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ELECTRIC VEHICLE REVOLUTION – POSITIONS OF THE JAPANESE AUTOMOTIVE SUPPLIERS IN CENTRAL EUROPE

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Electric vehicle revolution – positions of the Japanese automotive suppliers in Central Europe

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Abstract

Industry trends in recent years have confirmed that the production of electric vehicles in Europe will expand at an unprecedented rate in the coming years. Corporate strategies and new models also reinforce this statement: while maintaining traditional internal combustion propulsion, manufacturers are focusing on the production of electric vehicles. In addition to the emergence of new players, this raises a number of questions about the future and composition of the current supplier system. This working paper examines the role of Japanese automotive companies, focusing on the extent to which electromobility is changing their role in the supply chain. Taking into account short and medium term supply chain and industry trends and the expectations of automotive companies, there are three main factors that will determine the prospects for Japanese suppliers producing in Europe. Declining European production, changing type and quantity of components needed, and last but not least the different strategy of the OEMs and the European support system can displace the overseas companies.

JEL: L23, L62, O33

Keywords: Central Europe, automotive industry, electromobility

1. Introduction

In order to meet of the objectives of the Paris Agreement adopted at the 2015 UN Climate Change Conference, ratifying countries have defined a scenario for reducing greenhouse gases (GHG). Based on a global comparison, the European Union's targets for CO2 emissions are the most stringent (see Figure 1.). In international comparison, the specific CO2 emissions of motor vehicles in the European Union were basically low,

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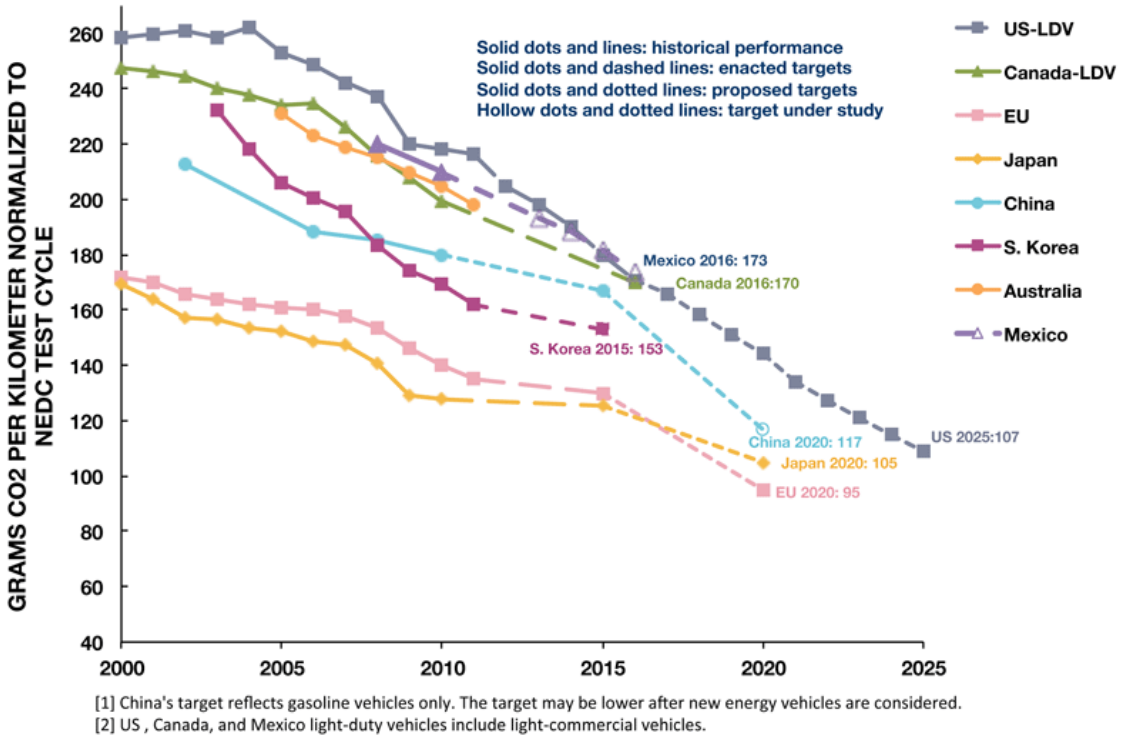
but this was due not only to the more favorable emission values of petrol vehicles, but also to the high penetration of diesel cars (Cames & Helmers, 2013). However, the improving trend is to be reversed. After 2015, European consumers bought fewer diesel cars than before, partly after the Volkswagen diesel scandal and partly due to lower maintenance costs for petrol cars. Fewer diesel car registrations and more SUVs continued to have an impact on CO2 emissions, from 2017, the specific emission values increased.[2] Sport utility vehicles (SUV) and crossover models have traditionally had a high share of the U.S. market (69%), but are also growing in the European market, growing from 8 percent to 38 percent between 2008 and 2019 (Stephan et al., 2019). The biggest winners in the growing market for electric cars and the car market that has been transformed by the coronavirus are undoubtedly the SUVs. Based on data from March 2021, nearly 45 percent of new car sales are internal combustion and electric-powered (plug-in hybrid electric vehicle: PHEV and battery electric vehicle: BEV) SUVs.[3] This process raises an additional problem. Due to their size and shape, these vehicles have higher than average emissions. The consequence of this contradiction is that, although the increase in sales of SUVs has a beneficial effect on the profitability of car manufacturers, their size and weight are distracting the car industry from meeting its emissions targets.

The automotive industry is moving towards electromobility. Due to changing consumer needs, technological change in the automotive industry is inevitable, as the ever-tightening emission limits cannot be met with current internal combustion engines. In the European Union's market, this change began in 2021, as the Commission regulation, which enters into force from 2020, included a one-year phasing out period.

[2] https://www.jato.com/new-car-co2-emissions-hit-the-highest-average-in-europe-since-2014/
[3] https://www.jato.com/european-new-car-registrations-increased-by-63-in-march-2021-but-still-far-from-pre-pandemic-levels/

Figure 1, Historical fleet CO2 emissions performance and current standards (g CO2/km normalized to New European Driving Cycle test) for passenger cars.



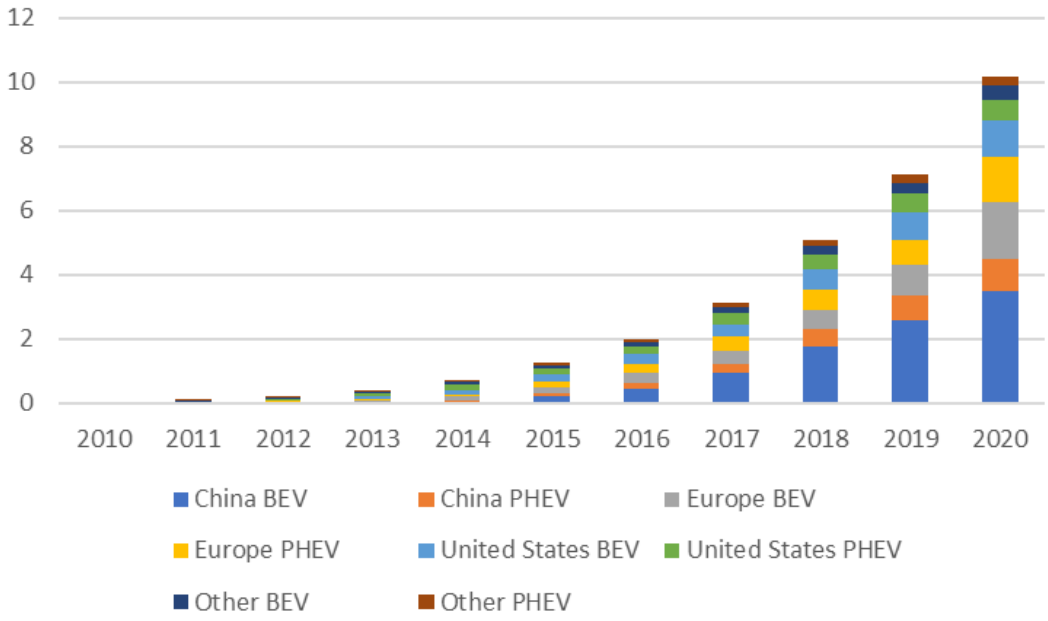
Source: automotive-iq.com based on ICCT data, https://www.automotive-iq.com/powertrain/articles/emissions-regulations-force-manufacturers-across-world-clean-their-act

Currently, automotive companies envisage replacing traditional internal combustion engine (ICE) in the development of electric vehicles based on battery technology. However, in terms of the alternative powertrains, the supply is quite diverse. There are multiple fuel combinations, including ICE hybrids (PHEVs), and hydrogen drive, in order to meet emission regulations and the needs of the market. Looking to the future, car developers (almost all producers such as BMW, GM, Honda, Hyundai, Toyota etc.) are exploring the possibility of fuel cell-based energy storage in addition to battery power storage.

Over the past decade, sales of electric cars have shown steady growth. By 2020, the global passenger car fleet would have exceeded 10 million units. (see Figure 2.). The most significant increase occurred in China and Europe (IEA, 2021). At the same time,

state subsidies play an important role[4] in boosting sales, just as European environmental legislation is moving the market towards carbon neutrality. At the same time, despite the reduction in subsidies in Europe, sales have increased, indicating that electric cars are attractive.

Figure 2, Global electric passenger car stock, 2010-2020



Source: IEA, 2021, p. 7.

The market for electric cars seems promising, while the Covid-19 caused a global car sales drop of 16% in 2020, so the electric car registrations grew by 41% (IEA, 2021). Despite the economic downturn caused by the virus, consumers spent 120 billion USD, 50 percent more than the previous year, on buying electric cars (IEA, 2021).

Due to the change in carbon-neutral transport (phasing out new internal combustion engines cars) by 2035 and compliance with emission regulations by 2050,[5] European automotive industry will phase out ICE production in the mid-term (2030-2035). According to the car manufacturers there are different deadlines phasing out ICE

[4] https://www.just-auto.com/analysis/recovering-china-increases-focus-on-overseas-markets_id199058.aspx
[5] https://ec.europa.eu/commission/presscorner/detail/en/IP_21_3541

vehicles,[6] the change is planned to be implemented from the end of the 2020s until 2040.

2. The transformation of the Central European automotive industry

The automotive industry in Central Europe

Almost all global car OEMs (Original Equipment Manufacturer) are presented in Central Europe. The largest player is the German Volkswagen, but also Asian companies are present (see Table 1.). The Central European automotive industry has shown outstanding development in the last 20-30 years, and it has been also into the global value chains. The region is still attractive among automotive investors. Besides its moderate market potentials, the geographical proximity to the 'Western markets' is also a crucial factor when investing into the Central European countries (Schmitt & Van Biesebroeck, 2013).

There are more than two dozen automotive factories assembling cars, light commercial vehicles and engines in Central Europe[7] in 2021. The output of 3.0 million road vehicles in CE reached 3.9% of the world and 21.8% of the European output in 2020 (OICA, 2021). Production is almost entirely exported, the most important partner is Germany. Production in the region is re-exported to global markets not only directly (e.g. VW Slovakia) but also indirectly. This means that vehicle production in the region is influenced not only by European but also by global demand. In addition to vehicle assembly, the Central European countries – especially Hungary and Poland – have significant internal combustion engine production. In 2020 there were more than 4.7 million units assembled that is a net production surplus of engines, compared to the car production. In Hungary Audi (Volkswagen)[8] and Opel (Stellantis)[9], in Poland Volkswagen[10], Opel (Stellantis)[11], Toyota[12] and FCA (Stellantis)[13] have independent

[6] https://www.euronews.com/next/2021/07/14/when-will-cars-go-fully-electric-the-europe-based-carmakers-dropping-petrol
[7] 8 in Poland, 5 in the Czech Republic, 6 in Slovakia and 4 in Hungary
[8] https://audi.hu/hu/hirek/reszletek/691_stabil_penzugyi_eredmenyek_az_audi_hungarianal/
[9] https://hipa.hu/uj-fejezet-kezdodik-a-szentgotthardi-opel-uzem-torteneteben
[10] https://menadzerfloty.pl/rynek/rosnie-produkcja-silnikow-w-polskich-fabrykach/
[11] Jacobs, A. J. (2017), Automotive FDI in Emerging Europe: Shifting Locales in the Motor Vehicle Industry, Springer
[12] https://www.toyotapl.com/about-us.json
[13] Stellantis (2021): 2021 Stellantis Group in Poland

engine production plants, those not directly connected to the local vehicle assembly, until in the Czech Republic Škoda (Volkswagen), and in Slovakia KIA[14] factories have integrated engine production. While in the field of assembly the factories are flexibly adapting to the technological change[15,16], stopping production of a major unit, like the powertrain, is a serious financial burden.

There are additionally remarkable bus and heavy commercial vehicle factories as well. Poland accounts for almost a quarter of EU bus production, along with major international manufacturers and domestically based companies. Major European manufacturers can all be found, such as MAN and Scania truck and bus factories (belonging to the Volkswagen Group). In addition, the Swedish Volvo and the Spanish-owned Solaris bus and tram factory, as well as the Polish Autosan bus factory. Annual production in 2019 was 19,438 trucks and 5,691 buses (PZM, 2020), making Poland a major player in this vehicle segment in Europe. In the Czech Republic, truck production is represented by the Tatra, which in 2019 produced 1,181 trucks and chassis (tarta.cz 2020). The bus is manufactured at Iveco Bus and the Czech-owned SOR plant. In 2019, 5,182 buses were built at the two plants (Autosap, 2020). Hungarian bus productions are the Hungarian-owned Kravtex and the Chinese BYD. The annual production of the two plants ranges from 300 to 400 units.

Parts and components represent a large part of exports. Except the Czech Republic and Slovakia where the export ratios of the assembled vehicles were 54 and 66 percent respectively, the export of components and parts gave most of the trade (in Poland 60-, in Hungary 62 percent) in the other two countries in 2017 (Túry, 2019). Components are produced not only by local suppliers (Humphrey & Memedovic, 2003), but by the OEMs' affiliates (Nunnenkamp, 2004; Túry, 2017), as we previously mentioned in the case of engine manufacturing.

The production of passenger and light commercial vehicles in the four Central European countries is still dominated by the assembly of internal combustion vehicles and the production of related main parts (engines, transmissions etc.). Recent investments can also bring conventional technologies. While the Indian Tata Motors

[14] Kia Motors Slovakia (2021), Annual Report 2020, Teplicka nad Vahom: Kia Motors Slovakia s.r.o.
[15] https://www.daimler.com/innovation/case/connectivity/full-flex-plant.html
[16] https://www.brand-e.biz/innovation/bmws-first-new-european-plant-in-20-years-builds-evs

owned car manufacturer Jaguar Land Rover Automobile moved U.K. production of Land Rover Discovery to Slovakia, the British plant will be upgraded for electric models.[17] On the other hand, electromobility of the company was outsourced. The first electric model of the company 'I-Pace' is assembled by the supplier company Magna in Austria.[18] In addition to conventional and hybrid models (as an intermediate technology), production is moving in the direction of purely electric drive (see Table 1.). With the shift to electromobility in the automotive industry, the assembly of electric vehicles has begun in Central European factories as well as hybrid-electric models. The transition to electromobility is ongoing, with companies announcing the production of their electrical models one after another.

Transformation of the automotive industry

In order to understand this transition period, broader contexts must also be considered. The necessary resources for the development of electric cars (i.e. R&D activities) should be created. Whether battery-powered or fuel-cell, in the context of technological change, is a challenge for automotive companies at the current low level of profits.[19] Financing the transition to electromobility will be further challenged by meeting stricter emissions standards for vehicles and ultimately, carbon-neutral (zero-emission) transport. According to the Alliance for Automotive Innovation's 2018 compilation, automakers worldwide have invested more than 125 billion USD in research and development for new technology, far ahead of other technology-driven industries such as the software and Internet industries and the entire global aerospace industry and defense industry. [20] Spending on automotive R&D ranks first in the European Union and Japan, leaving behind sectors such as information and communication technology and the healthcare industry, which are usually at the top of the R&D spending rankings. In order to raise funds, in addition to the current unfavorable sales data, it is necessary to consolidate operations. Of the measures, the focus is mainly on workforce reduction measures, as

[17] https://www.theguardian.com/business/2018/jun/11/jaguar-land-rover-to-move-production-of-discovery-from-uk-to-slovakia-jobs-solihull
[18] https://www.magna.com/company/newsroom/releases/release/2018/03/02/news-release---first-ever-all-electric-jaguar-unveiled-at-magna
[19] https://www.dw.com/en/german-car-industry-job-losses/a-54089880
[20] https://autoalliance.org/innovation/

the changes affect far more workers in addition to OEMs through the supplier network. In Germany, a consortium called "Elektromobilität und Beschäftigung" led by Hans-Böckler-Stiftung drew attention to the job-reducing effects of technological change as early as 2012. While the engine and transmission of a conventional vehicle consists of about 1,400 parts, in the case of an electric motor, including the transmission, only 200. As a result, assembling electric cars requires 30 percent less time. This obviously means that fewer workers will be needed today as a result of the change in technology. The German government research group researching future mobility in the Nationale Plattform Zukunft der Mobilität (NPM, 2020) has published a rather pessimistic forecast in 2020. Due to the rationalization measures needed for profitability and the transition to electromobility, in the next decade, nearly half of the automotive jobs in Germany – up to 400,000 jobs – could be lost in the worst case scenario. CAR-Insitut at the University of Duisburg-Essen is expecting 250,000 redundancies, where 125,000 employees can be re-employed through new tasks. In a 2018 report by the German Fraunhofer Institute, by 2030, less than about 75,000 jobs were likely to be lost by the worst-case scenario (Fraunhofer IAO, 2018). Redundancies are therefore to be expected, which, according to the most optimistic forecast, will lead to a reduction in the workforce of at least around 10 percent.

In the case of internationally organized production, this may redraw the geographical pattern of the value chain. In this division of tasks, Central European countries participate in labor-intensive activities (Lung, 2007, Barta, 2012). The assembly-oriented production means, that lower value-added manufacturing functions predominate in the function-based hierarchy of the global value chain (Pavlínek, 2019). The introduction of new technologies for electric cars could therefore have a negative impact on these emerging economies. On the one hand, due to the loss of jobs, and on the other hand, with the emergence of additional labor-intensive and less advanced technologies (battery production, tire production), it may push further the technological catch up. According to a study by Werner and his coauthors (Olle et al., 2020), Germany will gain a decisive advantage in the production of electric cars in the short term (until 2025), while the share of Central and Eastern Europe will fall short of previous values. At the same time, low-cost producer CEE countries can benefit positively from the post-pandemic recovery and the technological change of the automotive industry (McKinsey,

2020). The whole of the Central and Eastern European region will benefit from the development of the R&D activities of European car manufacturers. The production and R&D capacities of the countries in the region, labor supply, advanced infrastructure, competitive wages and state support are the biggest drivers.

The developments announced at OEMs in recent years, the emergence of electromobility in vehicle assembly in Hungary and the developments on the part of suppliers confirm that the transition to electromobility will also influence the Central European car industry, with certain differences in the global and regional strategy of each company. An example of this is Suzuki, which also produces in Hungary and is planning to switch to electric propulsion more slowly than its European competitors (e.g. Volkswagen). At Suzuki in Hungary, they focus on internal combustion models, and according to the company, in the medium term (5-10 years), hybrid propulsion will remain the main role.[21]

Geographical distribution of electric vehicle production does not show a significant difference from traditional ICE models, so there are models that are manufactured also elsewhere, but there are some that are used exclusively here. One example is the relocation of production in Germany, the assembly of the Volkswagen electric LCV (e-crafter) continued in Poland from 2020 onwards.[22]

Because of the growing consumer demand of EVs, there are also investments to increase production in vehicle assembly in the CE countries. PSA's plant in Slovakia, after the French and Spanish production, was the third to start assembly of the group's electric car.[23] This is the second model after the Volkswagen e-UP to be manufactured in Slovakia. In the Czech Republic, Hyundai and Škoda produce electric cars and batteries.[24] In Hungary, in the third quarter of 2021, series production of the electric model was launched at Daimler's Kecskemét plant.[25] In addition to assembly, the transition can also be observed in the production of main units and related supplier parts production.

[21] https://autosajto.hu/2021/06/23/magyar-suzuki-zrt-kozeptavon-a-hibrid-meghajtase-marad-a-foszerep/
[22] https://www.automotivesuppliers.pl/en/poland/production-of-the-e-crafter-begins-in-wrzesnia
[23] https://spectator.sme.sk/c/22210424/psa-showcased-its-new-electric-peugeot-208-in-trnava.html
[24] https://www.skoda-storyboard.com/en/press-releases/skoda-auto-produces-100000th-battery-for-models-with-plug-in-hybrid-drivetrain/
[25] https://hipa.hu/mercedes-benz-will-launch-series-production-of-a-purely-electric-vehicle-in-hungary

Toyota's Polish plant manufactures engine[26] and transmissions[27] for PHEVs. The Audi motor factory in Győr (Hungary) was the first to start the serial production of electric motors in 2018. Hungary's fifth car plant will be built in Debrecen in the eastern part of the country by BMW. The plant was originally scheduled to start production in 2022, but economic uncertainties due to Covid-19 has delayed the investment. In line with current plans, construction of the first service buildings (central office building and training center) will start in 2022, with the plant starting production in 2025, three years later than originally planned (hvg.hu, 2021). The factory, which will have a capacity of 150,000 vehicles, will assemble only electric cars. In Slovakia, PSA sets up battery production[28], and KIA invests in assembly electric and hybrid engines.[29]

The transition to electromobility has begun at the commercial vehicle manufacturers as well. In the case of commercial vehicles (heavy commercial vehicles and buses), significant progress has been made, mainly in bus production, partly due to the elimination of concentrated pollution from intensive urban use, and partly due to demand from significant state and EU supports. The construction and utilization of urban service infrastructure is also more favorable than in the case of outer city road use, which also promotes the spread of electromobility. Central Europe has advanced technological achievement in electromobility in public transport. On the Polish market, electric buses are produced by four companies: Autosan, MAN, Solaris and Ursus.[30] In 2019, 40 percent of the buses manufactured by Polish Solaris were fitted with an alternative drive, and one third were hybrids. In the Polish MAN plant, series production of the electric city bus started at the end of 2020.[31] The Czech company Škoda Transportation have a long history of cooperation in the field of electric busses and self-propelled trolleybuses manufacturing with Polish and Czech bus manufacturer companies. In Hungary, serial production is exclusively carried out at the Chinese BYD Electric Bus & Truck Hungary in Komárom. The Hungarian subsidiary is the second

[26] https://newsroom.toyota.eu/toyota-motor-europe-starts-production-of-new-20l-engine-at-poland-plant/
[27] https://newsroom.toyota.eu/poland-based-toyota-plant-begins-production-of-hybrid-electric-transaxles/
[28] https://www.electrive.com/2019/06/17/psa-sets-up-battery-production-in-slovakia/
[29] https://www.news24.com/wheels/news/kia-invests-r12-billion-in-electric-and-hybrid-engine-plant-amid-ev-demand-20201211-2
[30] https://businessinsider.com.pl/technologie/nowe-technologie/polskie-autobusy-elektryczne-jak-wyglada-rynek-elektromobilnosci/ps7ew6d
[31] https://www.electrive.com/2020/11/26/man-truck-bus-begins-e-bus-production-in-poland/

European manufacturing site alongside the French affiliate. As an additional investment, the Chinese multinational BYD is carrying out a significant expansion of its plant in Hungary: by 2022, the Chinese company will increase the capacity of the Komárom plant fivefold to the current level of about 1,000 buses per year.[32]

Table 1, Car and light commercial vehicle production matrix of the automotive OEMs in CE

Country/manufacturer (number of factories, incl. assembly of commercial vehicle)		ICE			EV			
					(P)HEV		BEV	
		vehicle assembly	transmission assembly	powertrain assembly	assembly starting	components/ parts production starting	assembly starting	compo-nents/ parts production starting
Czech Republic	Skoda (3)	x	x	x	2019	2019	2020	2019
	Hyundai (1)	x	x		2020		2020	
	Toyota (1)	x			2021			
Hungary	Audi (1)	x		x	2020			2018
	Daimler (1)	x					2021	
	Suzuki (1)	x			2019			
	Stellantis (1)		x	x		2023		
Poland	VW (3)	x		x			2020	
	Toyota (2)		x	x		2018		
	Stellantis [Opel] (2)	x		x				
	Stellantis [Fiat-Chysler] (1)	x		x			2022	
Slovakia	KIA (1)	x		x	2019	2020		
	VW (3)	x	x		2020		2013	
	Stellantis [PSA] (1)	x					2019	2019
	JLR (1)	x						

Source: author's compilation based on company reports and press releases

3. Japanese investments in the Central European countries

Trade and investment relations between Japan and the Central European countries incet he 1960s has been given a new perspective by the change of regime and economic opening. After 1989, investments provided opportunities for Japanese companies to enter Western European and former Soviet markets (Bakos, 1992). Japanese firms did

[32] https://magyarbusz.info/2020/11/26/otszorosere-noveli-komaromi-gyaranak-kapacitasat-a-byd/

not participate in the direct privatization, they preferredgreenfield plants instead (Linden, 1998). Higher growth has been observed since the accession to the European Union in 2004 and the years following the global crisis after 2008 (Varga, 2018). Accession to the EU has also reduced investment risk in these countries (Iwasaki & Suganuma, 2009), and Central European production has given Japanese companies the opportunity to enter the European Union.

Regarding the main drive for investment of the Japanese MNCs, efficiency-seeking and market-seeking motivations reason their presence in the CE region. Rationalization of international production and distribution networks by employing skilled and low-cost workforce as well as accessing to the wealthy European markets have key role. Kawai (2006) found that the low investment costs including land costs are favorable externalities and highlighted those investments where suppliers and service providers follow the partner company into the region. Štrach and Everett (2006) also highlighted the importance of the supply-chain linkages in terms of motivation factor. In addition, the active government support of host countries, including investment incentives, also plays a key role in investment decisions (Ikemoto, 2005). The Hungarian examples of Japanese investments support Varga's (2018) finding that government investment incentives and state subsidies provide additional impetus to investment.

In the early 1990s, large investments were made in the manufacturing industry. The most significant was Suzuki's investment in Hungary (Bakos, 1992). The importance of the manufacturing industry continued (Kawai, 2010). and still exists today, although a significant number of companies also arrive in the service sector. The Japanese FDI in Central Europe were concentrated especially in automotive and electronics industry (Ikemoto, 2005, JETRO, 2007, JETRO, 2012).

Despite more than 30 years of presence and expansion of Japanese companies in Central Europe, the region's share in Europe has remained very low. According to the Ministry of Finance Japan (2021), until 2019, the Czech Republic, Hungary, Poland and Slovakia accounted only for 0.8 percent of the total Japanese inward investment in Europe. In terms of share, we cannot expect a breakthrough in the coming years. The 2018 JETRO (Japan External Trade Organization) survey of Japanese companies showed

that the attractiveness of Central and Eastern European countries was declining, while the attractiveness of China and Western Europe was increasing (Marbot, 2020).

From a methodological point of view, it is not easy to estimate the size of Japanese investment, as the largest part of FDI comes through third (intermediary) countries. This is mainly due to a better knowledge of local conditions, which is particularly important for investments made through European countries. In addition, tax optimization also plays a role (Sass et al., 2019). In particular, the role of the Netherlands can be highlighted. In the analysis of the ownership data of the CE subsidiaries, Japanese companies invested often through their Dutch subsidiaries, but sometimes their German or UK subsidiaries are used for expansion (Orbis database, 2021). According to OECD (2021) data, Poland received the largest Japanese capital, followed by the Czech Republic and Hungary, and Slovakia lags significantly behind in the fourth place (see Table 2.).

Table 2, Japanese investment in the CE countries
Foreign direct investment position, inward, million US dollars

	2015	2016	2017	2018	2019
Czech Republic	2,676.8	2,519.3	3,284.3	3,328.8	3,457.2
Hungary	2,282.8	2563	3,186.7	3,248.8	...
Poland	3,759.9	4,118.6	6,167.7	5,286.4	6,177.5
Slovakia	44.2	72.1	127.9	102.8	83.6

Source: OECD (2021): OECD International Direct Investment Statistics 2020, Paris: OECD Publishing

The latest data shows, that there are about 160 Japanese companies operating in Hungary, employing 33,600 people.[33] Until the end of 2008, Japan was the largest direct capital investor among Asian countries. Currently, Japan ranks in the second position after South Korea in the ranking of investments from Asia (MNB 2021). The value of net capital investments exceeds EUR 1.4 billion in 2019.

Although Japanese companies have been present in the Czech Republic since the 1960s, interest in the country has grown since the velvet revolution. As a result, JETRO established its Prague office in 1993. According to the latest data of JETRO Praha, in the

[33] Joint event of the Ministry of Foreign Affairs and Trade, JETRO Budapest and the Embassy of Japan in Hungary on May 30, 2021

beginning of 2021 there were 276 Japanese companies in the Czech Republic creating 51,500 jobs. Of the 276 companies, 108 operate in the manufacturing industry, 63 of which are in the automotive industry. The amount of the total investment (Ministry of Foreign Affairs of Japan 2019) is 3.8 billion USD (cumulative amount as of October 2018), being at the second place, after Germany, among the investors.[34] The Japanese companies invested mainly in the automotive and electronics assembly industry. The Franco-Japanese joint venture, TPCA, was a milestone, the suppliers related to the plant have successively set up their subsidiaries in the Czech Republic.

There were 63 Japanese companies in Slovakia, employing about 13,000 people in 2019.[35]In 2019, there were 300 Japanese companies operating in Poland, employing about 40,000 people. Japan is the 9th largest investor in Poland, the Asian country has invested 10 billion euros by the end of 2018 (Amcham, 2020).

Japanese automotive companies in Central Europe

The first significant Japanese investments were made in the automotive industry (Bakos, 1992). The Japanese Suzuki launched car assembly in Esztergom (30 kilometers north of Budapest) in 1992. The Hungarian factory is the only European production unit of the Japanese company. The factory only carries out assembly activities. The plant is currently assembling internal and mild hybrid models. The significance of the plant lies in the fact that the share of suppliers of domestically owned companies is quite high compared to other OEMs in Hungary (Mészáros, 2009). The share of local suppliers is 36 percent (Urbán, 2011). At the end of the decade, Toyota set up a factory in Poland in 1999 to assemble engines. In 2002, Toyota, together with its French partner PSA, set up a factory in the Czech Republic. Although the size and complexity of the plant cannot be measured for Škoda, this will eliminate the previously 'single-player' Czech car industry. The emergence of OEMs has attracted a significant number of suppliers, including from Japan suppliers (Klauber, 2011). With the development of the Central European automotive industry, traditional suppliers from European and other overseas manufacturers have also emerged. The Japanese suppliers present in the region have

[34] https://www.ceskenoviny.cz/zpravy/advancing-together-with-the-czech-people/2009086
[35] https://spectator.sme.sk/c/22107324/japanese-pm-visits-slovakia-for-the-first-time.html

built intensive technology and manufacturing collaboration with them (based on company data). Employment in the Japanese companies well indicates this supplier relationship. The Czech employment figures of Japanese companies are much higher than in Hungary, which is due to the better opportunities created by OEMs in the Czech Republic. Furthermore, the extent of supplier relationships is also affected by acquisitions and mergers. A number of Japanese companies have acquired traditional (European) manufacturers (e.g. Magnetti Marelli, Pilkington) with which they have had the opportunity to further expand their supplier relationships.

Based on the list of Japanese automotive companies operating in Central Europe (see Table 3.), we can make the following findings. We have headcount data for a total of 110 companies, which is 74 percent of all companies surveyed. The majority of companies (54%) are large enterprises, 35 percent are medium-sized companies, and only 8 percent are small businesses or newly established (e.g. GS Yuasa, Mitsui High-tec). In addition to the production of plastic and metal parts (production of body parts), many companies manufacture parts for internal combustion engines. Examining the supply chain relationship system of Japanese companies, it can be concluded that there is a significant embeddedness in the supply chain of current internal combustion cars production. They have an intensive and long-standing relationship not only with Japanese (Nissan, Toyota, Suzuki), but also with European (BMW, PSA, Volkswagen) and North American (Ford) manufacturers. At the same time, the fact that there are many companies in production of automotive electronics creates an opportunity for them. However, in battery production there are Japanese companies only in Hungary and the Czech Republic. Nevertheless, we can already find examples of the transition to electromobility. In the case of OEMs, alternative propulsion has already started with the production of main units for hybrid cars in Poland. Toyota Motor Poland started production of a hybrid transaxles in 2018.[36] The Suzuki plant in Hungary currently assembles only internal combustion models. The Suzuki Group is also developing electric propulsion, but the company will only appear with electric models from 2030 onwards.[37]

[36] https://global.toyota/en/detail/13958678
[37] https://index.hu/gazdasag/2021/06/22/magyar-suzuki-hibrid-hajtas-elektromos-auto/

Technological change in the automotive industry, especially the transfer to electromobility offers a new opportunity for Japanese companies, primarily through battery manufacturing and related production and R&D activities (Huysveld et al., 2014). Credit Suisse's analysis (2012), however, draws attention to increasing global competition. Further decentralization of production (spreading from Asia to the US and Europe) and competition grows with South Korean and Chinese materials makers will be more challenging for Japanese companies (Yamaguchi et al., 2012). This may also affect the presence of Japanese companies in Central Europe. In recent years, Japanese companies have also invested in the development of electromobility in the CE countries. For example the Japanese Mitsui High-tec automotive parts manufacturer, launched in Poland its first European factory of motor cores for hybrid and electric cars (PAIH, 2019).

Table 3, List of Japanese automotive companies in the CE countries
Hungary

company	est.	products	employment (2021)	location
AEMSS Kft.	2008	automotive components and parts	13	Esztergom
AGC Glass Hungary Kft.	2004	automotive replacement glass	660	Környe
Aikawa Hungária Elektronikai Kft.	1998	metal stamping and metalworking, tool making	193	Dunaújváros
Alpine Európai Elektronikai Ipari Kft.	1998	car electronic component (audio and navigation systems)	1011	Biatorbágy
Bridgestone Tatabánya Termelő Kft.	2005	rubber tyres	1147	Tatabánya
Clarion Hungary Electronics Kft.	1998	car audio equipment	278	Nagykáta
Denso Manufacturing Hungary Kft.	1997	diesel common rail systems, VCT/OCV, EGRV and EGTS	3772	Székesfehérvár
Diamond Electric Hungary Kft.	2000	car electronic components	139	Esztergom
Eagle Industry Hungary Kft.	2010	fuel valves for petrol cars	152	Maglód
Enmech Hungary Kft.	1997	components for batteries and the sensors of self-driving cars	466	Pécel
Exedy Dynax Europe Kft.	1993	clutch disks for vehicle's transmission	177	Tatabánya
GS Yuasa Magyarország Kft.	2017	lithium-ion batteries	45	Miskolc
Hi-Lex Hungary Kft.	2007	shift cable, parking brake cable, clutch cable and front and rear window assembly	250	Rétság
Ibiden Hungary Kft.	2004	automotive ceramic products (diesel particulate filter, automotive functional product)	2850	Dunavarsány
JSR MOL Synthetic Rubber Zrt.	2013	synthetic rubber for tyres	146	Tiszaújváros
Magyar Suzuki Zrt.	1991	car assembly	10000	Esztergom
Mitsuba Automotive Systems of Europe Kft.	2001	automotive electronic equipment	427	Salgótarján
Musashi Hungary Füzesabony Kft.	2000	metalworking (brakes etc.)	114	Füzesabony
Musashi Hungary Ipari Kft.	2000	metalworking (steering and engine parts)	197	Ercsi

Cont. Table3. / Hungary

company	est.	products	employment (2021)	location
NHK Spring Hungary Kft.	2015	coil springs and stabilizer bars	271	Tata
Nidec Gpm Hungary kft	1992	oil and water cooling pumps for automobile engines and transmissions	191	Bercel
Plastimat Magyarország Kft.	2005	exterior and inteior plastic parts	150	Esztergom
Sanoh Magyar Kft.	2006	automotive parts	232	Esztergom
SEI Interconnect Products (Hungary), Kft.	2001	flexible flat cable (FFC) and cable assembly (CBA) for automotive	218	Alattyán
Seiren Hungary Kft.	2021	automotive interior (textile)	-	Pécs
SEWS Autókábel Magyarország Kft.	2003	electric cable	108	Kisbér
SEWS Components and Electronics Europe Kft.	2002	electrical components	726	Mór
Shinwa Magyarország Precíziós Kft.	1998	parts for automotive electronics	524	Miskolc
SIIX Hungary Kft.	2016	electrical components	282	Nagykőrös
Stanley Electric Hungary Kft.	2001	automotive lighting parts and other electronic products	245	Gyöngyös
Summit D&V Kft.	1993	assembly of automotive parts (brake tubes, fuel tubes, other tubular parts) for Magyar Suzuki Zrt	155	Esztergom
Taiho Corporation Of Europe Kft.	2000	metal parts for cars	171	Újhartyán
TDK Hungary Components Kft.	1994	electronic components for "smart car applications"	2312	Szombathely
Toray Industries Hungary Kft.	2018	battery separator film (BSF)	119	Nyergesújfalu
Toyo Seat Europe Kft.	2002	metal seat frames for cars, seat assembly	313	Százhalombatta
Ts Tech Hungary Kft.	2013	seats and interior accessories	46	Százhalombatta
U-Shin Europe Kft.	2000	lock sets, climate control, latches	360	Kisbér
Zoltek Zrt.	1985 (2014)	carbon fiber	1397	Nyergesújfalu

Source: JETRO Budapest 2014 and author's data collection

Czech Republic

company	est.	products	employment	location
Advanex Czech Republic s.r.o.	2018	engineering support for customers from the development stage to the mass production stage		Kněževes
Advics Manufacturing Czech s.r.o.	2014	car brake caliper	145	Písek
AGC Automotive Czech a.s.	1996	automotive replacement glass	1750	Bílina
AGC Automotive Replacement Glass Czech s.r.o.	1991	vehicle repair and maintenance	37	Teplice
Aisan Industry Czech, s.r.o.	2000	components for car and motorcycle fuel systems, air intake systems and exhaust systems	750	Louny
Aisin Europe manufacturing Czech s.r.o.	2002	engine parts	750	Písek
ALPS Electric Czech, s.r.o.	1995	electronic components and automotive infotainment		Sebranice u Boskovic

Cont. Table 3. / Czech Republic

company	est.	products	employment	location
Aoyama Automotive Fasteners Czech, s.r.o.	2002	production of metric bolts	408	Lovosice
Automotive Lighting s.r.o.	1997	production of automotive lighting technology car light lights	1750	Jihlava
AVX Czech Republic, s.r.o.	1992	production of tantalum capacitors	2500	Lanškroun
BBH Tsuchiya s.r.o.	1992	manufacture of dashboard dials (speedometers, tachometers)	150	České Budějovice
BENET AUTOMOTIVE s.r.o.	1993	manufacture of interior, exterior and body parts	394	Mladá Boleslav - Čejetice
Cataler Europe Czech s.r.o.	2018	manufacture of automotive catalysts (fuel cell globally)	37	Týniště nad Orlicí
Central Glass Czech s.r.o.	2017	manufacture and sales of electrolyte for lithium-ion batteries	75	Prague
Daido Metal Czech, s.r.o.	2005	manufacture of plain bearings	375	Brno
DAIHO CZECH s.r.o.	2000	interior plastic parts for automotive		Plzeň
DAIHO Schenk s.r.o.	2003	interior plastic parts for automotive		Liberec
DENSO Czech s.r.o.	2004	manufacture of electric motors and wiper systems for automotive	245	Zruč nad Sázavou
DENSO Manufacturing Czech s.r.o.	2001	manufacture of car air conditioners, evaporators, condensers, and radiators	2750	Liberec
Excell Czech, s.r.o.	2014	manufacture of rubber and plastic products		Plzeň
Fuji Koyo Czech, s.r.o.	2002	production of steering column		Plzeň
Fujikoki Czech s.r.o.	2001	manufacture of thermostatic expansion valves for car air conditioners	336	Louny
Fukoku Czech s.r.o.	2014	manufacture of rubber products (dust cuffs for the automotive industry)	37	Lovosice
Furukawa Electric Autoparts Central Europe, s.r.o.	2001	manufacture of SRC (Steering Roll Connector) modules, electrical parts of the car airbag system		Unhošť
Futaba Czech, s.r.o.	2002	production of body parts, chassis and exhaust systems	1000	Havlíčkův Brod
Harimatec Czech, s.r.o.	2007	production of aluminium parts for car heat exchanger	15	Zdiby
HI-LEX Czech, s.r.o.	2017	production of electromechanical devices and control cables	150	Most
Hitachi Astemo Czech, s.r.o. (Hitachi Automotive Systems Czech, s.r.o.)	2006	production of auto shock absorbers for automotive industry		Žatec
Hitachi Cable Europe, s.r.o.	2013	production of cables and electrical hand brakes for automotive industry	150	Žatec
Ishimitsu Manufacturing Czech s.r.o.	2003	production of small machine parts for automotive engines		Louny

Cont. Table 3. / Czech Republic

company	est.	products	employment	location
JCEE, s.r.o.	1992	production of machines for automation, mechanization of production processes for automotive industry		Lanškroun
JSP International, s.r.o.	2004	production of plastic workpieces		Cheb
JTEKT Automotive Czech Pardubice s.r.o.	2003	production of metal (mechanical) parts		Pardubice Staré Čívice
JTEKT Automotive Czech Plzen s.r.o.	2002	production of car steering systems		Plzeň-Skvrnany
Kayaku Safety systems Europe a.s.	1999	manufacture of pyrotechnic initiation elements used in passenger car safety systems	1000	Jablůnka, Vsetín
KD TEC s.r.o.	1997	manufacture of pyrotechnic initiators and gas generators for passive protection modules in cars	110	Kdyně
Keihin Thermal Technology Czech, s.r.o.	1997	manufacture of automotive air conditioning condensers and radiators		Kladno - Kročehlavy
Koito Czech, s.r.o	2001	manufacture of lighting equipment (headlights)	1250	Žatec
Koyo Bearings Česká republika s.r.o.	2000	production of bearing rings and assembly of bearings		Olomouc
Kuraray Europe Moravia s.r.o.		manufacture of rubber product	67	Holešov
KYB CHITA Manufacturing Europe s.r.o.	2006	production of springs for shock absorbers	65	Chrudim
KYB Manufacturing Czech s.r.o.	2003	manufacture of car shock absorbers		Pardubice
LIPLASTEC s.r.o.	2002	production of injection molding die for automotive companies	170	Liberec
Mektec Manufacturing Corporation Europe CZ s.r.o.	1997	manufacturing and Sales of flexible printed circuits(FPC)	600	České Budějovice
Mi-King s.r.o.	2004	metal processing		Kolín
Mitsubishi Electric Automotive Czech, s.r.o.	2000	manufacture of electrical rotating and electronic components for the automotive industry	750	Slaný
Muramoto Manufacturing Europe s.r.o.	2005	metal components for the automotive industry	170	Žebrák
Nachi Czech s.r.o.	2003	production of special bearings for the automotive industry	67	Louny
Neturen Czech s.r.o.	2014	hardened steel wires for the production of springs further used in the automotive industry	37	Žatec
Nichias Autoparts Europe a.s.	2004	production of seals and brake pads for the automotive industry		Mikulov
Nippon Paint Automotive Coatings (Czech) s.r.o.	2015	coating system for cars	26	Kolín
Nippon PGM Europe s.r.o.		recycling of Platinum Group Metals from spent autocatalysts, industrial catalysts, etc.	11	Liberec
Nitto Denko Czech s.r.o.	2007	Production of reinforcing and damping parts for cars	117	Brno
NPK Europe Mfg. s.r.o.	2001 (1961)	production of demolition and wrecking devices for construction machineries	100	Uhřínov

Cont. Table 3. / Czech Republic

company	est.	products	employment	location
OBARA s.r.o.	2016	production of spot resistance welding tip holders	3	Chrudim
Otsuka Brano s.r.o.	2010	production of handbrake levers, brake pedals and clutches	76	Olomouc
Panasonic Automotive Systems Czech, s.r.o.	2000	manufacture of car audio-visual equipment		Pardubice
proseat Mladá Boleslav s.r.o.	1997	production of moulded foam		Mladá Boleslav - Plazy
Steel Center Europe, s.r.o.	2004	production of rolled steel products	100	Humpolec
SumiRiko AVS Czech s.r.o.	2017 (1995)	manufacture of automotive vibration control technology products		Újezd u Valašských Klobouk
T. Rad Czech s.r.o.	2004	production of heat exchangers		Unhošť
Takada Industries Czech Republic, s.r.o.	2002	production of plastic parts for injection molding	111	Louny
TDK Electronics s.r.o.	2009 (1989)	production of electronic parts among others for cars (ferrites, piezo and protection devices)	1238	Šumperk
THK RHYTHM AUTOMOTIVE CZECH a.s.	1993 (1961)	production of vehicle suspension system	850	Dačice
Toray Textiles Central Europe, s.r.o	1997	production of polyamide technical fabric for airbags	353	Prostějov
Toyoda Gosei Czech, s.r.o.	2001	production of airbag module, plastic parts of steering wheel, and interior and exterior sealing and insulation	1500	Klášterec nad Ohří
Toyota Motor Manufacturing Czech Republic, s.r.o.	2021 (2002)	auto assembly	3500	Kolín - Ovčáry
TRCZ, s.r.o.	2001	production of seat belts, drivers, switches and other electronics	1051	Lovosice
Tsubaki Automotive Czech Republic s.r.o.	2015	manufacture of timing chain drive systems		Kolín - Ovčáry
UACJ Extrusion Czech s.r.o.	2002	production of aluminium multi-purpose tubes for evaporators and condensers for air conditioning in cars	195	Benátky nad Jizerou

Source: author's compilation based on JETRO Praha (2021)

Poland

company	est.	products	employment	location
AGC Glass Poland Sp. z o.o.	2001	automotive replacement glass	250	Koszalin, Słupsk
AKS Poland Sp. z o.o.	2005	processing of aluminum, brass, plastic, steel, etc.	80	Swinoujscie
Daicel Safety Systems Europe Sp. z o.o.	2004	airbag inflator	350	Żarów
Denso Thermal Systems Poland Sp. o.o.	1997	HVAC, heaters, cockpit modules and front end modules		Tychy
Fuji Seal Poland Sp. o.o.	2005	production of plastic products	450	Kutno
Joyson Safety Systems Poland Sp. z o.o. (Takata Parts Poland Sp. o.o.)	1994	seat belt assembly, airbag module production	600	Krzeszów
Jtekt Europe Bearings B.V. Sp. z o.o.)	2009	production of bearings, gears, gears and drive elements		Sosnowiec
Mitsui High-Tec (Europe) Sp.z o.o.	2018	prodcution of motor cores for hybrid and electric cars	n.a.	Skarbimierz
NGK Ceramics Poland Sp o.o.	2003	manufacturing of ceramic filters	3700	Gliwice
NGK Ceramics Poland Sp o.o.	2016	manufacturing of ceramic filters	1300	Dąbrowa Górnicza
Nidec Motors and Actuators Sp. z o.o.	2008	manufacturing of automotive motors	400	Niepołomice
Nifco Poland Sp. o.o.	2006	manufacturing of plastics products	302	Swidnica
Nifco Korea Poland Sp. z o. o.	2010	manufacturing of plastics products	270	Zory
NSK Polska Sp. z o.o.	2001	metalworking (ball bearing)	40	Kielce
Pilkington Automotive Poland Sp. z o.o.	1997	automotive replacement glass	2180	Sandomierz
Poland Tokai Okaya Manufacturing Sp. z o.o..	2006	manufacuring of stamped metal parts	300	Łysomice
Proseat Sp. z o.o.	1993	production of trim parts		Bielsko Biała
Sanden Manufacturing Poland Sp. z o.o.	2005	automobile compressor and automobile air-conditioning	1144	Polkowice
Sews-Cabind Poland Sp. z o.o.	2001	wiring harnesses for the automotive industry	1262	Żywiec
Sumitomo (SHI) Demag Plastics Machinery Polska Sp. z o.o.	1999	mechanical engineering		Czestochowa
Toshiba Carrier Air-Conditioning Europe Sp. z o.o.	2020	heating, ventilating and air-conditioning machines		Gniezno
Toyo Seal Poland Sp. z o.o.	2000	rubber product manufacturing	100	Tychy
Toyota Motor Manufacturing Poland Sp. o.o.	1999, 2002	engine and transmission assembly	3340	Wałbrzych, Jelcz-Laskowice
Toyota Boshoku Poland Sp. z o.o.	2008	motor vehicle parts and accessories	1000	Wykroty
Toyota Tsusho Europe SA Branch		wholesale	121	Bielany Wrocławskie
SumiRiko Poland Sp. z o.o.	2002	engine suspension, body and exhaust system, as well as polyurethane covers and engine covers		Wolbrom
SumiRiko Poland Sp. z o.o.	2013	engine suspension, body and exhaust system, as well as polyurethane covers and engine covers		Zagórze
Yagi Poland Factory Sp. z o.o.	2003	metal processing	170	Żarów
YAZAKI Automotive Products Poland Sp. z o.o.	2002	manufacturing of wire harness		Mikołów

Source: author's compilation

Slovakia

company	est.	products	employment	location
Akebono Brake Slovakia s.r.o.	2014	assembly of brake caliper	268	Trenčín
G-TEKT Slovakia, s.r.o.	2017	production of automobile body components		Nitra
Marelli PWT Kechnec Slovakia s.r.o.	2007	production of electronic systems (dashboards, navigation systems and on-board computers) and powertrain (throttles, suction manifolds and GDI/high pressure pumps)	200	Kechnec
Minebea Slovakia s.r.o.	2016	production of electric motors	251	Košice
Panasonic Industrial Devices Slovakia s.r.o.	1997	control boards, charger, car speakers, car switches and sensors, power supplies	1150	Trstena
		control boards, AMP, wireless modules	930	Hniezdne-Stará Ľubovňa
SIIX EMS Slovakia s.r.o.	2001	manufacture of semiconductor and other electronic component		Nitra
U-Shin Slovakia s.r.o.	2013 (2006)	production of latches, handles and locksets	1300	Košice

Source: author's compilation

4. Technological development in the automotive industry

Battery production

There are encouraging developments in the region's connection to new technologies development. To meet the growing demand for electric vehicles in Europe, companies have announced measures to increase production. In addition to investments in vehicle assembly (see above), significant investments have been made in components and main parts manufacturing. The emergence of new investments, mainly related to electromobility, will also notably redraw the production map in the region. In recent years, large number of investments have been made in electric vehicle's battery production (see Table 1.).

Central Europe plays an important role within the European production. Battery producing companies are investing heavily in the CE region. , With the European demand increasing, by 2025 Europe will have significant production capacity in four countries, two of which will be in Central Europe (McKinsey, 2019). Poland will play the leading role in the production of about 45 GWh of batteries, followed by Sweden with 32 GWh, Germany with 27 GWh and finally Hungary with 23.5 GWh. According to the

summary of the Hungarian Investment Promotion Agency (HIPA), Hungary has received 6.2 billion euros in capital investment in battery production in the last three years (HIPA, 2021). Based on the list of independent electric vehicle battery manufacturers (see Table 4.), Poland and Hungary are the main producers, Poland was the biggest exporter of lithium-ion batteries in Europe in the first quarter of 2019.[38] If the production of electric vehicles continues to grow, the Czech Republic and Slovakia still have plenty of room for growth in terms of investments. In Central Europe, the battery value chain is almost exclusively dominated by companies from Asia, with a particularly high share of Korean companies (see Table 4.). In addition to the largest Tier 1 companies (battery manufacturers), suppliers follow their partners from South Korea.

The production of Asian battery companies is not only dominant in Central Europe and throughout Europe, but also has a significant share within global vale chains (Lebedeva et al., 2017, Sharova et al., 2020). The development strategy of the battery producers meet the increasing demand in Europe, more and more European manufacturers are announcing ambitious plans[39] for the production of electric cars.[40] Therefore many battery companies announced further developments in order to increase their current production. Not only Europe's largest lithium-ion battery factory[41], but a significant part of Polish battery production is provided by LG Chem's Gigafactory near Wroclaw. In addition, European companies like the Swedish company Northvolt is building its facility in Gdansk. The second biggest production site among the four Visegrad countries is in Hungary. There are three battery manufacturers: 1. the GS Yuasa Corporation of Japan, which has established its first European factory in Miskolc. 2. Samsung SDI from South Korea, which converted and then expanded its existing plant in Göd, and 3. SK Innovation from South Korea, which launched production in Komárom and began building another plant in Iváncsa. With the completion of the investment, the new plant will supplement the production capacity of 17 GWh of the two plants in Komárom with an annual production of 30 GWh.[42] In the Czech Republic there are only two companies, one is the US-based, Chinese owned A123 Systems and the other is the

[38] https://www.energy-reporters.com/storage/poland-looks-to-create-car-battery-hub/
[39] Only Volkswagen plans to produce 3-4 million BEV per year from 2025 onwards.
[40] https://www.dw.com/pl/gigafabryka-vw-w-%C5%9Brodku-europy-spore-szanse-polski/a-56944774
[41] https://tsse.arp.pl/en/aktualnosci/lg-chem-is-building-a-new-factory2
[42] https://hipa.hu/giga-beruhazast-indit-az-sk-innovation-minden-idok-legnagyobb-zoldmezos-beruhazasa-ivancsan

Czech He3da. In addition, the Czech government and the largest energy supplier ČEZ (České Energetické Závody), signed an agreement to invest in the project, building a Gigafactory with an annual production capacity of 40 GWh.[43] The Slovakian company InoBat Auto, together with the U.S. company Wildcat Discovery Technologies, announced that they will establish an R&D and production unit in Slovakia. Due to the pandemic, the plant will start operating in 2022, a year later than planned.[44] As an additional investment InoBat Auto plans to build a 10 GWh factory in 2024.[45]

In addition to long-term agreements with external suppliers, several automakers want self-manufactured (in-house production) batteries. In 2019, the French PSA (belongs to Stellantis Group) also announced that batteries for its hybrid and electric cars will start assembling at its Slovakian plant in Trnava.[46] There are other OEMs and suppliers producing batteries for battery electric vehicles (BEV). For instance, in 2019 Daimler announced that it will build a new factory supplying for its new 'EQ' BEV family. Volkswagen also plans to set up its own Gigafactory – partly because of Tesla's European plant – Poland also has a good chance of possible location.[47]

Analyzing the European and the global battery production, many scholars (COBANK 2018, Horowitz et al. 2021) pointed out that Europe is lagging in the development and production of battery technology. The market is dominated by three countries, China, the United States and Korea. In addition, China's share of its own accounts for 74 percent of capacity, which is a leading position in manufacturing and development. The predominant, almost exclusive, presence of overseas investors is also characteristic for Central European production capacities. The dominance of South Korean investments can be observed in the region, not only the Tier 1 level, but in the case of the supplier companies as well.

[43] https://www.cez.cz/en/media/press-releases/the-first-step-to-towards-the-construction-of-the-gigafactory.-the-mit-and-cez-sign-a-memorandum-147566
[44] https://www.automotiveworld.com/news-releases/inobat-construction-begins-on-first-of-its-kind-electric-vehicle-battery-technology-centre-and-pilot-line/
[45] https://www.electrive.com/2020/07/02/inobat-auto-is-planning-a-10-gwh-cell-plant-in-slovakia/
[46] https://www.reuters.com/article/us-peugeot-batteries-slovakia-idUSKCN1TF1NG
[47] https://www.dw.com/pl/gigafabryka-vw-w-%C5%9Brodku-europy-spore-szanse-polski/a-56944774

Table 4, independent electric vehicle battery manufacturers and related suppliers in the CE countries

	company	country of orig.	products	location	year of investment
CZ	HE3DA	Czech Republic	battery factory	Horní Suchá	2015
	A123 Systems	China	battery factory	Ostrava-Hrabová	2016
HU	SK Innovation	South Korea	battery factory	Komárom	2018
				Iváncsa	2021
	Samsung SDI	South Korea	battery factory	Göd	2017
	GS Yuasa	Japan	battery factory	Miskolc	2019
	Inzi Controls	South Korea	battery parts	Komárom	2020
	Suppliers				
	Semcorp	China	battery separator foil	Debrecen	2021
	Solus Advances Materials/Doosan	South Korea	copper foil factory	Tatabánya/Környe	2020
	Toray/Zoltek	Japan	battery separator foil	Nyergesújfalu	1995
	Soulbrain	South Korea	electrolyte	Tatabánya	2021
	Mektec/enmech	Japan	battery parts	Pécel	2020
	Sangsin EDP	South Korea	battery frames	Jászberény	2018
	KDL Shenzhen Kedali Industry	China	battery parts	Gödöllő	2021
	Iljin Materials	South Korea	copper foil factory	Gödöllő	2021
	Dongwha	South Korea	electrolyte and recycling	Sóskút	2021
	Shinheung Sec	South Korea	battery frames	Monor	2019
	SungEel Hitech	South Korea	Battery recycling	Szigetszentmiklós	2017
	Bumchun Precision	South Korea	Aluminium battery terminals for electric vehicles	Salgótarján	2018
	Lotte Aluminium	South Korea	Aluminum anode foils	Tatabánya	2019
PL	LG Chem	South Korea	battery factory	Kobierzyce-Wroclaw	2005
	SK Innovation	South Korea	Lithium-ion Battery Separator (LiBS) and Ceramic Coated Separator (CCS)	Dąbrowa Górnicza	2018/2020/2021
	Nara Mold & Die Co.	South Korea	battery parts	Bielany Wrocławskie	2018
	Foosung	South Korea	electrolyte	Kędzierzyn-Koźle	2019
	Enchem	South Korea	electrolyte	Wroclaw	2018
	Umicore	Belgium	cathode materials	Radzikowice-Nysa	2018
	Johnson Matthey	UK	cathode materials	Konin	2021
	Northvolt	Sweden	battery factory	Gdańsk	2019
	JOYNEXT	Germany	battery control unit	Oborniki	2016
SK	InoBat Auto, Wildcat Discovery Technologies, Matador Group	Slovakia-U.S.	battery factory	Voderady	2019

Source: author's compilation

This technological and manufacturing gap of the European battery industry has already been recognized at EU level. According to the EU Commission[48] there is a need for more than ten Gigafactories in Europe by 2025 and 20-30 by 2050 to fulfil the demand for batteries in the EU. There are U.S., Japanese, South Korean and Chinese investment in Europe. This dependence also makes European carmakers vulnerable in terms of technology and supply, so far only Northvolt and Varta announced large investments (i.e. Gigafactories) so far to meet the needs of European carmakers in the future.

Connection to new mobility solutions

Technology change affects both the product portfolio and the organizational structure of companies. The German tire manufacturer, Continental, will focus on market developments and customer needs, and from 2022 onwards will restructure its organization[49] to focus on electric cars and new forms of mobility, including self-driving. This will lead to a significant transformation of the company's global production, with signs already visible in the Central European region, where significant research and development activities are taking place (Túry, 2019).

As McKinsey (2020) writes, the technology shift could generate significant R&D activity in the region, partly by existing companies and partly by new entrants. There is a good practice for research cooperation between entrepreneurs and universities. The cooperation between Audi and the Széchenyi University in Győr in education and R&D dates back to a long time. A research consortium from Budapest University of Technology and Economics, Institute for Computer Science and Control (Hungarian Academy of Sciences), Bosch, a Knorr-Bremse and Continental for autonomous vehicle development. The German Thyssenkrupp also carries out research in autonomous vehicle development in the center of R&D in Hungary.[50] In the Czech Republic Škoda has a unique position, although Škoda's in-house research and development activities would be transferred to Volkswagen's center in Germany, only design activities remaining at

[48] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52019DC0176&from=EN
[49] https://www.continental.com/en/press/press-releases/20210930-supervisory-board-meeting/
[50] https://www.thyssenkrupp.hu/en/component/content/article/16-news/422-sneak-peek-into-the-future-of-steering-press-day-in-hungary

the Czech company (Pavlínek, 2015). Together with the other companies in the Volkswagen group, Škoda also makes significant moves towards electromobility. Škoda 'Vision E' being the basis of an electric car will be launched by 2020 (Škoda, 2018). They do not only produce electric motors and electrical components but also a purely electric-drive vehicle at the Mladá Boleslav and Kvasiny plants to cover the needs of Škoda and the Group as a whole.

Production and development strategies of automobile manufacturers

EU regulation, which is phasing out internal combustion engines, has prompted manufacturers to accelerate the transition to electromobility. In the recent period, manufacturers have announced significant improvements, as well as ambitious plans for the number of new models to be introduced, as well as a target date for carbon neutrality. As a result, high amount of research and development expenditures have been realized in the automotive industry.[51] The introduction of new electric vehicles and the rise in electric car registrations in Europe, is an opportunity for battery cell suppliers. At the same time, the European development plans and the strategies published by the companies foresee a growing role for European Tier 1 battery producers. However, this does not necessarily mean the displacement of Tier 2 and 3 suppliers outside Europe.

Table 4, Top 5 automotive R&D spenders and major European automotive companies (during fiscal year 2020)

company	revenue	R&D spending	
		nominal	% of revenue
Volkswagen	$ 216.77 billion	$ 16.5 billion	7.61
Daimler	$ 182.97 billion	$ 10.21 billion	5.58
Toyota	$ 256.7 billion	$ 9.87 billion	3.85
Ford	$ 127.14 billion	$ 7.1 billion	5.58
General Motors	$ 122.48 billion	$ 6.2 billion	5.06
Renault Group	$ 53.108 billion	$ 3.358 billion	6.32
BMW	$ 120.926 billion	$ 6.950 billion	5.75

Source: https://www.nasdaq.com/articles/automobile-companies-and-rd%3A-top-5-spenders-2021-07-14 and https://www.fdiintelligence.com/article/79672

[51] https://www.acea.auto/figure/rd-investment-by-top-10-industrial-sectors-in-eu/

As a result of the coronavirus crisis, not only have car manufacturers' revenues fallen, but R&D spending has been lower than in the previous years. The Renault Group's 2020 revenues and R&D spending both fell 25 percent from the previous year. In contrast, the crisis has affected Volkswagen's major development plans less. The German company is not only the first in R&D expenditure as a proportion of revenue (see Table 4.), but its development expenditures fell less, by only 2.9 per cent, compared to the development of revenues (-11.7%). Volkswagen's spending is not only 1-2 percentage points higher than the average, but also nominally higher than the other automotive companies.

According to Transport & Environment's analysis (2021), only two of the ten major car European manufacturers, Volvo and Volkswagen, are ready to switch to electric cars at a pace that meets the EU's climate targets. Only Volvo and Volkswagen have both ambitious enough targets and a credible plan to achieve them. The analysis shows that Volkswagen leads in terms of strategy and Volvo in terms of unit sales (see Figure 3.)

Figure 3, OEMs ranking according to 'T&E EV Readiness Index'

Carmakers	Electric car ambition* (/50)	Strategy** (/50)	Overall readiness (/100)
VOLVO	41	29	**70**
VW	25	45	**70**
RENAULT	31	26	**57**
HYUNDAI KIA	27	25	**52**
Ford	28	19	**47**
STELLANTIS	22	24	**46**
DAIMLER	17	29	**46**
BMW	23	21	**44**
JAGUAR LAND ROVER	26	16	**42**
TOYOTA	14	21	**35**

Source: Transport & Environment 2021, p. 26.

At the beginning of 2021, Europe's largest automotive company Volkswagen presented its roadmap for climate-neutral mobility.[52] The company will achieve carbon neutrality by 2050 at the latest. At least one electric model per year will be introduced in the coming period, for which purpose the amounts for development will be increased, 14 billion euros will be spent by 2025 on decarbonization. From 2025, every fifth car of the Volkswagen Group will be BEV, which means about 3-4 million cars a year. In addition to the primary goals, such as battery technology development, battery recycling and building global EV charging network, the future is mostly about the capabilities of cars. Additional business opportunities are emerging in areas such as software development and the capability for autonomous driving, as well as mobility services.

In line with the development plan, the company is also making significant investments in battery manufacturing. It plans to build six Gigafactory in Europe by 2030, with a capacity of up to 240 gigawatt hours.[53] Volkswagen will spend a total of 41.7 billion USD on e-mobility by 2025. The factories will operate in joint production, similar to the (joint) Gigafactory of Tesla and Panasonic in Sparks, Nevada. The Volkswagen signed a strategic agreement with the Swedish Northvolt for a joint research a development as well as production.[54] As part of the agreement, Volkswagen has increased its stake so far to 20 percent in Northvolt. The capacity of Skellefteå (Sweden) factory will be expanded up to 40 GWh. The second unit will be in Salzgitter (Germany), as a 50-50 percent joint venture of the Volkswagen AG and Northvolt AB. The third would operate from 2026, with the potential for sites in Portugal, Spain or France. The next one would work from 2027, here the Czech Republic, Slovakia or Poland could be considered. The following two plants will be set up by 2030.

Volvo announced its latest development plans for electromobility in early 2021.[55] The company's aim is to become a leader in the fast-growing premium electric car market and will therefore be present on the market exclusively with pure electric cars from 2030. The company has recently withdrawn from the compact/small family car

[52] https://www.volkswagenag.com/en/news/2021/04/way-to-zero--volkswagen-presents-roadmap-for-climate-neutral-mob.html
[53] https://www.reuters.com/article/us-volkswagen-batteries-plants-idUSKBN2B71EW
[54] https://www.electrive.com/2019/05/15/vw-turns-to-northvolt-for-battery-cells/
[55] https://www.media.volvocars.com/global/en-gb/media/pressreleases/277409/volvo-cars-to-be-fully-electric-by-2030

segment, after the launch of the V40 and S40/V50. The company's ambitious plans thus make sense in the premium and high-end segment.

In order to achieve full electromobility, Volvo is investing heavily in innovation and production. A research and development joint venture with the Swedish Northvolt (50/50) would be operational from 2022.[56] It is envisaged that the new types of batteries developed here could give electric vehicles (EVs) a range of more than 1,000 kilometers, and the company is also looking at technologies that would enable rapid charging of these vehicles. The production of the batteries needed for manufacturing would also be kept in-house, for which the joint venture also plans to set up a battery factory in Europe with a production capacity of 50 GWh.

According to the Transport & Environment (2021), the French-Japanese Renault group is in third place. The Renault Group signed two agreements for EV battery design and production in France. The one with the global player the Japanese Envision AESC, and another one with the French start-up company Verkor.[57] The aim of the agreement is to develop European battery production, including France where the joint factory is built, and to provide the batteries needed to increase production. Renault plans to assemble 1 million electric vehicle in Europe by 2030. By 2025, the Renault Group's European production will switch to 65 percent electric cars, and by 2030 up to 90 percent of cars will be purely electric.[58] Previously, the ratio also included hybrids, making the new strategy significantly more ambitious. At the same time, the company will continue the cooperation with Korean LG Chem battery manufacturer.

Two things can be highlighted from the automakers' 10-year strategy. On the one hand, the supply chain, which follows Tesla's model, is built along a strategic agreement for a joint production with an independent manufacturer. The other is that car manufacturers are also seeking to acquire the technology and strengthen joint research and development through ownership in an independent manufacturer. We can see that

[56] https://www.media.volvocars.com/global/en-gb/newsalert/viewemail/11801?email=9VAA4C0dWfZH/X0sCsUd8c7JYLOPUi7vOdnC/YpitNc=&utm_campaign=NewsAlert_11801&utm_medium=Email&utm_source=view_in_browser
[57] https://en.media.renaultgroup.com/news/renault-group-places-france-at-the-heart-of-its-industrial-strategy-for-ev-batteries-55b2-989c5.html
[58] https://www.electrive.com/2021/06/30/renault-plans-to-cover-the-entire-bev-value-chain/

the future of current battery supplies depends on the company's financial position, i.e. financial resources and the amount spent on the change.

Automotive companies require state guarantees and subsidies for joint research and development projects and investments (see later). Further this limits the range of potential partners, as both the European Union and national governments have an interest in supporting European companies. Depending on the examples of support policy in Hungary and other Central European countries, it cannot be ruled out that the countries of the region are interested in involving not only European but also Asian companies. The European Commission has recently approved state support for a number of large investments in Poland and Hungary. Governments have made a significant direct contribution to investment, but in many cases indirect subsidies (infrastructure and utility developments, land transfers) represent a significant additional amount. LG Chem received 36 million euros in state aid[59] from the Polish government, Toray received 45 million euros[60] and SKBM, a subsidiary of SK Innovation, received 90 million euros from the Hungarian state[61] among others.

Alliances, EU- and country level development programs

Various industry associations have been set up to represent the interests of battery manufacturing and to obtain and distribute subsidies more efficiently. European battery companies lag behind the U.S. and Asian firms. In response, European decision-makers are supporting new initiatives. The European Battery Alliance was launched in 2017. The cooperation has currently more than 600 stakeholders. The Strategic Action Plan on Batteries as part of the third 'Europe on the Move' mobility package was adopted by the European Commission in May 2018.[62] This initiative brought together a set of measures to support national, regional and industrial efforts to build an European battery value chain. It will help to build up the entire value chain from raw materials extraction to re-use and recycling. In 2019 the first 3.2 billion euro package was approved by the European Commission. The support is expected to generate an additional 5 billion euros

[59] https://ec.europa.eu/commission/presscorner/detail/en/IP_19_744
[60] https://ec.europa.eu/commission/presscorner/detail/en/ip_20_1260
[61] https://ec.europa.eu/commission/presscorner/detail/en/mex_21_3322
[62] https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52019DC0176&from=EN

in investment on the entrepreneurial side. Seven countries participated in the program, Belgium, Finland, France, Germany, Italy, Poland and Sweden. The second phase of the program 2.9 billion euros across twelve countries (namely: Austria, Belgium, Croatia, Finland, France, Germany, Greece, Italy, Poland, Slovakia, Spain and Sweden).

Volkswagen and Sweden's Northvolt formed the European Battery Union in 2019[63] in order to improve Europe's global position in battery manufacturing. They applied to the German Federal Ministry for Economic Affairs and Energy for support in building the plant in Germany and Sweden.

A joint project between BMW, Volkswagen and Northvolt received a 525 million USD state guarantee from the German Federal Ministry of Economic Affairs in 2020 for the construction of Northvolt's battery cell plant in Skelleftea, northern Sweden.[64]

5. Final remarks

In the last three decades, the FDI-led economic growth has created a trap for the persistence of labor-intensive activities for the countries of the Central European region (Pavlínek & Ženka, 2011). Therefore, the role of the region is limited to supply (Barta, 2012). The answer to this would have been to increase value added, but automotive industry in Hungary could only show a functional upgrading so far (Éltető et al., 2015, Sass et al., 2013). Recent investments in electromobility have not changed this situation either, and policy instruments to encourage and retain FDI continue to facilitate the establishment of labour-intensive activities (Szalavetz, 2021). The technology gap between domestic and foreign companies is also a problem. Backwardness of domestic small and medium-sized companies at Tier 2-3 level (Rechnitzer et al., 2017) makes it difficult for them to connect to global value chains, so a significant part of Hungarian automotive exports is provided by foreign-owned companies. The modernization of small and medium-sized enterprises is high on the agenda.

[63] https://www.volkswagen-newsroom.com/en/press-releases/volkswagen-forms-european-battery-union-with-northvolt-4773
[64] https://www.spglobal.com/platts/en/market-insights/latest-news/electric-power/081820-german-government-pledges-525-mil-support-for-northvolts-gigafactory-in-sweden

The transition to electromobility (from ICE to EV) is already visible in Hungarian automotive production (see Audi, Mercedes). Electric vehicles (EVs) also tend to have fewer parts, therefore requiring less time to assemble, which in addition to reducing the need for parts also requires less labor. The consequences of the change in technology are already being felt by Hungarian suppliers. The analyzes described earlier in the study predict a reduction in the workforce of roughly 10 percent, but this is not evenly distributed across companies in the supply chain. Addressing this will continue to be a challenge for companies in the industry as well as for policy makers.

Last but not least, Hungary wants to join electromobility using its internal resources. One of these is bus manufacturing. it is a missed opportunity after the regime change that Hungary lack of indigenous 'flagship companies' like the Czech Škoda auto and Škoda Transportation or the Polish Solaris. There have been several attempts to take advantage of the traditions inherent in bus manufacturing, but businesses have not been successful for a number of reasons. In bus production, only Chinese BYD is able to export, domestic manufacturers such as Kravtex-Kühne (Credobus) depends on the domestic market and government orders, which poses a significant political risk in Hungary, and the other Chinese-Hungarian joint venture Electrobus Europe has not yet shows any results.

From a supply chain perspective, there are three main factors that will determine the prospects for European, Japanese and other Asian suppliers producing in Europe.

Firstly, in the longer term, the production of the European automotive industry is expected to decline, which, in addition to stagnating demand in Europe, is due to a decline in exports. Indeed, large international companies with global production and distribution systems are increasingly using local or regional production to meet growing demand from external markets, especially overseas. This reduces the number of vehicles assembled in Europe and the output of component manufacturers serving the industry.

Secondly, electromobility brings changes.. The production of electric cars will fundamentally alter the technical content of vehicles and with it the type and quantity of components needed. Existing suppliers will have to prepare for both volume reduction and technological change.

Thirdly, the EU and industry players, especially European companies, have a clear objective to build up their (own) supply chain for battery production in Europe. European companies will play a key role in this. The examples from the industry show that two of the leading companies in the field of electromobility, Volkswagen and Volvo, are also envisaging a future with European partners. However, it is uncertain whether European companies alone will be able to provide a secure supply, or whether there will be enough European companies at Tier 2 and 3 level. In this case, companies from the Far East and overseas will have the opportunity to join the European battery supply chain.

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