Doctoral School of International Relations and Political Science

THESIS COLLECTION

Tamás Stukovszky

for the

Innovation in the 21st century EU automotive industry in times of crisis

titled Ph.D. dissertation

Thesis leaders:

Prof. Dr. László Palkovics
DSc

Dr. Sándor Gyula Nagy
PhD habil. oecon., associate professor

Budapest, 2022

Department of World Economy

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1. Research background, rationale for the topic

In the previous century, the motor vehicle was the technological pinnacle of the age, and within a short period of time it had spread throughout the world. Not many products in human history have transformed not only the world economy to such an extent, but over time have become part of the daily lives of billions of people. It has taken the automotive industry just over half a century to evolve from its origins as a manufactural producing industry into a globally organised industry with an international production and distribution network. All this while conscious innovation has played - and continues to play - a prominent role in its development since Benz's first four-stroke explosion engine (Túry, 2017). While the automotive industry provides jobs for tens of millions of people worldwide, 77.9 million vehicles rolled off the production line in 2020, 16% lower than the 92.8 million in 2019, due to the Covid crisis and the industry's shortage of raw materials. (ACEA, 2021) Vehicles have changed and continue to change with humanity, often in response to events and shocks in the world (e.g. World Wars I, II - tanks, oil crises - lower fuel consumption, 2008 crisis - community car use).

In a time of global crisis, it is a practical choice for my research to focus on an industry that is and will continue to be a major global player (3.63% of world GDP in 2020), part of our daily lives; analyzable data are available, faces significant challenges, and finally, it is considered a highly research-developmental-innovation intensive industry (ranked first in the EU in terms of R&D&I expenditure, ahead of pharmaceuticals with €62 billion, and third worldwide with €135 billion in 2020 (ACEA, 2021)), such as the automotive industry. Over the last century or so, 3 major poles of world vehicle manufacturing have emerged: Asia, North America and the cradle of vehicle manufacturing, Europe. In 2020, only 4.1% of the world's vehicles came from other parts of the world (e.g. Africa, Australia) (ACEA, 2021).

The automotive industry was hit by the Covid crisis in 2020 in the midst of a major shake-up. The dominance of the North American and European markets, typically based on European knowledge, has been ruthlessly suppressed by the capital-rich and cheap human resources-rich Asian region. China is now the undisputed world leader in vehicle production, and there is a huge new demand for vehicles within the country and the region (Saberi, 2018). The explanation is that globalisation has not escaped China, and in recent decades the world has opened up to a huge capitalist class, with a huge demand for a wide range of everyday and luxury goods, including vehicles. Europe found itself in a difficult situation, as it was not and

still is not able to compete with China's economic potential. The major players in the market have realised that the only resource to which China has limited and terribly expensive access is knowledge. China is investing a lot of energy and money in acquiring more and more diverse technologies, and not only in the automotive sector. It is then an opportunity for the rest of the world, especially Europe, to invest in knowledge if it is to remain competitive in the long term.

In addition to objective reasons, my choice of subject was influenced by the fact that, from my undergraduate days onwards, I had consciously imagined my academic and professional career at the interface between the automotive industry and economics. Along these lines, my bachelor's thesis investigated the effects of the 2008 crisis in the commercial vehicle industry, and my master's thesis focused on the development of a model and procedure for crisis forecasting in the automotive industry. During and after my studies, I had the opportunity to work for the Knorr-Bremse Group for more than 10 years in various locations across Europe, which gave me a deep insight into the automotive industry and its key players from the perspective of a world leading systems supplier. Another aspect of my choice of topic for my dissertation is that, although the topics of innovation, the automotive industry and crises are quite well studied separately, the pairs of topics (innovation - crisis, innovation - automotive industry, crisis - automotive industry) are narrower, but still contain significant and valuable academic achievements; however, if the three topics are studied together, I have found a research gap that, in addition to its topicality and usefulness, may have considerable academic potential.

At the beginning of my doctoral studies, I was motivated to find more answers to the question of the role of innovation in times of crisis. Initially, I planned my research on the world economy as a whole, but over time I had to admit that this was a topic too broad and wide even for a PhD thesis, not to mention that a lifetime of work might not be enough to access and manage the data and to interpret and manage the differences (regional differences, levels of development, capital endowments, innovation maturity, state involvement, etc.) at the model level. In the hope of more focused research, I wanted to delimit the scope of the dissertation geographically. Europe is in a special position as the intellectual centre of the automotive industry. In terms of manufacturing capacity, no significant expansion is expected in Western Europe, typically for economic reasons (Central and Eastern Europe and Asia have significantly cheaper human resources and a more favourable tax environment, so outsourcing of production has already started in the last 30 years), not to mention that the vehicle markets in developed European

countries are largely saturated from the user side; there is no significant, high growth potential. Europe's industry leadership is no longer based on high production and sales figures - although the EU produced 25% of the world's passenger cars and 19% of its commercial vehicles in 2020 (ACEA, 2021) - in which Asia, led by China, has been overtaking Europe for well over a decade, although in many cases production is carried out in local subsidiaries of European or North American groups, so Europe's influence is still significant. The challenges of the 21st century require the ability to meet rapidly and constantly changing consumer preferences, and the knowledge and R&D&I capacities to do so are typically still in Europe, but China is doing its best to build up R&D and innovation (through legal or illegal channels) at a rapid pace, even by sucking away the knowledge from its Western rivals (Gunay & Kazazoglu, 2016).

The task is seemingly simple: focus local resources on industry innovation, dictate trends, identify latent consumer needs and respond to similar efforts by competitors. Even in an era without major exogenous shocks and crises and with predictable economic growth, this would be a major challenge to build the European automotive industry. In the 21st century, there have been only two periods of relatively calm and predictable growth: the period after the dotcom bubble of 2001 until the beginning of the 2008 crisis, and the period from the end of the 2008 crisis until the end of 2019, when the first signs of the Covid crisis appeared. Since the early 2000s, the term 'crisis', so rarely used in the past, has become almost part of everyday human life. The 1980s and 1990s were characterised by balanced growth and a globalising world economy - even if there were fluctuations of varying degrees (Mexican crisis, third generation crises), they were relatively rare - and the crises since 2000 have followed each other at a faster pace. While the crises of the 1980s and 1990s were mainly regional, the post-millennium crises have almost invariably extended beyond a single region, and the 2008-2009 crisis and the Covid situation can be clearly defined as a global crisis (Karabag, 2020).

As I complete my dissertation, the whole world is approaching a turning point. The fourth wave of the epidemic is on the rise, and with the start of vaccination, social and economic actors alike have had a breather, but the danger is not over. Vaccination does not yet appear to be sufficient and no one should be lulled into a false sense of security that life and the economy will return to 'normal' in the foreseeable future. I believe it is crucial that the various players in the economy, from individuals to companies to governments to the various federations, recognise that an acute problem (Covid pandemic) has fundamentally changed the economic landscape of the 2020s and that a short-term focus on immediate survival is no longer sufficient. New

plans, goals and a strategy to achieve them are needed. The above is particularly true for R&D&I intensive industries, which, as I would like to show in my thesis, have so far been among the first to reduce their RDI expenditure in a crisis situation, even though the few that have not done so have been in a better market position overall.

In my PhD thesis I examine the evolution of innovation in times of crisis in the automotive industry of the 21st century European Union. For my research, the automotive industry is sufficiently complex, innovative and high added value for the global economy to be a relevant field of study not only for experts but also for the average citizen, because of its everyday relevance. The role and importance of the automotive industry in the developed countries of the European Union is dominant, and there is a sufficient amount of data available, and my recent years of embeddedness in the EU automotive industry have given me the opportunity to collect and process a large sample of new data on specific topics for analysis. The concept of innovation and its relationship with the automotive industry is an interesting and relevant topic in itself; it is the engine of growth in the 21st century, and it is particularly interesting to examine its role and evolution in times of crisis. A crisis always oversets the balance of power, consumer preferences change rapidly, which is particularly difficult to respond to in an industry where the average time to realise a product idea is 5-7 years due to high quality, safety, environmental and social expectations (Sontheim, 2020). The timing of the period under review is also a key issue. I have chosen the period from the early 2000s to the present because the 20-year horizon allows for the study of longer, more complex processes and micro-cycles within them. My choice is reinforced by the fact that the literature places the end of the fifth Kondratyev cycle, the end of the information technology era and the beginning of the new, sixth Kondratyev cycle, which had a major impact on the automotive industry, in the early 2000s, after the dotcom bubble and the related crisis (Nefiodov & Nefiodov, 2014).

Finally, analysing periods of crisis is always a challenging but rewarding task, especially if the author is also working in a similar situation. My aim is to show that it is worth investing in innovation in the automotive industry even in times of crisis, despite the fact that most industry players have not done so and that it is particularly harmful to cut innovation capacity. The literature is divided as to whether the crisis environment is supportive or not of innovation, but I agree with the majority who believe that significant growth - even paradigm-shifting growth that could lead to a new Kondratyev cycle - i.e. a recovery from the crisis, will come from new basic innovation.

2. Research methodology

The aim of my thesis is to examine the evolution of innovation in times of crisis in the automotive industry of the 21st century European Union. The literature on this topic is practically non-existent in the complex research area I want to investigate, but it is rich, diversified and has a long history in the different thematic areas (innovation, automotive industry, crises), while the literature is more limited in the different thematic areas (innovation - automotive industry, innovation - crises, automotive industry - crises). For this reason, a thorough literature review was carried out before defining the exact research area and conducting the research.

For my quantitative research, I relied heavily on my questionnaire, which was available online in English and Hungarian for 2 months, targeting a large number of EU automotive companies (2500+ completions). The aim of the questionnaire survey was to investigate the impact of the 2008 and Covid crisis on the innovation activities of EU automotive companies. While a minimum sample size of 5% is considered sufficient to establish the population, I have chosen the more stringent and therefore more reliable threshold of 3% in order to achieve a higher precision, thus requiring a minimum of 1,066 companies to be representative. As target group, I chose automotive companies in the current EU Member States (and the UK, which left the EU in 2020), where the average annual contribution of the automotive industry to GDP exceeded 1 thousandth of a percent in the 21st century. The reason for this is that below 1 thousandth of a percent of GDP per annum, the automotive industry cannot be called a significant industry from the perspective of the country concerned, i.e. it may bias the results of my research.

Before presenting my hypothesis system, I think it is necessary to explain how the delimitation of the research area was developed. The two main topics, innovation and the automotive industry, are discussed in detail in the literature review of this thesis.

Delimitation of research areas

Innovation is the engine of modern economy. It is, to put it mildly, a matter of life and death for advanced economies to gain a technological advantage that they can convert into some kind of competitive advantage. According to I. Hargreaves (2011), the growth of market players is not based on competitiveness in the price of labour or raw materials, or simply on access to capital, but on building, nurturing and continuously improving innovation capacities. A typical response in a crisis is for market players to embark on large-scale cost-cutting as quickly as possible in order to survive, one of the most obvious solutions being to lay off certain non-essential workers or to radically reduce the wage bill at firm level, often even reducing by across-the-board principle. The same reaction can be seen in multinationals' attempts to 'force' suppliers (of raw materials or components) to cut costs, which can cause serious damage to the supply chain. I wondered whether the same process takes place in a research, development and innovation (RDI) intensive industry. Could the RDI capacities that are essential for the industry to thrive be damaged or even substantially reduced in the event of a major crisis?

I was interested to see how actors in my chosen field of research, the automotive industry, are managing their innovation capacities and opportunities in times of crisis. The answer is far from clear and the consequences of such behaviour will be serious in the short and long term. Arguments can be built for reducing, maintaining or increasing innovation expenditure in a relatively unpredictable crisis situation, but the most important thing is the system of objectives that explains the actions. It is interesting to observe the effects of a short-term, profit-driven mindset in the RDI-intensive automotive industry, I believe that the majority of industry players have reduced their innovation spending during the crises of the last 20 years. This may seem reasonable at first glance, but it does not help long-term growth, the ability to respond flexibly to exogenous shocks, and to meet rapidly and unpredictably changing consumer preferences, and weakens current and future competitiveness potential. On this basis, it would seem appropriate to increase, rather than reduce, innovative capacity to respond flexibly and innovatively to changing market needs in a highly changed environment during and after the crisis.

Indeed, there is not much time for planning and reflection in a crisis situation. With often hasty and unthought-through behaviour (not to mention the fact that many companies do

not even have a crisis strategy or protocol in place), many market players are driving themselves into a vicious circle, protecting their financial assets in fear of the crisis, and putting them in full reserve, which also prevents them from investing in themselves (e.g. developing RDI capacity). This leads to a reduction in innovation potential and opportunities, first at company level, then at industry level, then at national and world economic level, and can slow down economic growth. This will further worsen the outlook, reinforcing fears of the crisis and deepening its effects. I believe that after 2008, many industry players in the automotive sector were characterised by the above-mentioned attitude, and I hope that in the current Covid situation, market players will learn from the past.

For my research, the automotive industry is sufficiently complex, innovative and high added value for the global economy. Although it is a global industry, I want to limit my research to the current 27 Member States of the European Union and the United Kingdom, which has left in 2020. During the period covered by this research (2000 to 2021), the UK was a member of the EU for most of the period, and the transition period after the UK's exit lasted until the 31st of December 2020, so Brexit has no practical relevance for my research. Although the EU has undergone three waves of enlargement since 2000 (2004, 2007, 2013), in order to get a consistent picture, I will look at all 27+1 member states over the whole period and will not distinguish between member states in terms of entry. This is largely due to the fact that only Croatia was not a member of the EU at the time of the 2008 crisis, whereas all 28 Member States under study were members of the EU at the outbreak of the Covid crisis.

Furthermore, I chose the European Union because of the importance and weight of the automotive industry in developed countries, and because there is a sufficient amount of data available. The other two poles of the automotive industry - Asia and North America - were ultimately dropped from the logical screen because of the lack of reliable industry data in Asia and the lack of transparency in ownership, especially in China, where the situation is currently chaotic. North America is significantly behind the EU and Asia in terms of both size and R&D. Overall, the EU automotive industry is the perfect place to prepare and carry out serious research.

In order to examine the evolution of innovation in the automotive industry in the 21st century European Union in times of crisis, I had to conduct a thorough and in-depth research and literature review in several different areas. These are presented in the following chapter 3. As I accumulated knowledge through my exploration of different literature and databases, I came to the conclusion that, although the automotive industry is able to respond quickly to challenges in times of crisis, innovation has been 'mistreated' during the crises of the 21st century so far, except for a narrow group of people. In some ways, this statement may seem surprising, given that the automotive industry in the EU has had the highest R&D expenditure in the last decade, ahead of the pharmaceutical industry. (ACEA, 2021)

2.1 Hypotheses

I plan to structure my dissertation around two main hypotheses, the second of which builds on the results of the first. I break my hypotheses down into further sub-hypotheses, which are intended to support the acceptance or rejection of the main hypotheses.

The reader may think that at first reading, hypothesis H1 may seem almost self-evident, but this is not the case. A common reaction in a crisis is to reduce or even freeze cost elements that are not directly related to production or services - for example, innovation spending by companies is typical - rather than to reduce costs that are presented as medium or long-term investments. I think that the following chapters will demonstrate that the leading role of R&D&I spending in the EU by the automotive industry (with a significantly higher amount than the pharmaceutical industry, which ranks second in the relevant EU ranking) is, on the one hand, not accidental; on the other hand, it is far from clear that, in an RDI-intensive industry such as the automotive industry, it is evident that RDI, as the engine of a fast and dynamically changing industry, can be seen as one of the first crisis responses to be cut, if necessary. I would like to demonstrate that the majority of companies were not prepared and that those that were prepared did not reduce their innovation spending, as it is a key resource for the industry. As a result of my research, I also want to show that those that were not prepared and did not reduce their innovation expenditure were also better off after the crisis.

H1: Innovation spending in the EU automotive industry declined during the 21st century crises

H1.1: Automotive R&D expenditure in the EU declined at both aggregate and national levels during the 2008 and recent crises

To ensure a high degree of reliability, the data on R&D expenditure in the automotive sector required for sub-hypothesis H1.1 were obtained from the Member States and from the relevant EUROSTAT and OECD databases. In order to eliminate possible biases, I have excluded from the analysis at Member State level the trends of EU Member States where the weight of the automotive industry in the total national economy is negligible. I define this as a value below 0.1% of the EU Member State's expenditure on the transport sector as a share of GDP. I expect this to filter out distortions caused by Member States without a meaningful automotive industry. Based on this criterion, I have excluded Malta, Cyprus, Luxembourg, Greece and Ireland.

H1.2: EU intellectual property (IP) registrations declined at aggregate level during the 2008 and Covid crises

In order to examine sub-hypothesis H1.2, it is necessary to review the evolution of intellectual property (IP) related to the automotive industry over the period under study. For this purpose, I examined data from the European umbrella organisation (EUIPO) in addition to the automotive industry data of the national IP institutions (e.g. the National Intellectual Property Office (SZTNH) in Hungary). I wondered what happens to patent activity during an economic crisis, when the basic economic processes are disrupted and the financial instruments that support the creation of patents are transformed in a short period of time and to a significant extent, or are not available? Patent rights play a key role in the economy. If a company cannot recover its innovation expenditure on a product or service because the resulting knowledge would be quasi-immediately available to all market players, then, following a free-rider logic, far fewer would seek to innovate on their own, preferring to wait for others to do so in order to optimise costs. This would be far from optimal in terms of the potential level of innovation. (Roberts & Stephanidas, 2020)

H1.3: The number of RDI employees in EU automotive companies decreased during the 2008 and Covid crises

For sub-hypothesis H1.3, it was necessary to examine the human resources databases specific to the automotive industry. In addition to the central statistical databases, my questionnaire also covered the changes in the number of RDI employees over the period under study, so that I could use these data as a control group to prove sub-hypothesis H1.3.

H2: Prepared automotive companies have not reduced their innovation spending during the crises of the 21st century and have achieved demonstrable market growth

H2.1: The majority of EU automotive companies did not have a crisis plan or strategy in place before the crisis, when the crises of the 21st century broke out, because they were not prepared

Sub-hypothesis H2.1 is the first sub-hypothesis to be proven in my thesis, the proof of which is based solely on the questionnaire I have compiled and analysed. It is important to note that I have not found any meaningful research, survey or analysis of the automotive industry, either at EU or global level, that has measured the preparedness of a wide range of industry players to deal with a potential crisis. In this case, the questionnaire examined whether the responding automotive company had a crisis plan or strategy in place at the beginning of the 2008 (1,533 respondents) and Covid crisis (2,565 respondents) before the crisis started. The purpose of these crisis plans or crisis strategies is to prepare for a potential exogenous shock, to lay down and clarify certain corporate behaviours, actions, and commitments in a crisis situation, which will help and facilitate a more thoughtful management of a potential crisis situation, instead of a hasty and ill-considered crisis management.

H2.2: Among EU automotive companies that had a crisis plan or strategy in place before the crisis, the majority did not reduce their innovation spending when the crises of the 21st century broke out

Subhypothesis H2.1 results in two distinct groups: those who had and those who did not have a crisis plan or strategy in place before the crisis started at the onset of the 2008 and the Covid crises. In what follows, I will examine those who did have such a plan. For sub-hypothesis H2.2, I examine how these firms managed their innovation expenditures during the crisis situation, based on the data extracted from the questionnaire. My preliminary hypothesis is that the majority of these firms did not reduce their innovation expenditure. This may be because they were better prepared to face the consequences of an exogenous shock with economic consequences, and thus were able to respond better, faster, more flexible and more carefully thought through to changed circumstances and challenges than those who did not.

H2.3: There is a demonstrable link between at least maintaining innovation expenditure and market growth for EU automotive companies in the 21st century

The aim of hypothesis H2.3 is to prove that even in a crisis situation it is worthwhile to at least maintain, but rather increase, innovation expenditure in the automotive industry. To prove this sub-hypothesis, I examine the relationship between the previously described indicators of market growth and innovation expenditure. If I obtain a positive and strong relationship at the end of the analyses, it will be concluded that during the 2008 and Covid crises, it would be appropriate for EU automotive firms to maintain their innovation expenditure at least at pre-crisis levels. This result would be significant because it could provide a handle on innovation spending by automotive firms during the Covid crisis. By presenting the results to the companies participating in the data collection (and even to others), it would be possible to validate or, where appropriate, revise their actions on innovation spending to date.

3. The results of the dissertation

In my PhD thesis I studied the evolution of innovation in times of crisis in the automotive industry of the 21st century European Union. During my research, I reviewed the relevant literature and key industry characteristics grouped around three broad themes - innovation, the automotive industry and crisis. I then defined my two main hypotheses, to which three to three sub-hypotheses are linked. The adoption of the first main hypothesis required the adoption of sub-hypothesis H1.1 in any case, while sub-hypotheses H1.2 and H1.3 required the adoption of at least one of them, but all three sub-hypotheses were finally adopted. For the second main hypothesis to be accepted, all three sub-hypotheses had to be accepted, following a linear, sequential logic, which was achieved by the end of the dissertation.

1. Automotive R&D expenditure in the EU declined at both aggregate and national levels during the 2008 and Covid crises

After removing distortions caused by EU Member States without a meaningful automotive industry, R&D expenditure decreased in 20 of the 22 Member States examined during the 2008 crisis, increased in only Bulgaria and remained stable in only Poland. According to EuroStat data, the aggregate R&D expenditure as a percentage of GDP of the EU Member States surveyed fell from 0.28% to 0.19% in 2008.
For the data series at the time of Covid, it is important to note that Croatia is now included in the data, having been a member of the EU since 2013. This time, R&D expenditure on R&D in the automotive sector as a percentage of GDP decreased in 22 of the 23 Member States surveyed, with only Denmark being able to maintain the level of 2019 in 2020, albeit with the lowest expenditure rate of the 23 Member States surveyed.

2. Aggregate EU intellectual property (IP) registrations in the automotive industry have declined in the wake of the 2008 and Covid crises

In 2008, the number of IP declined, from a 3.6% increase in 2007 to a 2.9% drop in 2008 worldwide, which was even worse in the EU, with a 7.9% drop in 2008 after a 2.4% increase in 2007. In 2009, as the crisis subsided, aggregate global IP growth returned to 2.2%, while in the EU it fell by a further 1.7% compared to 2008. It is important to see that in the 21st century, Europe is far from being the cradle of IP of all types. Until the mid-2000s the US and then Asia

until today registered the most IP, for example in 2020 China registered 45.7% of the world's patents, while EU Member States (EUIPO and national data aggregated) registered only 12.4%. Although the dynamic IP growth that started in the 2010s continued into 2019, the 2020s have already left a serious mark on the EU automotive industry. By 2020, the volume of automotive IP registrations in the EU had fallen below the 2018 level. For the Covid crisis, I have been able to track changes in the internal structure of IP, which was not possible during the 2008 crisis. Overall, it can be concluded that the registration of automotive IP decreased from 1,296,913 units in 2019 to 1,022,609 units in 2020 in the EU due to the Covid crisis, which corresponds to a 21.15% decrease.

3. The number of RDI employees in EU automotive companies decreased during the 2008 and Covid crises

According to Eurostat data, the number of automotive RDI workers in the EU fell by 7.89% from 2007 to 2008, and although there was a small increase in 2009, when the recovery period started, it was still 3.5% below the 2007 level. In 2019, the relevant headcount figures had already fallen by 4.5%, as factory closures and downsizing in the automotive sector in Asia started at the end of the year, and the trend continued in 2020, with a further 2.71% drop in the number of automotive RDI workers in the EU during the covid crisis.
In this case I was able to use the results of my questionnaire research. The questionnaire examined how the number of RDI staff among the respondents changed as a result of the 2008 crisis, and the results confirm sub-hypothesis H1.3, with 39% of respondents reducing their RDI staff, 54% with no change and only 7% with an increase. In the case of the Covid crisis, there was an apparent smaller drop in the relevant statistics, with 26% of respondents reducing their stock of MFIs, 59% with no change and 15% with an increase.

4. The majority of EU automotive companies did not have a crisis plan or strategy in place before the crisis, when the crises of the 21st century broke out, because they were not prepared

At the onset of the 2008 crisis, 172 out of the target population of 1,533 had a crisis plan or strategy, 11% of the sub-population, and 415 out of the total target population of 2,565 had a crisis plan or strategy at the onset of the Covid crisis, 16% of the total population. It was also found that, when the data series were broken down by firm size, the proportion of firms with a

crisis plan or strategy increased as the size of the firm increased, but in neither category can the sub-population be considered even approximately prepared.

5. Of the EU automotive companies that had a pre-crisis crisis plan or strategy in place at the onset of the 2008 and Covid crises, the majority did not reduce their innovation spending

The results above are in two distinct groups: those who did and those who did not have a crisis plan or strategy in place before the onset of the crisis at the time of the 2008 and the Covid crises. In what follows, I will examine those who did have such a plan in place. A comparison of the two periods shows that respondents were significantly more negative about the impact of the 2008 crisis on their innovation activities. When looking at several aspects of innovation expenditure (e.g. penetration of new markets, introduction of new innovative products, etc.), it is clear that the sub-set of respondents was more conscious. In their case, this was matched by results, as the table below shows that innovation expenditure increased on average in both the 2008 and the Covid crisis for the companies surveyed that had a crisis plan, regardless of company size. Once again, the trend is that the values obtained are higher for the Covid crisis, but even for companies with a crisis plan during the 2008 crisis, the average increase in innovation expenditure is still clearly observed.

Foglalkozatottak létszáma	2008-2009	Covid válság
4-9	12%	17%
10-49	14%	31%
50-249	8%	14%
250-499	5%	3%
500-	6%	3%

To get the full picture, I think it is essential to look at the percentage change in innovation expenditure for the population under study, as well as the number of companies that have not actually reduced their innovation expenditure.

Foglalkozatottak létszáma	2008-2009			Covid válság		
4-9	4+	1Ø	0-	8+	10Ø	1-
10-49	29+	8Ø	2-	76+	41ø	8-
50-249	29+	13Ø	2-	46+	53ø	10-
250-499	23+	32Ø	7-	34+	79Ø	13-
500-	12+	7Ø	3-	8+	24Ø	4-

During the 2008 crisis, 14 out of 172 companies with a crisis plan reduced, 61 did not change and 97 increased their innovation expenditure, while during the Covid crisis, 36 out of 415 companies with a crisis plan reduced, 207 did not change and 172 increased their innovation

expenditure. In summary, 91.87% of the companies surveyed with a crisis plan reduced their innovation expenditure during the 2008 crisis, while 91.33% did not reduce their innovation expenditure during the Covid crisis.

6. There is a demonstrable link between at least maintaining innovation expenditure and market growth for EU automotive companies in the 21st century

My aim is to prove that even in a crisis situation it is worthwhile to at least maintain, but rather increase, innovation spending in the automotive industry. To prove this, I examine the relationship between the previously described indicators of market growth and innovation expenditure. Based on my four criteria for market growth (penetration of new markets, change in turnover, change in market share, introduction of new innovative products), I find that in all four cases the sub-populations performed significantly better, i.e. they achieved significantly higher market growth than the companies in the whole population that did not have a crisis plan and reduced their innovation expenditure.

7. The negative effects of crises in the automotive industry can be mitigated by proper and conscious preparation

I do believe that the results of my research can be of great importance in mitigating the impact of crises in the automotive industry (it is worthwhile to prepare company-specific crisis strategies, quasi-preparing for an exogenous shock, which is clearly becoming a more frequent phenomenon in our accelerated and globalised world than it was in previous decades), and can become a strong and professional argument, in a crisis situation, not only to take a short-term profit view (i.e. to divert resources away from areas not directly concerned with production, such as research and development or innovation), but also to consider that, overall, even in the face of short-term losses, it is worthwhile not to reduce innovation spending, and possibly even to increase it, in order to keep an eye on long-term market growth and unpredictable changes in consumer preferences. In the future, it would be worthwhile to examine more closely the extent to which increasing inputs increases potential market growth.

8. If resources for innovation are reduced or temporarily withdrawn altogether by the market players concerned, they are depriving themselves of the possibility to adapt flexibly and respond better to new challenges, thus jeopardising their own future

In both crises, I found examples where innovative responses to a fundamentally non-innovation-specific problem have emerged within the industry. Examples include the emergence and global spread of the "sharing economy" (various forms of car sharing [UBER, Telekocsi, Mol Bubi, LiMo, etc.]) in the wake of the 2008-2009 crisis, or the shortage of semiconductors or chips in the automotive industry during the current Covid crisis. Remember, the crisis has led to a sharp fall in travel, while restrictions have led to a surge in demand for consumer electronics products, these companies have paid more for the semiconductor chips that the automotive industry has incorporated into its products, and, as will be discussed in more detail in Chapter 5, there has been a serious shortage of semiconductors, leading to several production stoppages for domestic vehicle manufacturers (e.g. Mercedes, Suzuki).

It is also important not to reduce or, if possible, increase innovation spending, because it is not possible to adapt to a change such as the one described above without some loss of market share and without innovative capacity. The current crisis may reshape supply chains, destructive innovation is experiencing a renaissance, open innovation may proliferate, but most importantly, the future is still not predetermined, so threats and risks cannot be excluded. On the contrary, by learning from past patterns, it is possible to prepare for the potential challenges of the future, so that market players are not caught unawares by unexpected exogenous shocks. This will minimise potential losses, buy time in crisis management and allow for more flexibility to adapt to changing market conditions and rapidly and unpredictably changing consumer preferences.

9. The majority of the market participants in the study had learned little or nothing from previous crises and could not be considered prepared for a potential crisis.

It is both personal and empirical experience that at the level of words, during and immediately after a crisis, there is a willingness to mitigate the potential impact of future crises, but then in a business cycle, somehow concrete action falls by the wayside, moves further down the priority list and then, unfortunately, is dropped. Between 2008 and 2019, I have been in contact with hundreds of EU automotive companies, and unfortunately the number of those that have fully delivered on their 'promises' during crises is negligible. This is why encouraging or supporting innovation spending at Member State or EU level is an issue worth exploring, as its positive economic effects can be demonstrated.

As an added value of my research, I have shown that EU companies in the 21st century automotive industry were unprepared for global crises when they emerged; and that, despite being an RDI-intensive industry, most of the players in the market have reduced their innovation spending. For those automotive companies that did so, I want to give an example of the results of my analysis of their peers who prepared for the potential consequences of a potential crisis, failed to reduce their innovation spending and then achieved demonstrable market growth as a result. I believe that the results of my work will not only encourage the automotive industry to prepare and allocate their innovation resources more wisely, but will hopefully also support the protection and promotion of innovation spending at national or EU level, both in and out of crisis situations.

The information currently available suggests that the 2008 crisis has hit the automotive industry harder than the Covid crisis has so far. Of course, the fourth wave of Covid is far from being the end of the pandemic, but it seems that the automotive industry was somewhat better prepared for the effects of a crisis than during the 2008 crisis, but this is far from sufficient, and indeed not nearly enough. I think that the chip shortage, which seems to be a pressing problem even today, will help the positive transformation of the automotive industry in the long term, especially in the EU. Despite the difficulties, as it can serve as an excellent lesson for industry players to review and reflect on their value chains, in particular their geographical location, sustainability and the likely changes in the post-Covid period, especially with regard to the transformation of customer preferences.

10. Innovation is essential for the type of adaptation that a crisis and its aftermath require

Overall, the automotive industry needs to adapt to the new trends of the 2020s. Within the industry, there is a growing emphasis on environmental awareness (significant reduction of CO2 emissions, Green Deal), sustainability (new raw materials - e.g. composite materials instead of metal parts; recycling), e-mobility, and micromobility (the rise of scooters, bicycles, motorbikes). An instructive consequence of Covid is that, for example, the boom in public car use after 2008 is now experiencing a serious crisis, as in times of pandemic it may not be safe to use a vehicle that you do not know who was driving it, or to disinfect it, or to share your own vehicle with strangers whose exact health status you may not be 100% aware of.

Despite all the difficulties, I believe that the automotive industry will be a key player in the future of innovation and development, alongside the health industry. Providing transport for people will continue to be essential and may change in form, distance, speed, appearance, but this knowledge-intensive industry will always be able to innovate and meet expectations. I believe that the conclusions of my doctoral thesis can be an important stage in this renewal and in providing appropriate responses to the exogenous shocks that 'lurk' in the industry at changing intervals.

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