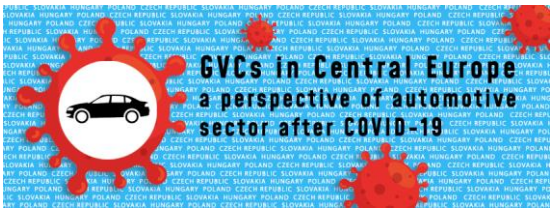


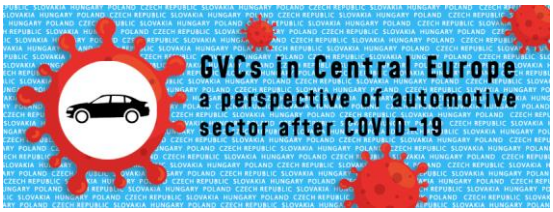
Visegrad Fund

Upgrading Slovak value-added via Industry 4.0 and innovations

A case study by Stanislav Zábojník and Marek Nagy

The case was developed with support of the Department of International Trade, Faculty of Commerce, EUBA and by the Visegrad Fund in 2022. It is intended to be used as a base for discussion in courses focusing on Global Value Chains and International trade.

The project is co-financed by the Governments of Czechia, Hungary, Poland and Slovakia through Visegrad Grants from International Visegrad Fund. The mission of the fund is to advance ideas for sustainable regional cooperation in Central Europe.



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We are witnessing a time of change, crises, and constant unrest. We are witnessing a dynamically changing world of the economy, environmental policy, power influences, inflation, and, last but not least, watching the massive development of technological innovations. The struggle for competitiveness and market share is conditioned by the continuous improvement of technology, automation, and digitization of production, cost reduction, or more innovative marketing.

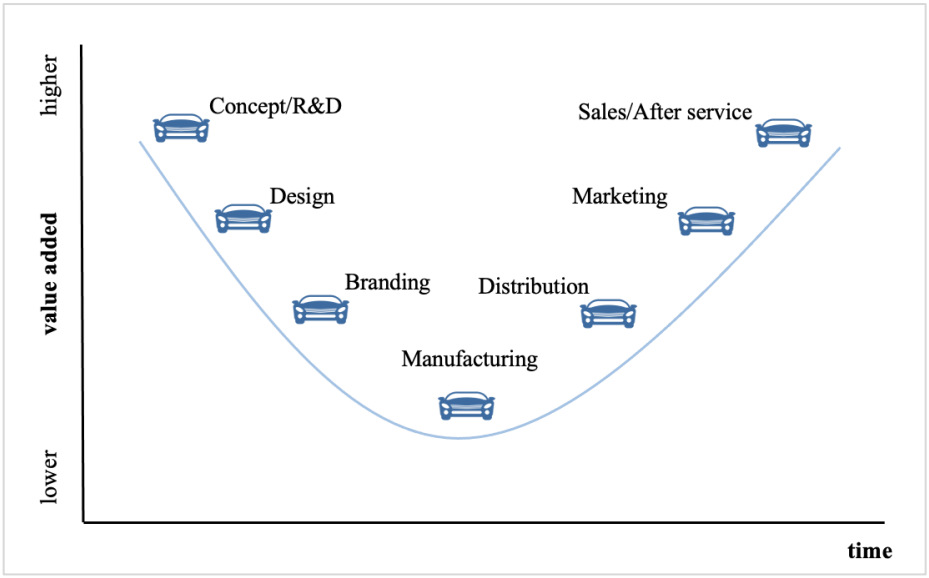
The growing importance of the fourth generation industry (Industry 4.0) as a key for any company that has the vision to become innovative and prosperous is striking. Such a demanding process of integration of the Industry 4.0 concept is closely related to the issue of global value chains and multinational companies, which in the Slovak Republic are primarily engaged in the automotive industry. From various analyses, we can already confirm the dependence of the Slovak Republic on the automotive industry and its lower added value in car production. Through the application of high-tech operations and current trends in this industry, Slovakia can become visible and bring the long-awaited proactive character of the innovative country.

Trends and opportunities for value-added growth in the automotive industry

Porter's (1985) conclusions about the acquired competitive advantage can answer the question of increasing the added value of the automotive industry. For example, in Japan, it can be a quality supply of labour that is considered a source of innovation. A level change in the value chain in favour of creating higher added value can be achieved in four ways - by shifting strategies in global value chains (Gangnes, Assche, 2011; Sampath, Vallejo, 2018):

1. **Process upgrading –** Evolutionary changes and higher process efficiency.
2. **Product upgrading** – Changes in the product portfolio to increase their value-added.
3. **Functional upgrading** – Application of activities with a higher rate of added value: research and development, sales/service, design, and marketing.
4. **Interchain upgrading** – Changes in the production base of companies that will allow entry into new global markets.

Figure 1 GVC in terms of value-added (individual processes)



Source: own elaboration based on Zábojník et al. (2020).

Intelligent processing

Information technology has already simplified human-to-human (P2P) communication, later human-machine communication, and can now help with machine-to-machine (M2M) communication. Development of this type can pave the way for continuous, higher automation through many communication channels and digital control systems.

Design and question of raw materials

With the onset of the fourth industrial revolution, the issue of product design is directly linked, which contributes a firm effect on the personalization and individual needs of customers. Computer-Aided Design (CAD) technology is a system that uses virtual and augmented reality and simulation in design.

Interoperability and standardization

It is necessary to register these two concepts as another critical factor in increasing competitiveness and growth in the digital economy. They can streamline cooperation between

elements of the digital environment, enabling better levels of communication and transparency in global supply networks (CEIT, 2020).

Creativity

Creativity is a very important and current concept in the field of digitization and innovative technologies. This is a process where the design becomes more important than the technology itself, the production process or the final product (PF, 2020).

Smart research

Research and development in ICT, cybernetics, and artificial intelligence is the primary reflection of intelligent manufacturing, which will enable a sharp increase in value-added. Research and development in the conditions of the Slovak Republic must be subject to changes that will ensure its higher expertise, critical research capacities and, last but not least, sufficient funding (Šajgalík, 2020). It is important and almost necessary to "network" application and research centres with the possibility of using the already existing research and development infrastructure of the Slovak Republic.

Intelligent energetics

This includes the need for a new concept that will be needed to engage in smart technologies on both sides (production and consumption). The essence of the concept is to create a so-called smart grid in the Slovak Republic as a key technical solution for developing the electricity system (SI, 2021).

Transcendence of new trends into other industries

Technologies trigger innovation and productivity in business, industry, and many other sectors. For the end-user, this will mean operational efficiency and lower costs. The most advanced intelligent transport systems, telematics, and multimodal integration will support cities in terms of increasing mobility, reducing emissions, and personalizing the user experience. Transport systems in the sense of Industry 4.0 represent the basis for the proper functioning of the "smart city" concept, which supports the overall integration of technology and communication.

Current trends in the automotive industry

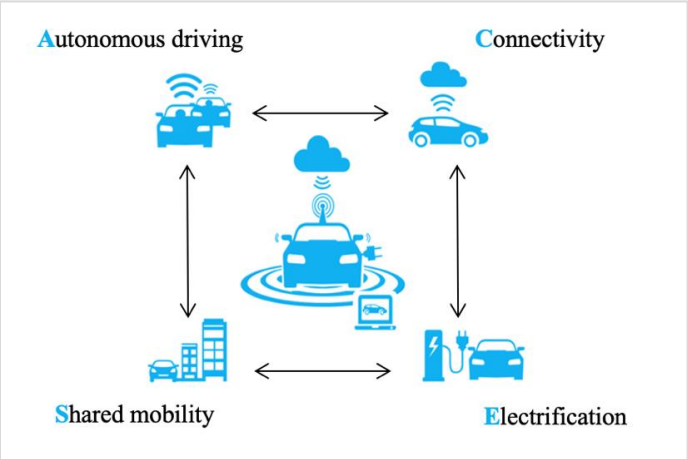
Recent years have been marked by an excellent increase in electromobility trends and megatrends, which is mainly associated with the fourth industrial revolution in the automotive industry. As a general rule, there is an increase in value-added, comfort and safety, which results from electrical engineering and connectivity (IBM, 2008).

These trends naturally affect the production parameter by their demands, and therefore it is of priority to monitor the adaptability of automobiles through the adoption of innovative elements in vehicle production. The next section presents key trends that evoke the need for innovative solutions (Zábojník et al., 2019).

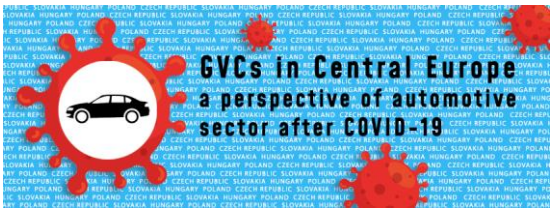
„ACES“ model

As a result of already known data on the automotive industry, it is justified to claim that the AP will remain in the territory of the Slovak Republic at least in the medium term and its key role for our economy. Current trends in the automotive industry are described by most experts as the transition and transformation to the so-called ACES model (from English A - driving autonomy, C - vehicle connectivity, E - electromobility, S - shared mobility services) (McKinsey, 2018). According to research and study by the author of the ACES model, up to 80% of trucks will be "online," by 2030. This is primarily an increase in traffic safety. The number of potential customers who would like an electric car has increased by almost half.

Figure 2 ACES Model



Source: own elaboration from (McKinsey, 2018).



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E-mobility

The vision of building electromobility in public and individual passenger transport is a long-term character. However, more significant support for this trend has been reaching since 2010, mainly from national governments, local governments, and various organizations due to slowing global climate change and missing investment opportunities.

Innovative ability and sustainability of competitiveness in automotive industry

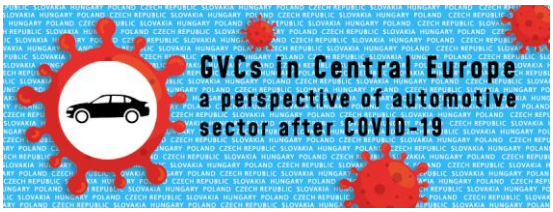
The starting point for the highest competitiveness in the automotive industry, using previous analyses, belongs to Germany. A wide range of innovations in the sector can be seen as the reason for this sustainability and economic progress. According to the Centre for European Economic Research (ZEW, 2019), the German automotive industry achieved the highest number of innovations in its production (50.57%).

Quality workforce

One of the positive aspects of Industry 4.0 is the value creation effects resulting from increased efficiency and new business models. However, technological changes can have positive and negative effects on employment (Roblek et al., 2015). Advances in technology and flexible development depend on innovation intent and corporate policy, education, and quality work skills. Job restructuring will be a challenge, as some more minor demanding occupations will quickly disappear (Kane et al., 2015).

Digitization

Increasingly connected vehicles will change business strategies, from product sales to offering customer experience-focused value (Hoffmann, 2019). Digitization will significantly improve the value chain by increasing efficiency, reducing costs, and creating more collaboration and innovation. It will evolve from business-to-business approaches through its dealerships to a business-to-consumer model, with new ways of interacting with customers and partnering with suppliers interacting through data.



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Impulses of „R&D“

In order to determine the right policy and the right tools, an analysis of the current state of the environment and follow-up capabilities is necessary for the right response to stimuli. It is an initiative to create tools that would be used to condition the Automotive Industry's investment in R&D (Zábojník et al., 2019). We characterize three levels of R&D:

1. **Self-implementation of R&D** (internal activity) – Companies have R&D activities declared as part of their own business.
2. **Specialization R&D** (external service) – When the company dominates the existing infrastructure, it is possible to specialize in completely innovative activities (practice).
3. **Public R&D sector** – Public investment and activities within schools. They still do not have the desired effect, on the contrary, they are risky investments.

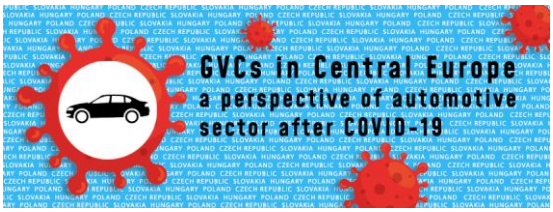
Innovative subcontracting chains in automotive industry

The production of the automotive industry is a sophisticated system based on quality supplier-customer relationships within the existing value chain. Automobile production includes suppliers across various industries, economic divisions, and sections. The traditional supply chain structure is grouped by levels (SIEA, 2015):

TIER 1: First-stage suppliers who deliver directly to assembly plants. They need design and innovation capacity.

TIER 2: Second-tier suppliers. These companies often work on assembly plants or global mega-suppliers' designs.

TIER 3: Third-party suppliers supply primary products. They have only basic engineering skills and experience.



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CHASING UP THE VALUE-ADDED DURING PANDEMIC ERA

PSA GROUP SLOVAKIA - CASE STUDY

Stanislav Zábojník, Marek Nagy

Historical context

In January 2003, the Government of the Slovak Republic accepted the investment plan of the French automobile concern PSA Group (at that time the second-largest automobile producer in Europe) to build a new production plant in the Slovak Republic. According to PSA Group's strategic expansionist considerations, it was most advantageous to build a factory near new core markets closer to the centres of Central and Eastern Europe (as a fast-growing region with huge sales potential). In six Central European countries (Czech Republic, Croatia, Hungary, Poland, Slovakia, and Slovenia), the French manufacturer had a 12.7 percent market share, compared to 5% in 1998.

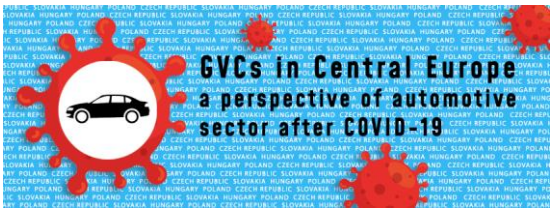
At the time of the investment, the investors and experts analysed and presented the following circumstances leading to the decision to build a new production plant within CEE in Trnava, Slovakia:

Table 1 Criteria for deciding on a new PSA Group site in CEE

Localization criteria officially published by the investor:	**Other factors** of the investor's decision-making - according to analysts:
• position in central Europe • building land with an area of 190 hectares, which is easily accessible by rail, highway, and navigable river • the possibility of creating a supply park near the plant • the industrial tradition of the region, and available workforce with a good level of education • proximity to important markets in which the PSA Group is expanding rapidly	• political stability • reform and integration-oriented government • government activity and involvement in the project • established and potential subcontracting base • quick access to the airport • proximity to Vienna, where the children of French managers can study in their mother tongue schools • plans of the Slovak school system to open French schools in Trnava as well • openness of universities in Trnava and Bratislava for cooperation with the investor • the potential to efficiently install and use the technical equipment of the plant • the potential to increase the added value of own car manufacturer

Source: (Government of the Slovak Republic - material for government meetings, 2003).

The Government of the Slovak Republic naturally agreed with this investment plan and provided several investment incentives. The rationale for supporting this project was primarily the benefit for public finances (taxes, levies, reduction of social expenditures), the growth of the volume of industrial production in the Slovak Republic, and the increase in overall economic growth (GofSR, 2003). After the start of the operation, the volume of production was estimated at 100 billion SKK per year (approximately € 3.32 billion). The value-added realized by the new investor was estimated for 2006 by government advisers at the level of 10 billion SKK (approximately € 332 million) represented up to 1% of Slovak GDP at that time. Thanks to this investment and the creation of value-added within the new plant, Slovak GDP would grow by 1% in the future. The government's ambition was to increase the share of domestic suppliers to increase added value in exported cars. Another positive impact was employment growth (and a decrease in high unemployment at the time) and a positive impact of investment for the trade balance (export growth and a promising decline in imports due to greater involvement of Slovak suppliers).



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Contemporary development

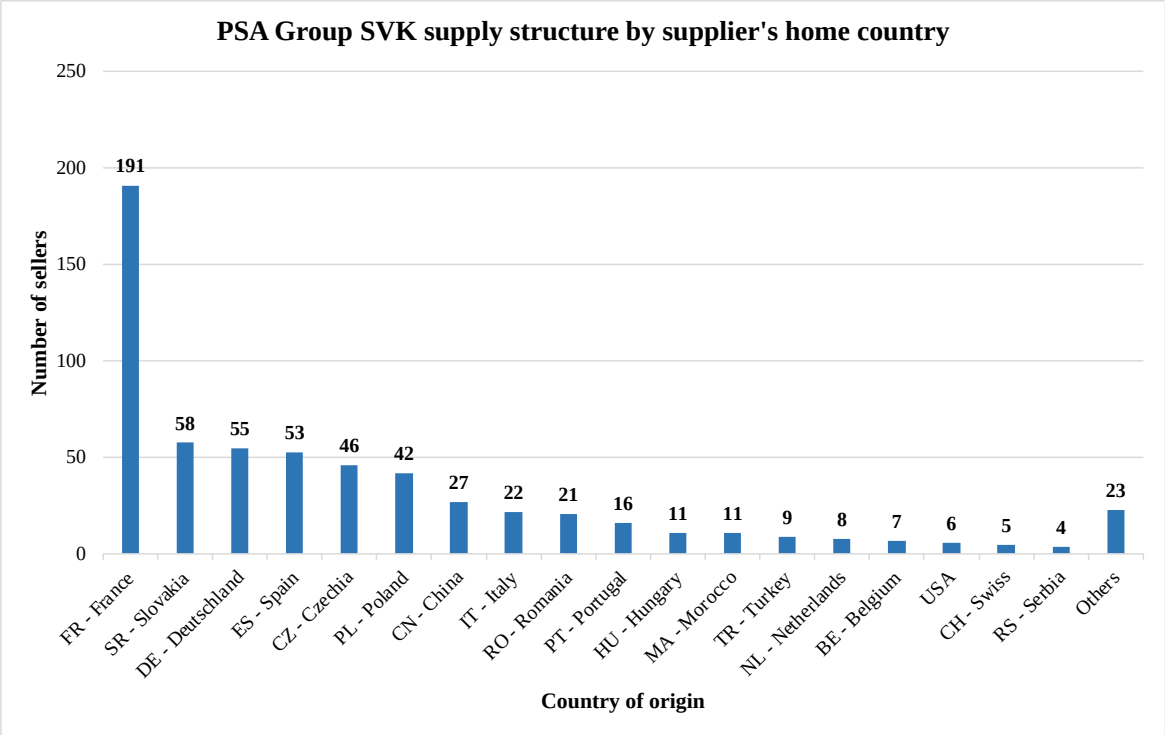
The carmaker based in Trnava is a leader in producing small vehicles in the B-mainstream segment. It currently produces the extremely popular Citroën C3 and Peugeot 208 models. In July 2020, the carmaker had already produced 3.5 million vehicles. Serial production at the carmaker plant began in 2006, and its products are aimed at satisfied customers on almost every continent (PSA, 2021). At a production cadence of 62 vehicles / h, it produces approximately 1,395 vehicles per day (PSA, 2021). The Trnava carmaker directly generates almost 4,400 jobs. In addition, it employs almost 20,000 people through its subcontractors located in Slovakia. In 2019, the carmaker in Trnava ranked 4th among the largest non-financial companies in Slovakia. It also has a dominant position in the foreign trade of the Slovak Republic. In 2019, it became the third-largest exporter within Slovakia. It currently ranks fourth. In 2020, it produced 338,050 vehicles. In the seventh consecutive year of year-on-year growth, production at the Trnava production centre increased by 5.1% compared to the previous year, 2019. Of the total number of vehicles produced, 33,334 were electric, with the e-208 monogram. Last year, the "battery-factory" completed 35,922 battery packs. The establishment in Slovakia of the parent company made and still makes sense; the production is situated in the middle of the automotive cluster within the V4 region. The cumulative value of the Group's foreign direct investment in Slovakia has already exceeded 1.2 bln. € (PSA, 2021).

1. Basic Fundaments of PSA Group Slovakia

The main objective of this case study is to analyse PSA's attitude toward the Fourth Industrial Revolution, innovation, electromobility during and after the COVID-19 pandemic and use particular examples from production management to identify how this trend significantly affects and helps more efficient and error-free production, which in turn generates also increased value-added in car exports and at the same time point out sufficient resp. insufficient state support in the parameters of the business environment. The right business environment and conditions for innovation activity can be seen as a major incentive for Slovak suppliers to participate more in subcontracting for PSA Group and thus increase the rate of the value-added generated in the Slovak Republic (and thus maximize the positive effects of FDIs for the host economy). To characterize and answer these questions, the case study identifies the

primary areas where it is possible to define the innovation potential of this company, also based on the supply structure to identify potential gaps and analyse the attitude to environmental policy (since decarbonization policy has seriously impacted the European industries).

Figure 3 PSA Group SVK supply structure by supplier's home country



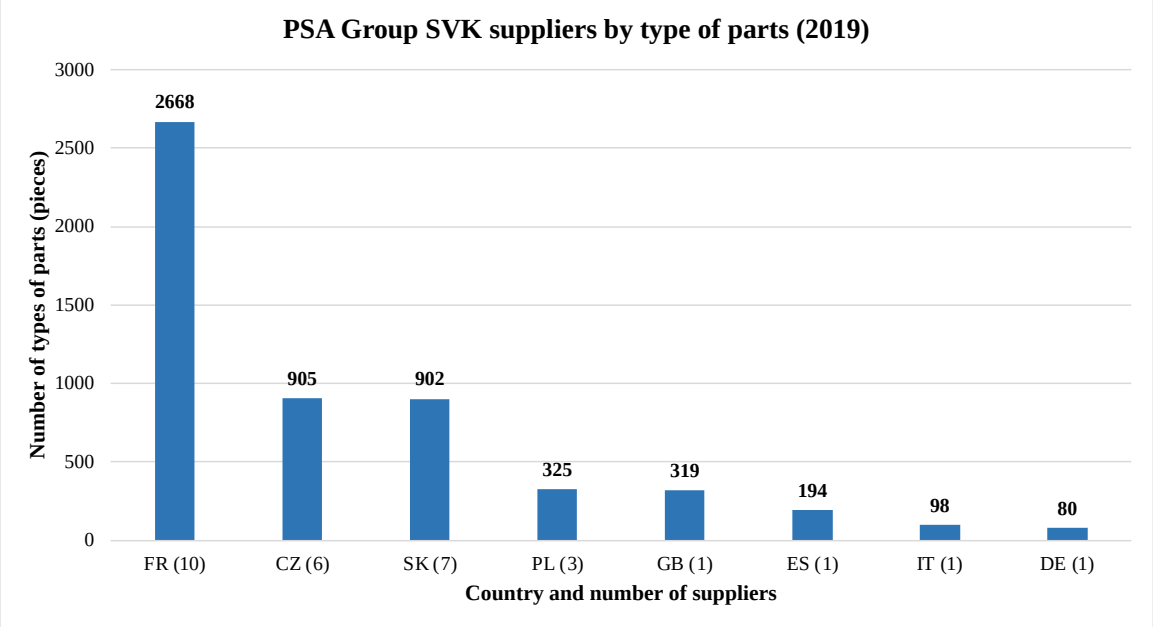
Source: Own elaboration.

The figure represents all suppliers based on the country of origin (categories - specific and joint suppliers) in 2020. The figure represents the international supply chain, the number of suppliers has increased to 615 compared to other years, and in the international context, their structure is more fragmented. The first, most robust suppliers are suppliers from France with 191 companies (approximately 31%); this country, therefore, represents a particular supplier leader, which the registered office of the parent company could be assumed. The second is the Slovak Republic with 58 suppliers (approx. 9.43%), and the third place is represented by Germany (55 - approx. 9%).

In the analysis of previous years, it can be identified that in each year the number of suppliers was dominated by France. It also directly creates the highest value-added, as it is a

French carmaker, which is dominant on the so-called “smile curve”. The smile curve comprises following the most demanding value chain activities (the highest value-added): the original idea, know-how, and car design come from here. The influence of suppliers from the Slovak Republic is less significant: it represents the second place in terms of the number of suppliers.

Figure 4 Suppliers of PSA Group SVK by part types in pieces (2019)



Source: Own elaboration.

Looking at PSA Group's suppliers by type of parts, France is the first to import about 2,700 types of parts to the carmaker (10 companies - 2,668 types of parts). Import from the Czech Republic follows; PSA Group Slovakia imported 905 types of parts from six Czech companies. The third place belongs to the Slovak Republic - domestic supplies (7 companies - 902 types of parts). When the French carmaker was established in the Slovak Republic, the share of domestic suppliers was naturally high; Slovak companies carried out 90% of construction works during the plant's construction. Unfortunately, Slovak subcontractors, who would participate in creating value-added intended for export (serial production activities), do not have such a significant role in the production of cars. The leading suppliers related to production in Slovakia are Faurecia, Lear Corporation Seating Slovakia, Plastic Omnium, Visteon Electronics, Eurostyle Systems, Slovakian Door Company, Bourbon Automotive

Plastic. Approximately 54% of the company's revenues come from Central and Eastern Europe (V4 + Romania), 21% of turnover from Slovakia. The priority intention of the French management was to produce at lower costs in the Slovak Republic and subsequently export to other European countries using the barrier-free single market of the EU, which is also confirmed by current export statistics. From the point of view of the territorial structure of PSA exports, most exports are to the EU (80%) and other countries, such as Japan, New Zealand, or Egypt. The transport of vehicles to customers is provided by the subsidiary GEFCO. About 60% of the vehicles produced in PSA Group SVK reach customers by rail, the remaining 40% reach clients by truck.

Table 2 The most important Slovak suppliers of PSA Group SVK by number of imported types of parts (2019)

Order	Seller	Town (Region)	Products	Parts (pcs)
1.	Faurecia Automotive SVK s.r.o.	Trnava (TN)	Car seats	279
2.	Adhex Technologies	Senec (BA)	Foam parts	158
3.	Lear Corporation Seating SVK	Prešov (PO)	Seating systems	119
4.	Eurostyle Systems s.r.o.	BnB (TR)	Plastic parts	95
5.	SMRC Automotive Solutions	Nitra (NR)	Modules, cockpits	92
6.	Leadec s.r.o.	BnB (TR)	Technical solutions	81
7.	PSA SVK s.r.o.	Trnava (TN)	Production parts	78
8.	Plastic Omnium Auto Inergy	Nitra (NR)	Fuel systems	54
9.	Eurostyle Systems s.r.o.	LM (LM)	Plastic parts	54
10.	Steep Plast SVK	Nitra (NR)	Plastic parts	52

Source: Own elaboration.

Faurecia Automotive Slovakia s.r.o. is the most critical Slovak supplier for PSA TT. based in Trnava, which manufactures car seats, and exhaust systems and deals with innovations in these areas. It dominates by importing 279 kinds of parts. The second company is Adhex Technologies (158 foam parts), and the third is Lear Corporation Seating Slovakia, based in Prešov. Its main area consists of seating systems, which it imports with 119 parts. The Slovak Republic contributes to the production of cars (the year 2020) by sourcing materials and components approximately 9.43%, with the number of 58 suppliers. However, these are mainly plastic components with a lower rate of value-added. The cars are manufactured in Slovakia; they are mainly engaged in domestic assembly. Insufficient expenditures and a weak focus on research and development in the automotive industry (concept I4) represent the lower value-

added in subsequent exports. Quality education and innovative activity of employees within subcontracting companies are also important.

Employee training and development

Employees´ training and development play a crucial role in the perspective creation of the value-added. In 2020, the costs of training employees amounted to 178 000 €, 63 567 hours, including training for both regular and agency staff. The training with the most funds was: technical training in industrial automation and robotics (Boost school project), legislative training, and English language training. The training with the most significant number of realized hours included the primary activities of the operation - assembly, initial training of newly hired employees, technical training of industrial automation, and robotics (PSA, 2021). Education helps to meet the company's main goals and, of course, also to meet legislative requirements, especially in the field of environment, safety standards, and fire protection, which is also one of the company's main goals. In the dual education system in 2020, there were 43 pupils in the teaching and study fields: Car-repair worker - electrician, mechanic - electrician, and mechanic - mechatronic. As a part of dual education, the Trnava car company cooperates with three secondary vocational schools (SOŠ automobilová Trnava, SOŠ technická Galanta and SOŠ elektrotechnická Trnava). In 2020, 6 new students (PSA, 2021) passed the selection procedure for dual education. For each new employee who joins group PSA Slovakia, the education department will prepare a training plan related to his / her job classification and socio-professional category (PSA, 2021). This plan aims to prepare the best possible employee to acquire the competencies necessary for the performance of their job position.

Natural environment

The negative impact of car production on the environment can not be eliminated, but the company is trying to minimize it. The paint shop is the most critical production process in terms of environmental impact and falls under the law on integrated pollution prevention and control. It is a significant source of volatile organic compound (VOC) emissions to air, wastewater, and hazardous waste (PSA, 2021). In order to limit these effects, the Trnava carmaker uses water-based primarily paints. The paint shop also includes a physicochemical wastewater treatment plant, which treats wastewater from the surface and painting processes. Heavy metals from

these waters are precipitated here in the form of sludge. The biological wastewater treatment plant, which is located on the premises of the production centre, treats sewage and industrial wastewater. Sewage sludge is further recovered (PSA, 2021).

2. Production and Covid-19 Pandemic impact

At the beginning of March 2020, due to the COVID-19 risk, it was decided to stop production unprecedentedly in all European PSA plants. The production line in Trnava did not run for 55 days since March 19. As a result of the shutdown of the production line, more than 72,000 vehicles lost production. At the first production change, the gradual start of production began on May 12. Since Saturday, June 6, as the first carmaker in Slovakia, Trnava returned to production at total capacity (PSA, 2021).

Innovations

A significant milestone in PSA's development activities was establishing the InoLab team in 2020. The main task of InoLab is to connect the traditional production plant with the world of intelligent technologies and the university environment. The main activities of InoLab include:

- development of automation solutions for the production and logistics process,
- digital business transformation,
- building cooperation with universities, technology companies, and state institutions,
- management of EU grants, contributions, and funds,
- cooperation with students of Slovak and French universities (PSA, 2021).

Figure 5 Main areas of InoLab in PSA Group SVK

Source: Own elaboration.

The Trnava carmaker does not carry out activities in product research and development (PSA, 2021)! This is one of the fundamental problems of creating higher value-added in the long run. Shortly, the application of research will be an essential part of the carmaker's innovation activities to remain competitive (.

Development perspective

The carmaker's priorities will be indicators of client quality, economic efficiency, and operational performance. In addition to continuing the transformation project "Future in our hands" to increase efficiency from its resources, the priority is the carmaker's partnership with the Slovak government and improving the external business environment in Slovakia.

The good news came at the beginning of 2021: the merger of the Fiat Chrysler Automobiles FCA Group and the Groupe PSA Group, of which the Trnava carmaker is a part, created a new company, Stellantis, on 16 January 2021. This is good news for the future of the carmaker. In addition to the new identity, the company in Trnava is gaining new opportunities from the new global potential.

The merger of two world car players and the emergence of Stellantis, which is the fourth largest carmaker in the world, is not caused by the crisis. It connects the potential of two healthy groups. The goal is not to be big but strong in products and services and thus better prepared

for the industry's challenges - compliance with demanding CO2 limits and meeting customer demand for new and innovative types of mobility (PSA, 2021).

For a more profound and broader analysis of current trends in the automotive industry, the implications of Industry 4.0, and other topics, from the perspective of PSA Group SVK, the work also presents a comprehensive, joint questionnaire (based on consultation), which was sent to the Industry 4.0 department in this company (25 employees - respondents). It consisted of 20 questions and answers a wide range of questions.

3. Industry 4.0 and value-added in PSA Group Slovakia

The following part was processed based on a questionnaire, which was prepared with employees of Industry 4.0 and digitalization department of the company's production; it can be listed and characterized through the answers to a comprehensive questionnaire and identified key conclusions that this questionnaire and subsequent synthesis of conclusions brought. The first goal of the questionnaire was to find out the knowledge of the employees of the selected company about the Industry 4.0 concept. The second goal was to determine the readiness of PSA Group SVK for the transition to a digital company as a tool for technological - product, and process innovations in the company and thus increase value-added in the company. The prerequisite was the establishment of innovative approaches based on the transformation (upgrade) of GVCs at the level of process upgrades and/or product upgrades for value-added growth.

Question no. 1 Importance of Industry 4.0 within the Slovak Republic and the automotive industry

Through the first question, the respondents confirmed the crucial role of Industry 4.0 in PSA Group Slovakia and their expectations for the transformation of the industry at the Slovak level, especially in the perspective of several years. It is important to implement this concept and address it at the national level, as innovation and investment in research and development can move the Slovak economy and industry forward. Due to the dominance of the automotive industry in the Slovak Republic and thus the technical industry, the Industry 4.0 concept is significant for the Slovak industry as such. By applying the Internet of Things connection,

machines within the company will be able to communicate with each other faster and more efficiently. The whole plant will cooperate and communicate with each other, which will make the production site intelligent. With Cloud and Big Data applications, it will be able to synchronize and receive various requests, data, and "orders" in real-time. The digitization process eliminates excessive consumption of paper and other consumables and enables faster communication. This results in reduced product error rates, better control, and a smoother production processes.

Question no. 2 The importance of Industry 4.0 in PSA Group Slovakia

In the second question, I4 considers this concept crucial for the company, particularly in terms of better and higher quality products, more efficient production, and lower product error rates. For PSA Group SVK, after merging with the fourth-largest carmaker globally, Stellantis, innovation appears to be essential for the future. Through this cooperation and higher capital investments, the company's innovative capacity will be even higher than before. PSA dominates most recently with the InoLab department, which deals with the Industry 4.0 concept.

Its main activities comprise:

- development of automation solutions for the production and logistics process,
- digital business transformation,
- building cooperation with universities, technology companies, and state institutions,
- management of EU grants, contributions, and funds,
- cooperation with students of Slovak and French universities.

Education and training of students/staff for this transition are also very important.

Question no. 3 Society and its approach to digitization

PSA Group's management understands digitization as a better, more comprehensive, and faster interconnection of products, suppliers, customers, and car manufacturers. It is a digital supply chain. In production, the communication offline and machine workers is currently being digitized (it has replaced paper production). Naturally, everything cannot be digitized yet, it is a complicated and lengthy process, but significant changes will be possible shortly. According to several respondents, staff training, relevant training, retraining are crucial.

Question no. 4 Company knowledge of Smart factory, CPS (Cyber-Physical Systems), and Internet of Things (IoT) concepts

These concepts have been known to the company for several years, especially to the I4 department, which uses them daily and considers them the essential elements of production in the Industry 4.0 concept. They perceive cybernetics and artificial intelligence as a system whose task is to ensure mutual interaction and data exchange between production processes, which will lead to autonomous coordination of units and optimization of the set task.

Question no. 5 Readiness of the company (in terms of personnel, technical and technological) for the transition to a digital society

The Trnava carmaker dominates with its excellent infrastructure and has a vast potential to become one of the most innovative companies in Slovakia. It also considers its location concerning distances to critical suppliers and innovators to be a strategic advantage - it is located in the west of Slovakia, i.e., it is directly connected to all modes of transport. It also provides ongoing staff training, dual education, and a broad focus on cooperation with universities. In 2020, it spent 78 000 € for 63,567 hours for the employees, including training for both regular and agency staff. The unrealized in-house research and development represent this company's most significant pitfalls and gaps in the transition to a digital and innovative company. For a better innovation process, it must carry out this research and development shortly. In this context, respondents assess its readiness to transition to a digital society as partial.

Question no. 6 Implementation of the plan for a successful digital transformation and transition to Industry 4.0

PSA Group has implemented almost all steps and mapped its strategy; after the merger with Stellantis, its vision and strategy are even more robust, to produce more quality cars and electric cars in the future. The creation of PSA Group SVK pilot projects is implemented by InoLab, which deals with a wide range of innovations. It can be mentioned, e.g., the virtual reality of building a car and its parts. This company is at the forefront of staff retraining. As already mentioned, more and more is invested in employees every year, especially in education. The fourth step is a perfect data analysis; in this part, the company records significant shifts, especially in supply structures. By mutual acceptance of her vision across the entire production

process, she transformed into a digital enterprise, but of course, not at all levels. It is also integrated into the ecosystem; its environmental policy is one of the leading in Slovakia. It uses the ISO 14 001 standard - environmental management. The company adheres to strict limits on the discharge of wastewater or emissions into the air and respects the storage conditions of chemical products.

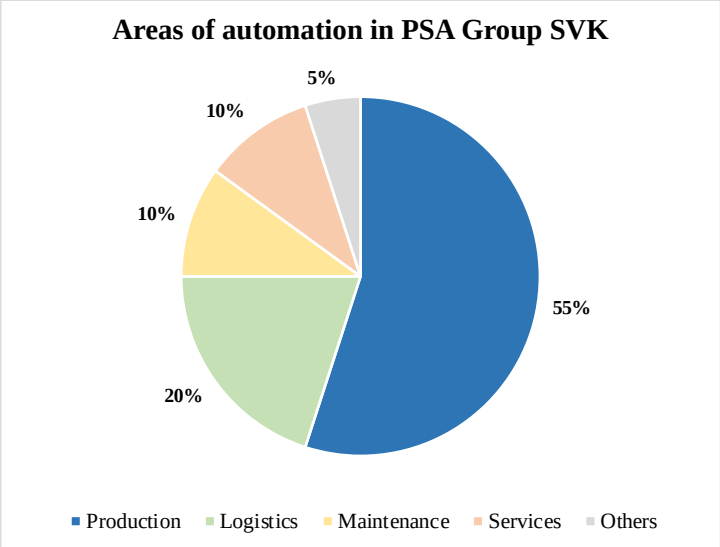
Question no. 7 Digitized activities in society

In terms of options in the questionnaire, all activities are digitized. Namely, it is about digital relationships with suppliers and the entire supply network. Subsequently, it covers the technical preparation of products, where paperless production helps, and the relations with customers, which are also laid at the digital level, especially today.

Question no. 8 Using elements of automation in the company

Automation in PSA Group SVK occurs mainly in the "core" areas, i.e., in the main activities, such as assembly lines with robots (675 robots). With the advent of the Peugeot 208, laser welding, with and without consumables, "Full Kitting," was introduced, supplying the edge of the line in operation (3.5 million parts distributed daily) or laser geometry control. The following chart shows the areas where PSA Group SVK currently focuses most on automation elements.

Figure 6 Areas of automation in PSA Group SVK



Source: Own elaboration.

From the above figure, we can observe the dominance of automation in production, which is about 55%. This mainly concerns robotic processing (675 robots) and laser solutions. Logistics follows this with a 20% share, and maintenance and services with a 10% share. 95% are automated core solutions, and the remaining 5% are other activities.

Question no. 9 Transformation of the product portfolio in the company in the last five years

Table 3 Car production in PSA Group SVK in a period of 10 years

Year/Model	Peugeot 207	Peugeot 208	Citroën C3 Picasso	Citroën C3	NG Peugeot 208	Total Production
2011	109 219	82	68 375	0		**177 676**
2012	45 576	113 532	55 509	0		**214 617**
2013	-	184 740	63 671	0		**248 411**
2014	-	206 562	48 614	0		**255 176**
2015	-	259 388	43 630	0		**303 018**
2016	-	236 691	35 525	42 834		**315 050**
2017	-	82 445	17 677	235 174		**335 296**
2018	-	111 251	-	240 744	87	**352 082**
2019	-	80 947	-	234 443	55 762	**371 152**
2020	-	-	-	178 276	159 774	**338 050**

Source: Own elaboration.

As can be seen, the company's car production has increased chiefly each year observed (more than 25%). In 2020, new Citroen C3 and Peugeot 208 models were produced. A total of approximately 338,050 cars were produced. Compared to 2015, production increased by approximately 35,032 cars. The company is mainly engaged in electric cars and the production of batteries (33,334 electric vehicles were produced). Here it is possible to see the impact of the current electromobility trend.

Question no. 10 Increase in data volumes in the company over the last five years

Of these options, more than 50%, as the company switches to a wholly digital environment, means a massive increase in digital communication networks from machines to customer structures. The company also replaced paper production with digitization, which also increased production data volume.

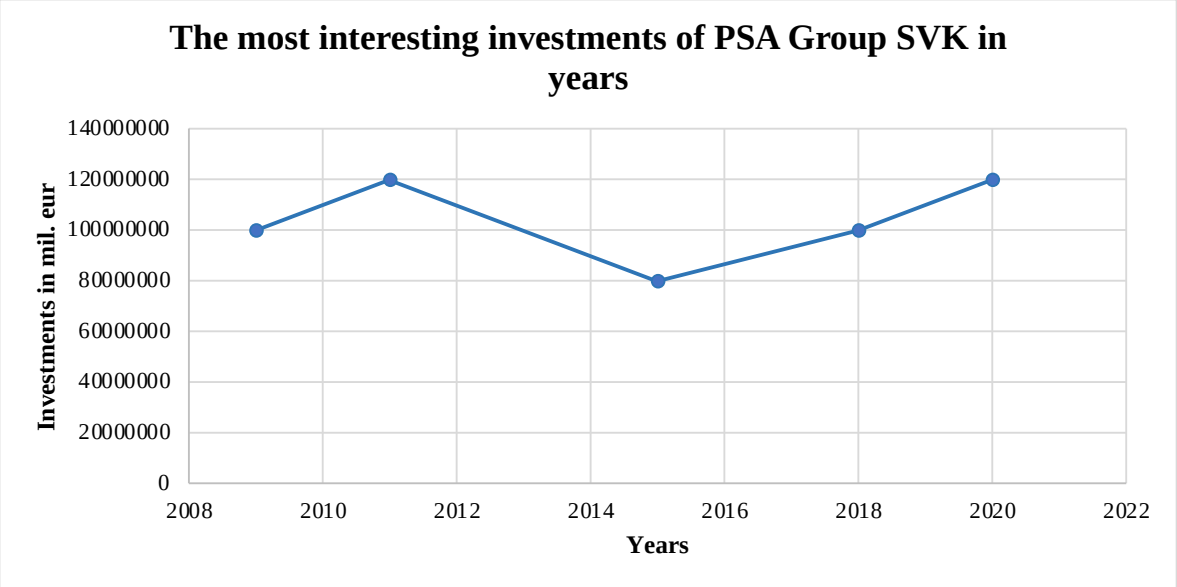
Question no. 11 Investment activity of the company in new technologies, machines, and equipment for the last five years

Selected investments by years:

- Investment in the construction and start of production of the 1st Peugeot 207 model: 700 mil. €.
- Investment in the start of production of the Citroën C3 Picasso: 100 mil. €.
- Investment to start production of the Peugeot 208: 120 mil. € per year (2011).
- Investment to start production of the new Citroën C3: 80 mil. € (2015).
- Investment to start production of the new generation Peugeot 208 and e-208: 100 mil. € (2018).

The total amount of the group's investments in Slovakia: more than 1.2 billion €

Figure 7 The most interesting investments of PSA Group SVK



Source: Own elaboration.

The company currently invests heavily in electromobility (battery production) and the environment (over 20% compared to last year), also develops the projects and technologies in laser solutions, automated logistics systems, and the like.

Question no. 12 Success of shortening the product innovation cycle

This is a debatable issue; due to the COVID-19 pandemic, all production at the company was suspended. Also, in today's energy crisis and under the constant shortage of chips, it is questionable how to shorten the innovation cycle. Once the company has the relevant information and enough raw materials, it is possible to apply techniques to shorten the innovation cycle of the production process. Examples are SixSigma (define, measure, analyse, improve and perform control) or production environment analyses.

Question no. 13 Method of registration of finished products

Finished vehicles are registered by a combination of sensors that sense them as they leave the last production line and then head to the warehouse to take them away. A worker also intervenes here who performs a record and marks the final model with a "reader" device (electric form + communication totem).

Question no. 14 Opportunities for retraining PSA Group Slovakia employees to achieve the required skills

As already mentioned, approximately € 178,000 was invested in staff training and development in 2020, amounting to 63,567 hours. These are in particular:

- Technical training in industrial automation and robotics (Boost school).
- Legislative training.
- English language learning.
- Basic crafts of operation - assembly.
- Initial training of newly hired employees.

In 2020, the corporate project "Boost school AUT / ROB" was launched, which is intended for maintenance workers in production plants to increase industrial automation and robotics competencies. He is also involved in dual education; currently, PSA Group SVK has 49 dual education students.

Question no. 15 The company's interest in the topic of electromobility

Electromobility is currently the driving force of the company. Of the complete package of manufactured vehicles, 33,334 were electric, with the e-208 monogram. Last year, the battery factory completed 35,922 battery packs. The investment to start the new generation Peugeot 208 and e-208 amounted to 100 mil. € (2018). The first battery assembly plant was also exhibited and applied in Trnava.

Question no. 16 The latest innovations of PSA Group Slovakia in connection with I4.0

Establishment of InoLab in 2020, transition to paperless production and digital network supply structure. Also, the construction of a hall for battery production and investments in laser welding and "full-kitting." Also worth mentioning is the quietest press shop in the Group PSA, laser geometry control, ecological paint shop, and predictive maintenance.

"PROCE55" is an innovative, agile software for maintenance management and mobile maintenance in Industry 4.0. It provides an online overview of production, provides accurate and objective data from machines, and integrates various systems. It is dominated by high adaptability to specific innovative processes. The application of Industry 4.0 innovations can significantly streamline the production process. It shortens its time, increases quality, and strengthens subsequent product control. To detect errors, the company uses a plant quality indicator ("DVT").

Question no. 17 Respondents' estimate of the potential of Industry 4.0 and the Internet of Things to become the standard.

It is difficult to predict this development, but I4 staff stated that it is feasible by 2025. With the growing interest in electric cars, they expect the process will accelerate and gain importance. They unequivocally agree that this will have a significant impact on the automotive industry, especially in the Slovak Republic. They also point to the importance of supporting legislation, education, research, and development, because without this support, its application and potential to become a standard is unclear.

Question no. 18 Use of European Structural and Investment Funds by PSA Group Slovakia

Currently, from the perspective of Industry 4.0, PSA Group SVK has received an investment in a new segment B production program at its production centre in Trnava (2021). The gradual start of production of the new production program of segment B is planned for 2023. In order to significantly contribute to increasing carbon neutrality, a large part of the production program will also be represented by fully electric motors. Industrial investment in the new production program will also mean a significant mobilization of activities related to innovation, further application of Industry 4.0 technologies, reduction of energy intensity, and environmental protection (PSA, 2021). Of course, the company used them (to a limited extent), for example, EU funds for employee trainings.

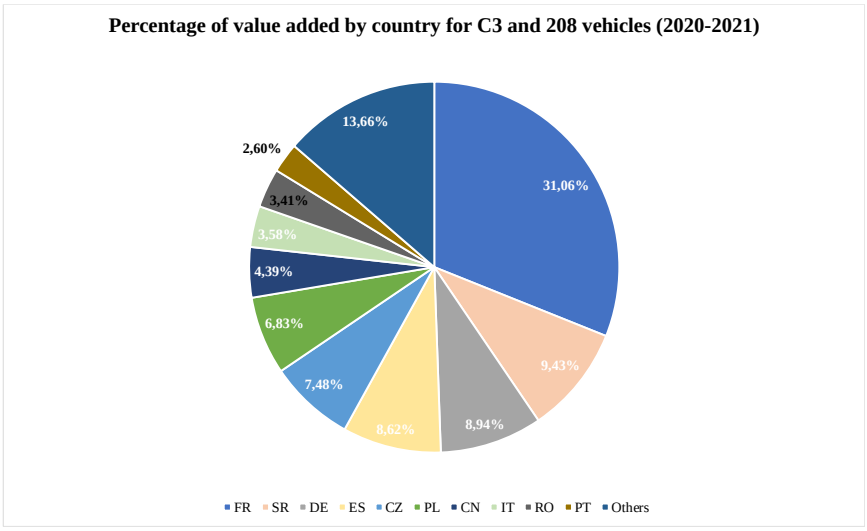
Question no. 19 Positive and negative impacts of Industry 4.0 according to respondents

According to experts, I4 certainly brings more positives, such as higher competitiveness, cost minimization, lower stocks, higher production efficiency, etc. Respondents included the possible loss of some job positions as negatives/threats. They also confirm the need to apply this concept in its entirety and shortly, mainly due to higher competition from neighbouring countries.

Question no. 20 The impact of 4th generation industry on exports in terms of the amount of added value within PSA Group Slovakia and its potential

The Industry 4.0 concept positively affects the car company's exports. It can transform it into an intelligent, digital enterprise in which all parts of production, machines, and people are connected in real-time, which enables higher production efficiency, lower error rates, and production costs. As a result, the company can dominate with a higher number of quality goods with a quality supply network. These segments will also positively affect its subsequent export and contact with customers.

Figure 8 Percentage of value added by country for C3 and 208 vehicles (2020-2021)



Source: Own elaboration.

Based on the analysis of available company data for the years 2020-2021, we found that the percentage of value-added for C3 and 208 vehicles consists of several countries; the parent country of the company creates the highest value, i.e., FR (31.06%), followed by Slovakia with almost 9.5% share, it is mainly assembly work. FR dominates only thanks to the fact that it is a French carmaker; the vehicles were invented right here, and the most modern technologies were applied for their design, design, etc. The Slovak Republic will probably not reach the same level of value-added as FR, as it is not the parent country of the company, but the Slovak goal must be to maximize the share of value-added of Slovakia in the production process and increase this share every year.

By applying innovations and essential research and development, with which the company does not yet dominate in Slovakia, the products will achieve higher value-added. They will be more desirable on the global market. This will make the car company an innovator and set the trend for its competition. However, it is questionable when and how the Slovak government and overall legislation will be able to respond to this trend in order to support companies with innovative policies, better conditions, and laws. In particular, two parties, the company and the state are needed to make the innovative concept a reality. Respondents consider this to be a weak point of the Industry 4.0 concept in the territory of the Slovak

Republic. Legislative conditions are currently insufficient and, in some places, chaotic compared to the outside world. When companies have the necessary capacities for their research and development, only then will the path of the Slovak Republic grow exponentially in terms of added value.

4. Proposals and recommendations

There is a strong need to spread the idea of Industry 4.0 across all sectors so that these industries understand and benefit from it. The vision and one of the most important goals of the Slovak industry is to combine research and development activities, together with innovation, including broad-based application, which will enable the contribution of all relevant technologies, knowledge, and skills from industry and enterprises in various sectors to society and quality of life in Slovakia (SI, 2021). Comprehensive analyses must achieve all this, and it is necessary to create a so-called "Slovakia's Intelligent Industry Platform." We can understand this Platform as the leading and managing body of Industry 4.0, consisting of a group of experts, which will consist of key actors and government bodies. The right step would be to appoint ambassadors for each sector, with the aim of continuous improvement and support for implementing expert recommendations (SI, 2021). The main document of this Platform would be an "action plan" that would be specifically designed for a specific area. This plan would bind the platform and set long-term goals in the field of various strategies of energy, materials, nanotechnology, robotics...

Table 4 Comprehensive table of recommendations

Areas	Recommendations
Awareness raising and cooperation	1. Information campaign
	2. Support for IoT experimentation
	3. I4 Implementation Manual
	4. Better promotion
Industry Research 4.0	1. Support for applied research
	2. Research agenda for Industry 4.0
	3. Sector-oriented consortia
	4. Efforts to reduce the amount of rest. N and R&D
Smart Factory	1. Support for the introduction of new technologies and materials
	2. Standardization (reference architecture)
	3. New models and their entry into dod. strings
	4. Use of Big Data
Financing	1. Better funding mechanisms
	2. Address the needs of the research agenda
	3. Innovative public procurement
	4. Implementation of pilot projects
Labor market and education	1. Analysis of the main requirements of the present
	2. Creating predictive curricula
	3. Providing more specialized skills
	4. Following the European agenda (new skills)
Legislation and E-Government	1. Continuous development of skills in the public sector
	2. Commercial use of data (Big Data)
	3. Active participation of the government in supporting the implementation of I4
	4. Proposal of a transparent VS digitization plan

Source: Own elaboration.

Environmental policy, which is also essential in matters of progress, must also be remembered and addressed.

Recommendations for Slovakia in terms of environmental policy:

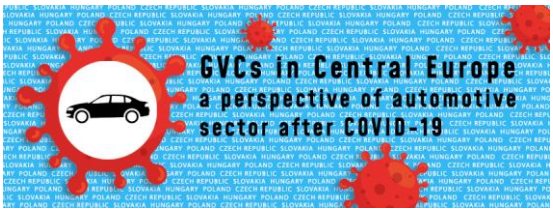
1. The Slovak government needs to create favourable conditions for businesses to become green, which is in its interest to attract foreign investment to ensure economic growth and employment.
2. Businesses in Slovakia must press the government to create the proper regulatory framework for greening.
3. The car headquarters needs to work with its suppliers in Slovakia to help them adapt to new technologies and production processes through retraining and skills upgrading.

4. Retraining and improving the quality of staff to meet the job requirements of the emerging e-mobility sub-sectors requires new training programs and cross-cutting cooperation between the public and private sectors and academia.

Conclusions

Based on the answers from a comprehensive questionnaire, it is possible to characterize a high level of knowledge about the latest trends in PSA Group Slovakia and a quality workforce that is ready for the challenges of this concept. The conclusions of the questionnaire confirm the significant impact of I4 on the company's product portfolio growth with value-added growth and point to insufficient state support, especially in the areas of education, financing ("R&D"), and legislation.

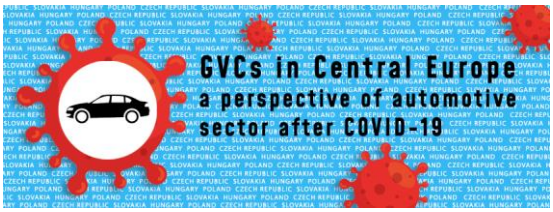
The last part of the study is the proposals and recommendations of the authors. The content of this section contains two concepts of recommendations, the first in terms of the implication of Industry 4.0 for Slovak industry, in six areas/steps that follow the need of Slovakia to innovate, apply the latest available technologies, change educational programs and thus achieve high value-added in the industry and subsequent exports of the goods and services through the Action Plan. The second concept is devoted to the environmental policy of the Slovak industry, its importance, and its impact. Based on implementing these proposals and recommendations, the Slovak Republic can acquire the proactive character of an innovative country, otherwise, it will remain an "assembly country."



Visegrad Fund

Questions related to the case study:

1. What has been the primary source of the increasing value-added within PSA Group Slovakia?
2. Which measures have to be adopted by the Slovak government to maximize the positive effects of Industry 4.0 in the value-added of the Slovak automotive gross exports?
3. What are the most significant barriers for PSA Group Slovakia to design the new models in Slovakia?
4. Compare the incentives provided by the government for the foreign automotive "innovators" among the V4 countries.
5. How can ACES trends impact the value-added creation in Slovakia?



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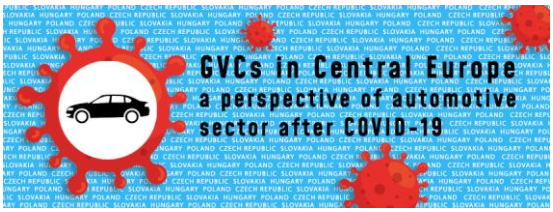

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