruptive » dimension, especially if its aim is to structure investment in the highly uncertain context of the transition to the EVs. The « twin transition » aims to create a coalition of economic and governmental players to defend their relative positions in the core/periphery structure of the European automotive industry, in the face of new players that threaten these positions, in particular American (Tesla) and Chinese (BYD) firms.

7 Conclusion

In this paper we have described the regional structure of the automotive industry as a dynamic relationship between a core and an « integrated periphery » and how this could be transformed by the potential of a « twin transition ». However, everything seems to indicate that this could deepen the dynamics already observed in the past, where the core continues to specialise in strategic functions and R&D, with a vast affluent market for new vehicles, while the « integrated periphery » will continue to specialise in a factory economy, and in the production of high volume low-cost and low value-added products, as well as dependence on foreign capital.

Digitalisation is contributing to the further fragmentation of value chains (Butollo, 2021), while electrification implies a risk that production of ICEs will gradually shift to peripheral countries, and that some EVs will be allocated to factories in the same countries, reinforcing the dependence of these countries on FDI. Despite the efforts of governments to reindustrialise Western Europe through an active industrial policy (Lechowski et al., 2023), competition on the price of labour will force many manufacturers to produce high-volume EVs or source batteries produced in low-cost countries. Rising vehicle prices due to electrification will put additional pressure on costs, forcing central countries to renegotiate labour costs and/or relocate their production even further to low-cost countries, particularly the low-cost segment (Pardi, 2022). We are therefore likely to see more race to the bottom, where competition between workers in the European automotive sector will continue, this time on the allocation of electric vehicles and battery factories.

We have also demonstrated that there are few interactions between electrification and digitalisation in the automotive industry. The few possible interactions take place at the product level and not at the level of the production process. This leads us to question the institutional uses of « twin transition ». By drawing on the literature on the performativity of economic concepts, we see that this term has a performative vocation, that of structuring investment in a context of absence of coherent industrial policy and increased international competition in the automotive sector.

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