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A way to sustainable automobile production: game theory view

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Contents

Abstract

The problem of unsustainability of the world automobile industry leads to inefficiency, inconveniences and financial losses for economies, society and environment. The way the industry has developed during all its history offers no effective solutions to this problem. The present work argues in favor of a major change of the standard industry business model as the key method for improvement of sustainability. It aims to test how good are chances for a car manufacturer with the sustainable business model to be competitive on the market. Basing upon the oligopolistic nature of the car market, where strategic actions of each player have influence on actions of other players, this work uses game theory as the methodology. The Micro-Factory Retailing (MFR) concept is chosen as an example of highly sustainable automobile production. The forecast of viability for this concept is made by means of games played between a speculative startup and the groups of existing car brands that the startup is going to compete with. Scenarios that are most likely to develop, are represented by Nash equilibria of these games, and include Startup player opting either for MFR or traditional production and Cluster player, that can either actively fight the opponent or accept its presence on the market. The results show low competitiveness of the MFR model in the groups of brands with high focus on innovative technologies, and higher competitiveness in the groups where customer service level or total cost of ownership are of high priority for end customers. There is a number of limitations in the study, originating from simplified and generalized game model and incompleteness of the value chain analysis. By removing these limitations, one will be able to get more precise and in-depth results in further studies of this subject. Another important question to be addressed in the future is how the established car makers can find good incentives to change their methods of work to more sustainable.

1.0 Introduction and literature review

1.1 The problem of unsustainability in the automotive industry

Sustainability is traditionally defined as an ultimate expression of its three dimensions – economic, social and environmental sustainability [2]. It's how good a product category, supply chain or industry can sustain its normal functioning and development without negative consequences in these three dimensions. A sustainable industry is one that considers economic, social and environmental costs of production and consumption of its products during their entire life cycles.

How sustainable is today's automobile industry? Does its sustainability get higher or lower year by year?

Among automobile manufacturers a lot of sustainability reports are made by industry representatives every year. They present figures that overall show slow but certain improvement of sustainability parameters in the industry [1]. However, even while telling the truth from a statistical perspective, the industry struggles to give somewhat deeper overview than that, when it comes to a holistic vision of the perfect automobile industry from all stakeholders' standpoint. In addition, I haven't found any comprehensive overviews of sustainability development for the global car industry. This fact, together with a review of the SMMT 2017 UK Automotive Sustainability Report raises questions: Are the sustainability concepts that are claimed in the industry reports, feasible and suitable for all the stakeholders? How do we know that they are not mutually exclusive? At least some of the KPI's in this report do not look very suitable to include in the sustainability report, for example Total number of cars produced. Why should it be there? And why does the report include quite a little attention to the current problems of the industry – problems that annually cost a lot to the economies, societies and environment? The status quo is as important for our complete understanding as the goal of sustainable development, because only knowing both well, we can estimate the workload necessary for the full transition to a sustainable industry.

Furthermore, there is a variety of articles focusing on particular problems of sustainability of the industry and proposing ways of solving them. This category of articles is created primarily by independent experts, contrary to the previous one [1], where authors are often directly employed by the industry. In my work I decided to start with description of the existing problems, sustainability goals that industry should proclaim, and main

barriers on the way to reaching them, all this from the perspective of articles I have found on the subject. This section will aim to comprise the automobile as an entire phenomenon, including not only production but the rest of lifecycle issues as well. And by this means, it will shape the scope of analysis for the rest of the work.

1.1.1 What makes the industry unsustainable

As the overall complexity of car systems grows year by year, so does the complexity of their failures. The background of the problem is simple: even though reliability of single components has definitely done a significant progress during the whole history of car engineering, the ever-increasing complexity makes car failures happen. And, the character of the failures is changing: the focus gradually shifts from mechanical to electronic components, from replacement of single parts to complete assemblies, and from predictable to unpredictable failures [3]. Even though modern cars fail less often than their predecessors, average time spent per failure as well as economic cost involved, is now higher than ever before. I have specified this issue as "Disparate durability of car components", where the word disparate depicts uncertainty for car owners, dictated by increased qualitative and quantitative complexity and degree of unpredictability of failures. The negative consequences of this issue, described in the three sustainability dimensions, are always present. For a manufacturer, a certain design or assembly flaw can cost millions of dollars paid for a recall campaign. Economies of end users bear losses in cases when failures are not covered by campaign or warranty. End users also waste time for repairs, regardless who pays for them. And the environment suffers from scrappage of components, which on a grand scale turns out to be a severe abuse of resources, thinking of all the cases of scrapping of complete assemblies instead of only replacing small parts inside them, along with scrapping good parts by mistake in process of diagnosis of complicated malfunctions.

As another issue, I have included the tendency of manufacturers to produce cars over the level of demand. Nieuwenhuis et al. even mention overproduction as the main issue leading to unsustainability of automobile as a system [4]. For manufacturers, this attribute of economies of scale plays out as extra costs of unnecessary production and losses due to unsold new cars (including transportation, storage and handling). End users get their new cars rapidly depreciating due to oversupply of newer models.

Wells [5] indicates that the automotive industry, as the largest single manufacturing sector in the world, constitutes a major consumer of raw materials accounting for about 16% of global steel use (and nearer 40% of high-grade wide strip steel), 30% of aluminium, 5%

of plastic, 85% of magnesium die casting and significant proportions of other materials such as rubber and copper. For manufacturers this means high costs of production, which they try to mitigate by development along the lines of economy of scale. High usage of non-renewable resources in the industry is of course an environmental problem too.

High total cost of ownership (TCO) for modern cars is a logical consequence of ever-rising standards of safety and environmental performance, as well as manufacturers' response to increased customer expectations in all segments. However, TCO is also a product of industry's business model. For practically all of today's cars it is driven by markups and maintained by car dealerships. To my mind, this combination keeps the model from being truly cost-efficient, because cars are followed up along the lifecycle by organizations totally different from those that make them. And so, the long-term interest mismatch is in this case inevitable. Dealers are pure sales organizations; therefore, it's natural to expect financial income to be their first priority, while customer loyalty may have not as significant meaning for them as for manufacturers. Meanwhile, magnitude of TCO is to high extent defined namely by dealerships, making all the aftermarket maintenance of cars. High TCO can in long term contribute to erosion of new car sales due to lower willingness to pay. End users of cars get losses from two sides – higher investments in own cars that they would like to make, and fast depreciation of those cars (fueled also by other factors). Low economic viability of repair leads to premature scrapping. This is additional overload of environment, which should be avoided in a sustainable industry.

Finally, there are two issues that are related to car usage rather than production. Pollution by internal combustion engines costs a lot to manufacturers, governments and end users in material terms, due to high complexity of car engine systems, as a result of tightening norms. Health problems, climate change and other environmental damages are common problems caused by pollution.

Cars, when used in densely populated areas, take huge spaces on roads and parking lots, which heavily affects traffic and human-friendliness of streets and public places. There is a number of factors, integrated the into common category "Inefficient car usage patterns", leading to that. Public authorities try to solve this issue with better road planning and imposing of restrictions on traffic, which costs certain effort and money. Car users waste time in heavy traffic, while cars consume more fuel per kilometer and tend to get higher wear and tear. Naturally, societies and environment close to areas with high traffic take hit.

Table 1 shows the summary of sustainability issues and their consequences.

Issues	Consequences		
	Economic	Social	Environmental
Disparate durability of car components	- Manufacturers bear recall campaign expenses - End users pay extra money for repairs	- End users waste time for repairs	- High scrappage rates of components
Overproduction	- Extra costs of unnecessary production - Losses due to new cars not sold within year of production - Fast depreciation		- Transportation and handling of overproduced cars
Very high resource intensiveness of production	- High production costs for manufacturers		- High usage of non-renewable resources
High TCO for end users of cars	- Manufacturers lose new car sales due to lower willingness to pay - End users invest in ownership more money than they would accept - Fast depreciation		- Excessive scrappage of cars due to low economic viability of repairs
Pollution by engine exhaust	- Manufacturers bear expenses for conformity of cars to the ever-toughening norms - Governments spend resources for maintenance of norms - End users get extra expenses on car maintenance due to added complexity		- A lot of health problems due to harmful emissions - Climate change and other environmental damages
Inefficient car usage patterns	- Governments, authorities and companies	- Society faces overall life quality	- Environment suffers extraordinary in

	spend extra resources fighting against traffic congestion and lack of parking space - End users get losses due to higher fuel consumption, higher damage and wear rate in tight traffic conditions - End users get losses due to time wasted in congestions	fall where there is high density of traffic	the places with high traffic

1.1.2 Sustainability goals

Next question is: how to reach sustainability within all three dimensions?

I have addressed this question by summing up the key economic, social and environmental sustainability goals, means of their achievement, and desirable results after achievement in Table 2.

I assume that some clarifications will be necessary before moving to the table.

Economic dimension.

Each of the three main economic goals show attachment to own category of stakeholders. *Effective levelling of economic consequences of social and environmental unsustainability* is most relevant for society. *Good returns of investments in sales and research & development projects* is relevant for manufacturers. *Making cars more attractive durable goods to pay for* is relevant for end users. Means of advance towards these goals can be described by two concepts: efficiency and transformation. Manufacturers should efficiently use their R&D capital, and authorities should efficiently take congestion and pollution reduction measures. Efficiency is especially important for the society as stakeholder. As we move further to corporate and individual stakeholders, transformation gains greater importance. In conditions of extremely low product sales margins [], improving the share of value added activity becomes highly relevant. According to principles of lean thinking, the common understanding of lean measures throughout entire corporation is a required component for success [4]. So, transformation of business model which not only enables but also secures increase of value added activity, is desirable. For customers this would also be a good possibility to get lower TCO. Today we see that progressively lower

share of potential first-time car buyers opt for owning a car on developed markets [6], as their priority shifts from a demand for car to a demand for transportation. Various types of mobility-as-a-service concepts emerge nowadays on the background of this. Transformation of the business model is highly related to upcoming transformation of customer value and therefore, car usage patterns.

Social dimension

A sustainable automobile in this interpretation is a topic of interest for both members of industry supply chain and end users of cars, as well as for all traffic participants.

There are certain problems with the realization of the mass-customization concept in the industry, as stated by Wells [5]. Among other sustainability issues, Wells mentions that production concentration and extensive distribution systems lead to long delivery times for customer-ordered cars and high levels of stock in the system. Parry and Roehrich [7] tell on the same subject that the industry suffers from global overcapacity and rising stock levels and exhibits inherently low profitability. Whilst lean thinking has enabled the automotive industry to optimize systems for mass production with minimal waste, it has not tackled the problems of capacity and demand. We find ourselves in a position where a car can be built from flat steel within 11 hours, but a customer ordering a car in a dealership has to wait around 40 days to purchase their desired vehicle or buy one from stock. When manufacturers are still oriented on large scale production, the dealerships can never reach the product variety potential of the supply chain due to the bulky nature of car as a stock keeping unit. So, the conflict between manufacturers and sales is whether the former should optimize their distribution channels, or the latter should show smarter order planning and build up stocks.

Due to very large size of car plants, their share in work and wealth generation is concentrated into particular locations, poorly spread across the country and society as a whole [5]. This problem displays another conflict of interest – between manufacturers and local societies, that either become highly dependent on the dominating industry, or lack possibilities to offer qualified workforce to this industry at all. A balanced situation is rare within country regions and never happens on a country level.

So, if today we have huge car plants with plenty of dealerships, could the above-mentioned problems be solved with transformation of production sites into much smaller integrated cross-functional facilities, given that their amount will be sufficient to effectively function as a decentralized supply chain? And if a workable “all-in-one” concept, unifying all functions related to car lifecycle from manufacturing to recycling under one roof, have

chance to establish? To this point, these questions are left open, to be addressed later in this work.

Automobiles are made to provide convenient transportation in all inhabited areas. Convenient here means fast, reliable and acceptable for all traffic participants. However, idling time of about 95% for an average car as well as disorganized and egoistic nature of decision making of traffic participants, in fact, eliminate convenience in the whole idea of the automobile. But, we can clearly observe the development of three powerful trends approaching the industry – it's connectivity, shared mobility and autonomous driving. Together they aim to return the privilege to be the most highly-demanded type of transport to automobiles. However, there are various estimates of time frames for mass application of these trends.

Environmental dimension

To be more environmentally sustainable, automobiles should greatly reduce emissions in the atmosphere, and use as little energy and non-renewable resources during the life cycle as possible. The former goal appears to be achievable with electrification of the world car fleet, which is now finally an uprising trend, especially in some countries. Other alternative power sources for use on cars are developing as well, but electricity has recently become the front-runner in this race. It can also greatly contribute to the latter goal, simply because of high output-input ratio of an electric motor: up to 98%. There are many factors of facilities design, that can allow for better energy use along the car life cycle. But, staying in the framework of this research, I would name best practices of design for maintenance, retrofit and remanufacturing the key factors that should be changed in automobile design for better environmental sustainability of cars. This has potential to save incalculable amounts of man-hours in car workshops and prolong lifecycles of cars and components.

Dimension	Goal	Means of advance	Desirable results
Economic	Effective levelling of economic consequences of social and environmental unsustainability	- Efficient usage of R&D capital by manufacturers - Efficiency of congestion and pollution reduction measures taken by authorities	- Lower economic burden for end users from cars that are built to last - Lower economic burden from more efficient traffic

	Good returns of investments to automobile makers in their sales and research & development projects	- Efficient usage of R&D capital by manufacturers - Transformation of business model, allowing for higher share of value added activities	- Lower economic burden from cleaner environment - Lower fixed costs - Lower financial risks at introduction of new car models - Realization of mass-customization potential - Flexibility in response, shorter lead times, later configuration - Flexibility in factory design
	Making cars more attractive durable goods to pay for, in terms of TCO and total share of utilization time during life cycle	- Transformation of business model, allowing for higher share of value added activities - Transformation of car usage patterns and customer value (need for car -> need for transportation)	
Social	Eliminate conflicts between manufacturers, sales and customers	- Transformation of production sites into integrated cross-functional facilities	- Balanced communities of true automobile professionals - Realization of mass-customization potential - Reliable and speedy transportation
	Provide speedy and reliable transportation in all inhabited environments	- Reduction of idling time and more efficient total fleet capacity usage - Decision making in traffic out of common interest	
	Provide comfortable traffic environment for all participants	- Decision making in traffic out of common interest	
Environmental	Reduction of harmful emissions by motor vehicles	- Electrification of daily car fleet - Development of other alternative fuel types	- Cleaner environment - More efficient resource usage
	Reduction of total external consumption of	- Electrification of daily car fleet	

	energy and non-renewable resources by a car during the whole life cycle	- Development of Design for maintenance/ retrofit/remanufacturing best practices	

1.1.3 Barriers on the way to sustainability

Surely there are issues that can and will inhibit the rebirth of the car industry to some extent. Here are those I would characterize as the most significant.

The car industry in the developed world consists of highly concentrated actors, and by today is marked by relatively low returns on investments. This makes competition harsh with differentiation as a must-have skill. Car makers up to nowadays have been very reluctant and/or cautious in introduction of sustainable innovations, because of high uncertainty in terms of returns on investments in them. The new common car production culture is developing only now, raising the overall confidence. Still, car makers, caught between society demands, market and government regulations, and their own financial ambitions, must take hard decisions. They must continue to differentiate, test strategies and predict behavior of competitors in order to prevent their own market shares from shrinking.

Buying and utilization habits are another restrictive factor on the way to sustainability of automobiles. End customers are naturally cautious to the ground-breaking technologies when it concerns such a costly thing as a car. This is especially a characteristic of markets in developing countries. Transparency should always be present in innovative car business models, and the customer value must be properly explained [8]. Additionally, customer preferences on local markets should be followed up, as an effective measure of customer retainment.

Furthermore, a poorly controlled and unstructured second-hand market is an issue tightly related to steep value depreciation of new cars. More than that, as mentioned in my previous research [9], car makers in fact consider only the first buyer as an end customer and put very little effort into improvement of perceived quality for second-hand buyers. This concerns not only production technology but also service. Control of entire lifecycle allows for greater market value of used cars, and their longer life cycle before scrapping.

I offer the already named features of micro-size distributed car production facilities as solutions that can successfully counterweight sustainability barrier issues. With many factories of smaller size manufacturers will have much greater flexibility in launching new

products and implementing innovations, because this will allow for stepwise changes. This way, confidence of manufacturers in return of investments in their projects will rise. Higher regional representativeness of integrated cross-functional facilities will help customers to feel healthier attitude from manufacturers in regard to knowing local needs, clearer explanation of customer value and stronger aftermarket support without intermediates. Control of entire life cycle will allow manufacturers to gain significant additional income from aftermarket activities and reduce depreciation of new cars. With micro-factories overproduction issue will be much easier to control, because only local market forecasting will be needed. Modular design, rebuilding and remanufacturing will make aftermarket activities more value-added and by this means increase willingness to pay both for new cars and aftermarket service. Altogether, these features will be able to further reduce depreciation of cars during lifecycle and increase longevity.

Sustainability barrier	**Lacking component**	**Solutions**
Manufacturers get low returns on investments and are focused on differentiation rather than on sustainable innovations.	Confidence of manufacturers in profitability of sustainable innovations	Modular design. Small production-distribution-service facilities
Buying and utilization habits restrict end users' willingness to pay for sustainable innovations.	Transparency and proper explanation of customer value. Local preferences follow-up.	High regional representativeness of production facilities, which combine all lifecycle functions.
Second-hand car market is poorly controlled and unstructured. New cars rapidly depreciate.	Improvement of perceived quality for second-hand buyers.	Modular design. Control of entire product life cycle.

1.2 How MFR is supposed to solve the problems

The original concept of Micro Factory Retailing for automobile industry is described by P. Wells and P. Nieuwenhuis in 1999 [8]. My suggestions about benefits of its principles for sustainable development of the industry are strongly based on the material I have read

about MFR. How MFR could be helpful for sustainability? The answers are extracted from the text by P. Wells [5] and put into Table 4.

Category of advantages	Economic	Social	Environmental
Agile business	- Investments in new assembly capacity can be incremental and can more easily expand or contract in line with the market. - Incremental expansion of capacity can also have a geographic component in that new plants can be added to develop new market territories. - New products can be introduced incrementally, on a factory-by-factory basis, with much lower overall financial risk associated with them.		
Standardization	- Through duplication of MFR sites investment savings could be achieved by means of the multiple ordering of machines and equipment and the use of a standardized layout. - In transport terms, it is more efficient to move components and sub-assemblies rather than complete vehicles.		- Environmental benefits can be achieved because it's only necessary to move components and sub-assemblies rather than complete vehicles.

Value capturing	- Factories become locations for repair and aftermarket activities (e.g. body panel change, engine upgrades, refitting of interior trim), which allows the manufacturer to benefit directly from them. This eliminates conflict of interest between production and retailing.		- Factories become centers for trade-in vehicle sales and End of Life Vehicle recycling. Material recovery and remanufacturing become viable at the local level because transportation costs are often the major barrier to such efforts. - Factories do not depend absolutely on the continued sale of new cars. This helps to mitigate the tendency to over-production with all associated environmental and market benefits.
Benefits for customers	- New levels of customer care can be built. MFR makes possible flexible response, shorter lead times, and late configuration.	- Modular refit allows for functional flexibility, which allows for realization of true mass customization. - Consumers may benefit financially from a reduction in depreciation of the vehicle - the largest single cost of new vehicle ownership, which in existing systems is a product of product wear, overproduction, and the step-change	

		introduction of a new model. - Customers can be taken around the plant, can meet the people who will make their car, and can thereby feel 'closer' to the product. Information about customer needs in a particular region goes transparently to the factory management.	
Benefits for communities		- The MFR concept allows for creation of local employment in high-value manufacturing activities. It also embodies the desire to increase labor and reduce fixed investment in order to reduce cost, increase flexibility and social cohesion. - Stronger worker commitment to the product and to customers. The small factories escape from the 'mass' culture of traditional high-volume manufacturing. - Lower social impact of plant closures, as a smaller plant would be closed in each location.	- Manufacturing processes have a lower local environmental impact compared with traditional high-volume manufacturing and even give the option of doing without a paint plant which is generally regarded as the largest single problem area in traditional car assembly. - MFR does not require a large, flat, dedicated site with extensive support services. A modern traditional car plant occupies several square kilometers of land. Compared with this, MFR requires a classic 'light industrial' facility, and is highly

			suitable for brownfield sites.

Table 4. Potential advantages of MFR

This concept is in essence very simple: the manufacturing operation and the distribution/retail operation are combined in the one entity. Between 25% and 40% of the market price of a car is attributable to the distribution system [5].

The business model has two main aspects by which social sustainability is potentially superior to that offered within the traditional automotive business model. The first aspect is that of enhanced customer access to environmentally friendly products, more closely aligned with their particular needs, along with long-term support. The second aspect relates to labor, where MFR creates the possibility of more varied, interesting and rewarding work along with more stable employment patterns distributed more widely across spatial areas.

More significantly, this change in product technology (which as a by-product can yield lightweight cars of lower environmental burden) and the associated process technologies not only changes the terms of competition, it provides the basis for a more sustainable business model. For example, alternative vehicle architectures and materials are much more conducive to modular repair and retrofit, which in turn means that the economic cost of such activities will be much lower. Therefore, the economic incentive to scrap a vehicle is lower, vehicle longevity can increase dramatically because it can be continually renewed and updated with the latest technologies (with the attendant environmental benefits). The vehicle becomes more of an asset to be retained by the vehicle manufacturer and leased to the consumer, thereby generating stable and long-term income streams.

None of the above actually directly relates to the issue of ownership. For example, this type of structure could be achieved through the fragmentation of an existing vehicle manufacturer, or by a new-entrant start up, or various intermediate business forms. Moreover, local ownership might be one means whereby communities derive the additional social benefits of local control: a key problem with traditional globalization is that local communities or indeed entire countries feel powerless in the face of large multinational companies [5].

1.3 How application of MFR in the car industry can be described by Game Theory

Game theory and its methods applicable for this thesis will be described in detail later in the Methodology section. Generally, game theory should aggregate preferences of the manufacturers (referred to as players), driven by abovementioned trends, problems and restrictions, into market development scenarios and final states likely to happen. The thesis will include identification of Nash equilibria in strategic games with simultaneous moves of the players, with strategies of one player to be MFR or traditional car production. Subsequent elaboration on results will also include some thoughts on dynamic games, where strategy choices can reflect degrees of expansion of MFR production or other market competition tactics aimed to improvement of the competitive advantage. However, dynamic games will not be highlighted in the section of results. Static games, according to the scope of this work, will provide enough suggestions to be developed in the section of discussion.

The research will constitute on several hypotheses to be listed in the next sub-section. In the Discussion section proof or disproof for each hypothesis will be derived. The hypotheses and further elaborations over them will reflect the questions why the MFR model is not practiced in the mass production of cars and which prospects does MFR have in the future automobile industry.

1.4 Hypotheses.

Assumption. MFR is a central tool for reaching sustainability of a business model for a car manufacturer, however, existing manufacturers may find it not rational to undertake a complete change of their business models to MFR. Therefore, its application within the scope of this work will be restricted to only new speculative players on the market. Costs of change to MFR as well as possibility of fractional change, are not included in the scope of this work.

H1. MFR is more suitable for custom production, than for mass production.

H2. Existing players will find it more rational to fight newcomers that apply MFR business model, rather than accept.

H3. MFR startups will be unable to affect actions of other players in case of active rivalry.

2.0 Methodology

2.1 Why Game theory?

Game theory is a theory that deals with the situation when one individual's actions depend on what other individuals may do. It is concerned with how several individuals make decisions when they are aware that their actions affect others and when each individual takes this into account [10]. According to OICA report [11], 17 car makers with international presence have made 80% of all cars in 2016. Given that today's car market hence is close to an oligopoly, this study considers game theory as an appropriate tool for decision makers in the industry to predict market development.

A game normally consists of a set of players with strategies that are available to them. The outcome is the result from the sequence of actions played by all players, with each player hoping to achieve their own desired outcome [12].

The gap in knowledge that is supposed to be reduced by means of this study, exists due to very insignificant amount of research made both within fields of game theory and innovation [13]. Automobile industry, one of the world's most capital-intensive industries, faces rapid structural changes. Decision makers deal with uncertainty, so they increasingly need reliable tools for scenario forecasting. I believe that the development of this study can become one of such tools.

Game theory in the framework of this study allows for modelling of market development situations by means of static and dynamic games. Adoption of the MFR concept is supposed to be described here using the basic elements of a game. Players are car manufacturing companies. Rules of the game specify three things: timing of players' moves, actions available for the players, and information available for the players at each move. Outcomes are the sets of actions taken by the players. Payoff for each player could then be defined as a measure of competitive advantage of the player in the end of the game.

2.2 Game models

Static games in normal form will be applied to simulate different market situations and see where Nash equilibrium should be expected, given the outcomes. There will be two players in each variant of the game: a newcomer on the market (startup), and a group of established manufacturers (cluster), representing a market segment the newcomer is aiming to occupy. The startup's strategies will be to choose MFR ("MFR") and to go for traditional

business model (“no MFR”). The cluster will choose between strategies “Fight” or “Accept” startup, where “Fight” means taking measures within marketing, research and development, supply chain management or customer service, aimed for further improvement of *existing* competitive advantage. Outcomes will represent simple superiority of customer preference of one player over customer preference of its opponent after the actions are completed. This superiority is believed to be the determinant of the market success of a winning player. The characteristics that will shape game outcomes are a logical estimate, are discussed in Section 3. An example of a such normal form game is shown on Fig. 1. Payoff figures are exemplary; they stand for degree of customers’ preference (number of cars sold), as compared to that of the outcome {MFR;Fight}, which is [x;y].

	Fight	Accept
MFR	x; y	1,5x; 1,5y
No MFR	2x; y	3x; 2y

Fig. 1. Example of the static game “MFR vs. traditional car manufacturing”. Payoffs show relative customer preferences for each player after implementation of the chosen strategy.

3.0 Results (facts of research)

3.1 Data

The European car market showed sales volume of 15,6 million of passenger cars in 2017. This is about 20% of world car sales the same year, which makes the European market relevant as the unit of analysis in this work. I use the detailed data for 2017 provided by ACEA [14] for description of market shares of the players, and data from ICCT 2017 report [15] to demonstrate market trends and historical development.

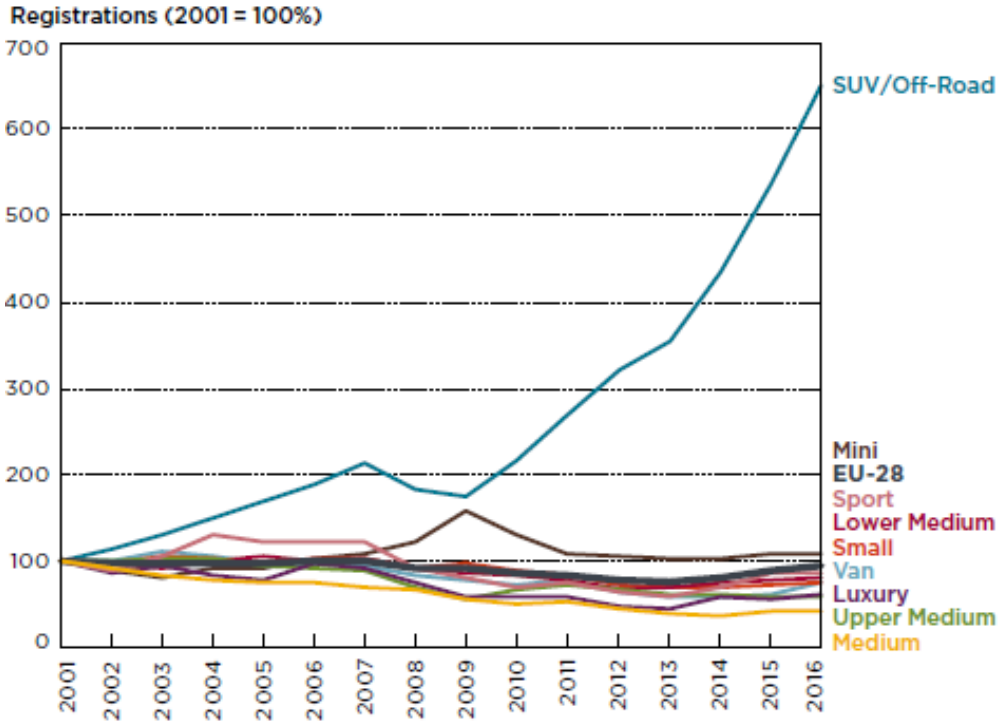

Fig. 2. New passenger cars registrations by class, 2001-2016.

New registrations by class in 2001 through 2016 are shown on Fig. 2. The graph shows that the total increase in sales during this time is almost solely provided by contribution of SUV class share. This class have risen in sales figures by 550% during the whole period, while the other classes showed 2016 values 50-110% compared to 2001. Customer preferences leaning to SUV is one of the clearest trends on the car market today.

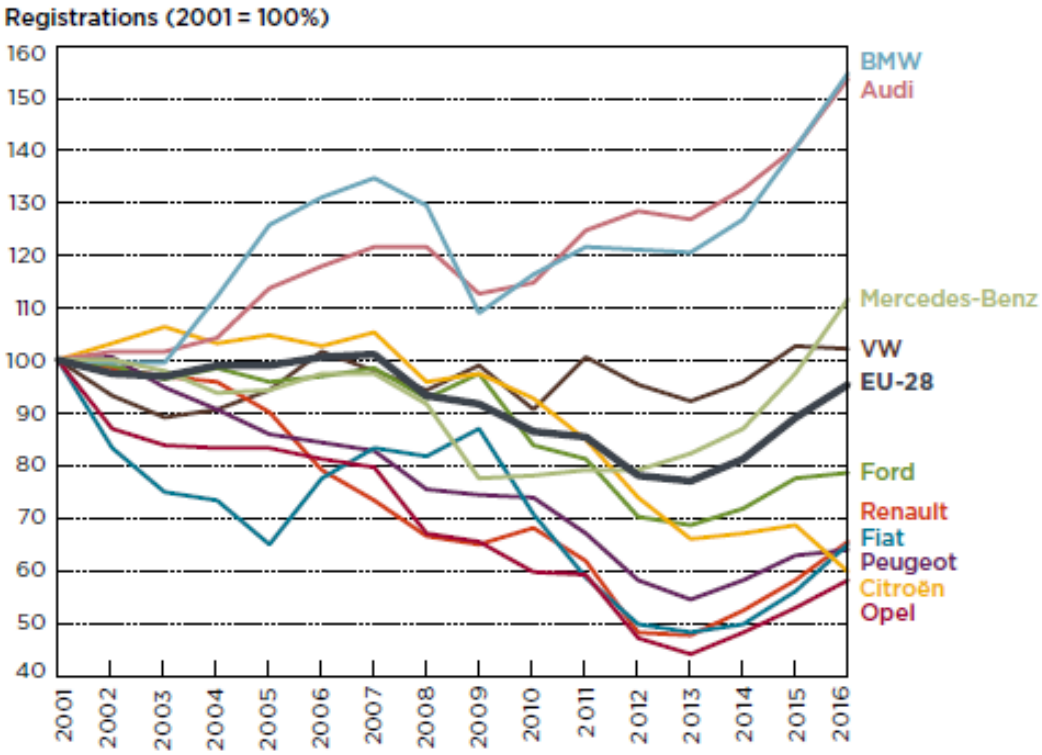

Fig. 3. New passenger cars registrations by brand, 2001-2016

New registrations by brand for the same period are on Fig. 3. BMW and Audi are the only producers that show significant growth in sales with more than 150% new registrations in 2016 compared to 2001. BMW, Audi, Mercedes-Benz, as well as FIAT, Renault and Opel showed considerable and stable growth rate in 3-4 years up to 2016. Meanwhile, Volkswagen, Ford, Peugeot and Citroen have not been on the rise.

The ICCT report shows that Toyota is the market leader in the segment of hybrid electric vehicles, with a rapidly growing share in the total sales volume. About 37% of new Toyota passenger cars registered in Europe in 2016 have been hybrid electric, while other manufacturers showed either moderate growth or decline of this share. In the segment of plug-in hybrids and electric vehicles, BMW and Mercedes-Benz have been on the rise with 4% and 1,8% share in the total sales volume respectively, while others showed no rising trend and no more then 1,7% share. Another trend is the increasing share of new cars with start-stop technology, where Audi, BMW, Mercedes-Benz, Volkswagen and Renault are leaders with the share of new passenger cars with this technology approaching 100%. I will let myself derive the innovation level of the players from these data, displayed on Fig. 4.

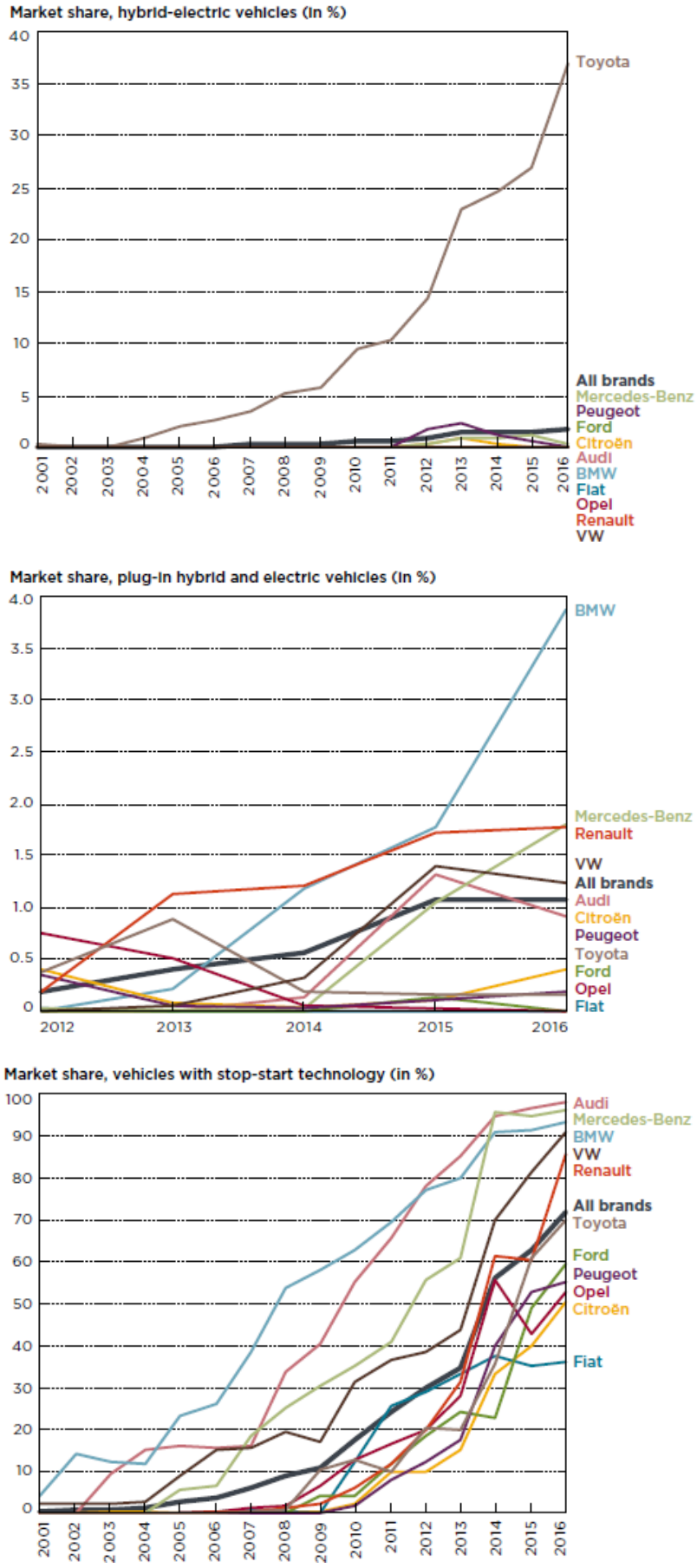

Fig. 4. Determinants of players' innovation level.

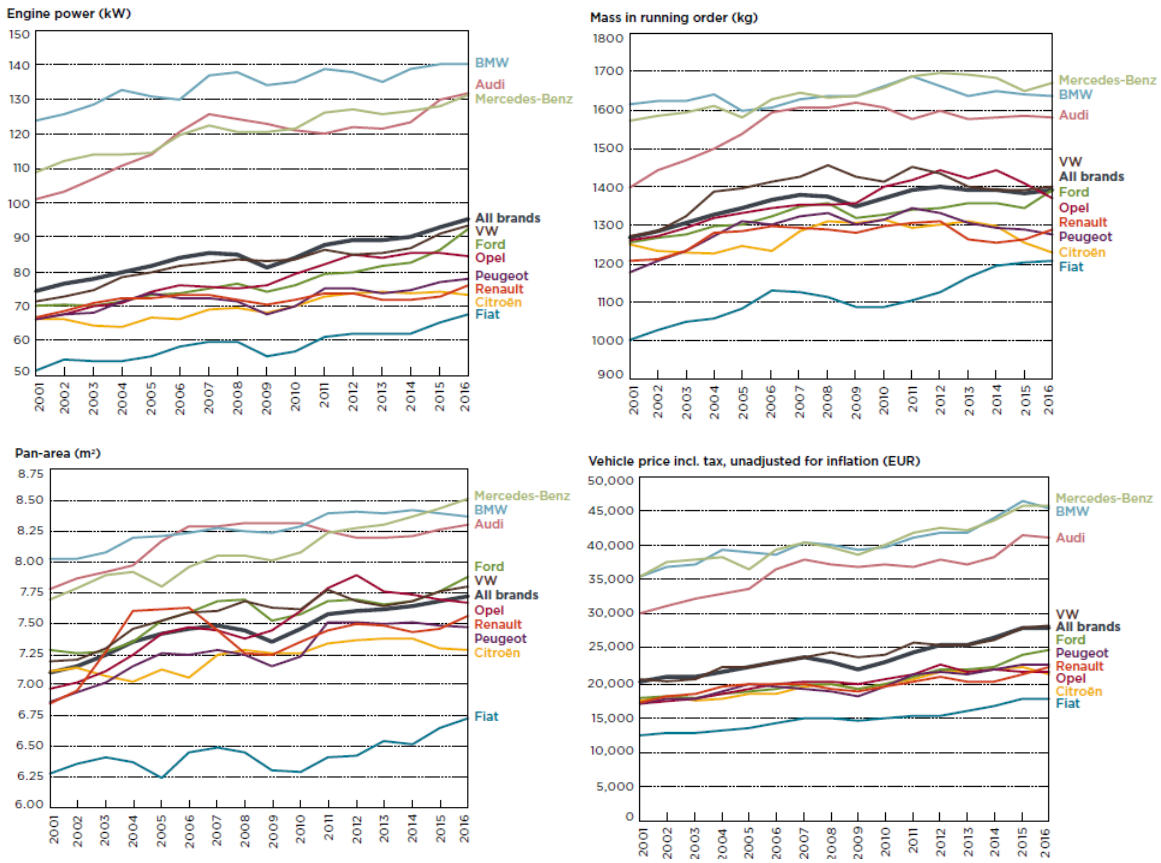

Fig. 5. Determinants of players' prestige level.

Fig. 5 shows development of average engine power, mass, size and pricing for each leading manufacturer (with more than 5% market share in 2016) for the period of 2001-2016. I define them in this study as determinants of prestige level of the players.

Report by ACEA [14] depicts sales volumes and market shares of 32 car manufacturers introduced on the European market in 2016 and 2017, by exclusion of only some few brands with very low sales figures (top class prestigious brands). The important detail to emphasize is that, unlike the ICCT report, which includes numbers of new registrations, ACEA report features numbers of sales. For each manufacturer these two figures may differ, but still the picture of market share distribution is identical in both reports. The data from ACEA report appear preferable for this study, because they include more manufacturers and are available for 2017. They are introduced in Table 5.

The introduced data will be used as a framework for classification of the players by groups. Grouping will make it possible to simulate games with various outcomes and by this means to make the further analysis more realistic.

	Carmaker	Sales 2017	Sales 2016	% Change 16/17	% Share 2017
	EU & EFTA	**15,631,687**	**15,131,719**	**3.3**	**100.0**
1	– VOLKSWAGEN	1,706,369	1,721,899	-0.9	10.9
2	– RENAULT	1,150,498	1,101,221	4.5	7.4
3	– FORD	1,031,957	1,034,635	-0.3	6.6
4	– OPEL (PSA & GM)	943,227	993,464	-5.0	6.0
5	– PEUGEOT	925,113	864,565	7.0	5.9
6	– MERCEDES	893,574	839,779	6.4	5.7
7	– BMW	827,137	822,724	0.5	5.3
8	– AUDI	826,370	830,933	-0.5	5.3
9	– FIAT	779,534	746,197	4.5	5.0
10	– SKODA	705,421	663,147	6.4	4.5
11	– TOYOTA	673,510	593,760	13.4	4.3
12	– CITROEN	569,728	541,561	5.2	3.6
13	– NISSAN	566,191	550,584	2.8	3.6
14	– HYUNDAI	523,258	505,377	3.5	3.3
15	– DACIA	472,800	421,644	12.1	3.0
16	– KIA	472,125	435,316	8.5	3.0

17	– SEAT	400,968	350,508	14.4	2.6
18	– VOLVO	303,312	291,473	4.1	1.9
19	– SUZUKI	244,877	202,949	20.7	1.6
20	– MAZDA	231,925	237,034	-2.2	1.5
21	– MINI	215,443	209,116	3.0	1.4
22	– LAND ROVER	151,566	153,071	-1.0	1.0
23	– HONDA	140,343	159,187	-11.8	0.9
24	– MITSUBISHI	114,182	117,086	-2.5	0.7
25	– JEEP	108,655	105,015	3.5	0.7
26	– SMART	98,954	105,295	-6.0	0.6
27	– ALFA ROMEO	85,691	66,167	29.5	0.5
28	– PORSCHE	73,456	71,172	3.2	0.5
29	– JAGUAR	69,473	68,687	1.1	0.4
30	– LANCIA/CHRYSLER	60,805	67,230	-9.6	0.4
31	– DS	45,864	65,656	-30.1	0.3
32	– LEXUS	44,339	44,658	-0.7	0.3

Table 5. Car sales on European market in 2016 and 2017 by manufacturer.

3.2 Choice of players

Based on the market data shown in the previous section, I have created a classification of the market players. This classification uses two-dimensional space, formed by axis named “Prestige level” and “Innovation level”. Today car manufacturers experience low sales margins and high necessity to differentiate. I believe that namely levels of prestige and innovation are the categories that define customers’ perception of differentiation of a car make as a whole in the most correct way. The diagram on Fig. 6 shows how differentiated are the manufacturers in the European car market from the perspective of their location along the axis “Prestige level” and “Innovation level”. Market shares of each manufacturer are added for better overview. Based on their position on the diagram, players are classified into different groups. When the games will be played, startup (row player) will always play with each of the groups (column player). Then, outcomes and payoffs may depend on the particular combination of players in the game.

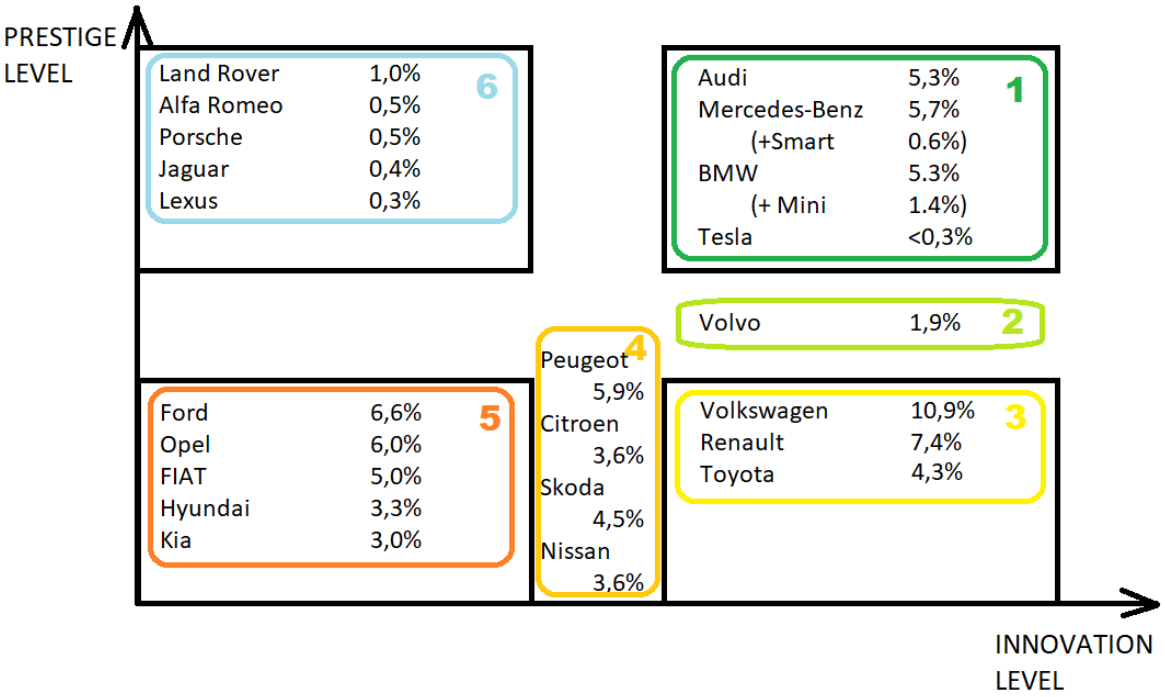

Fig. 6. Grouping of market players by differentiation.

The classification results in 6 groups of players. Together the 24 players introduced in the groups, account for over 87% of the market volume in 2017.

Group 1 – Flagships. The members of this group are highly differentiated by both prestige and innovation, which is confirmed by their maximum brand strength in Europe and the world. Audi, BMW and Mercedes-Benz take close market shares and have good control in most of the market segments. Smart and Mini are compact car brands for Mercedes-Benz

and BMW respectively. The German "Big Three" pays highest attention to technologies and promotion and has got global market presence long ago. Tesla, on the contrary, have entered the market very recently. It is included here despite low market share, not only because of the brand's ability to innovate and the iconic image, but also due to the high brand exposure in Norway, the country where the present study come from. All the members of the first group set justifiably higher prices for their cars, compared to closest competitor models from other groups. They also tend to work on the customers' perception of their brands as more "approachable" by offering top class models in non-premium market segments. The total market share of the Flagships is 18,5%

Group 2 – Flagship Candidate. Volvo is striving to establish in the quadrant of Flagships with its active renewal of the product line. It's image of the safest car make is still robust and honed with the cutting-edge technologies. Volvo's pricing level is therefore can be directly compared to that of Flagships. Still, moderate width of the product range and overall low market share (1,9% in 2017) prevent Volvo from being included in the first group so far.

Group 3 – Technology Mainstream. This group includes members with somewhat different background, but their high progress in innovation to the time of this study is recognized, not least due to strong positions in the segments of electric and hybrid cars. Volkswagen with its 10,9% market share in 2017 (highest among all the manufacturers), has the highest brand power in the group, and the highest presence in product segments. Volkswagen, Renault and Toyota are included in large multinational corporations which ensure them high ability to retain market positions through corporate cooperation. Given lower prestige level, compared to the Flagships, members of this group set moderate pricing for the cars. They also have more widespread physical distribution channels. Because of the ongoing major technological changes in the car industry, I estimate that Technology Mainstream companies, taking together 22,6% of the market, are soon going to experience much fiercer competition due to new establishments inside their group.

Group 4 – Technology Candidates. I have judged these players to form a separate group, however they start to make a direct competition to group 3, especially Peugeot with 5,9% market share. Citroen is included in group PSA together with Peugeot, while Nissan belongs to alliance with Renault, and Skoda is a part of VAG together with Volkswagen, Audi and other manufacturers. Nissan is represented globally on the market, while other members have less global presence. The power of alliances and high ambitions of

participants of group 4 allow to estimate that they have high chances to enter competition in Group 3. Together the Technology Candidates take 21,6% of the market.

Group 5 – Budget Mainstream. Ford, Opel, FIAT, Hyundai and Kia stand out from others as cost leaders. Opel have been acquired by group PSA in 2017 and so far, it hasn't shown any intention to change strategy. FIAT is particularly strong brand in Italy and Poland, and it has overall good brand exposure in compact car classes. The total market share of the Budget Mainstream is 23,9%.

Group 6 – Premium. The most remarkable premium brands by market share are Jaguar, Alfa Romeo, Land Rover, Porsche and Lexus, even though none of them have exceeded market share of 1,0% in 2017. The total market share of the Premium companies is 2,7%.

3.3 Estimation of payoffs

Payoffs in games will be estimated with help of following characteristics, applied to both types of players: Brand strength, Product variety, Customer service, Innovation rate, Pricing model, Promotion strength. Values of the characteristics can be: "0" or "1" for Cluster / Player 1 and "+", "-" or "+/-" for Startup / Player 2. The values are of schematic character and based on my personal estimate based on the common knowledge and marketing mix reviews for existing car manufacturers [16]. Specific values for players are displayed in Table 6.

For Startup/Player 1, a "+" value means definite competitive advantage over Cluster/Player 2 in a particular characteristic, a "-" value means stands for definite competitive disadvantage. A "+/-" value shows that a startup can adequately compete with a group of existing companies, but the stability of competitive advantage depends on the strength of the opponent. For Cluster/Player 2 value "1" stands for presence of strength, or ability to replicate the competitive advantage of the startup and "0" stands for lack of strength, or inability to replicate the advantage in the respective characteristic. Thus, in the short time perspective (3 years, according to the scope of this research) performance of a "1" player is considered impossible to exceed by that of a "+/-" startup player, but a "0" player can be beaten by a "+/-" startup in a particular characteristic. If Cluster/Player 1 chooses strategy "Accept", its strength in all characteristic except *Brand strength* is considered to become "0" (so that only "-" startups will certainly have disadvantage in the particular characteristic). The *Brand strength* of "1" players will still be "1" even if they choose "Accept". The summary of the advantages in all characteristics will be drawn for each game,

with elaboration and conclusion about the market forecast for the startup. An example of payoff assessment is in the Table 7.

	Cluster (column player / Player 2) – strategy "Fight" (strategy "Accept")						Startup (row player / Player 1)	
	Group							
Characteristic	1	2	3	4	5	6	MFR	No MFR
Brand strength	1 (1)	1 (1)	1 (1)	0 (0)	0 (0)	1 (1)	-	-
Product variety	1 (0)	0 (0)	1 (0)	1 (0)	0 (0)	0 (0)	+/-	-
Customer service	1 (0)	1 (0)	0 (0)	0 (0)	0 (0)	1 (0)	+	+/-
Innovation rate	1 (0)	1 (0)	1 (0)	1 (0)	0 (0)	0 (0)	+/-	+/-
Pricing model	0 (0)	0 (0)	1 (0)	1 (0)	1 (0)	0 (0)	-	+/-
Promotion strength	1 (0)	1 (0)	0 (0)	0 (0)	0 (0)	0 (0)	+/-	+/-
comment	Interpretation of sub-outcomes (components of the total outcome, related to each characteristic): ["-"; "0"], ["-"; "1"] – Startup/Player 1 is not able to compete with Cluster/Player 2 in this characteristic. Cluster/Player 2 wins. ["+/-"; "0"], ["+"; "0"] – Startup/Player 1 is able to compete, Cluster/Player 2 cannot replicate the advantage. Startup/Player 1 wins. ["+/-"; "1"] – Startup/Player 1 is able to compete, Cluster/Player 2 can replicate the competitive advantage. Cluster/Player 2 wins. ["+"; "1"] – Startup/Player 1 is able to compete, Cluster/Player 2 can replicate the advantage only in the short run . Startup/Player 1 wins.							

Table 6. Values of the characteristics for customer preferences for the players.

Customer preferences in each characteristic can be in favor of either player, but never equal. So, if, like in this example, one player is preferred by customers in 5 characteristics, the opponent will be preferred in 1. The standard assessment is always applied to the outcome {"MFR"; "Fight"}. The number of customer preference winnings is summed up

for each player and equated to *x* for Startup/Player 1 and *y* for Cluster/Player 2. Payoffs for all the other outcomes will be then expressed through *x* and *y*.

	Startup	Cluster
Brand strength		×
Product variety		×
Customer service	×	
Innovation rate		×
Pricing model		×
Promotion strength		×
Result	*x*	*y*

Table 7. Example of assessment of payoffs for a game outcome {"MFR"; "Fight"}.

As the next step, I will explain assignment of values to the different players in the Table 6.

Brand strength. Flagships, Volvo, Technology Mainstream and Premium have stronger brands than Technology Candidates and Budget Mainstream. Mercedes-Benz, BMW and Audi have earned it over many years (although the least two – more recently) by means of systematic effort in differentiation towards brand superiority. Tesla, a player which is only 10 years on the world market, is now the strongest brand in the electric vehicles segment thanks to impressively competent marketing of the Model S and accompanying active development of the production of electric vehicle components. Volvo has wide recognition by the public as the manufacturer with the strongest focus on car safety. Volkswagen proves its brand strength with the highest market share in Europe, Toyota has secured its position due to the visible result of the forward-looking approach to quality management, and Renault has been able to appear in the same group as an effect of diversified and adaptive market policy with attention to the idea of "value for money" as well as skillful promotion through racing events. Premium brands, although serving a very limited part of the market, are strong because of the exclusivity, ensured by the excellent customer focus. It is generally not expected from a startup in the automobile industry to show the strength of the brand comparable to that of the established competitors, simply because this characteristic is always earned over some period, even though (as with Tesla) this period doesn't necessarily have to be very long. The important notice about *Brand strength* is that it is always the same for Cluster/Player 2 regardless of the choice of strategy,

unlike the rest of the characteristics, that become zero in case of choice of the strategy "Accept".

Product variety. Variety in the context of this work includes both product width (variety of the model range) and depth (variety of versions for every single model). While every manufacturer is doing great effort improving the product depth in pursuit of mass customization, the product width is more variable throughout the market. Flagships, Technology Mainstream and Technology Candidates are doing greater in this characteristic that the other three groups. Flagship Candidate has at the moment not reached presence in as many car segments (specifically, electric vehicles) as the Flagships. Budget Mainstream companies generally abstain from presence in the upper-class segments. To the contrary, Premium brands limit their model ranges to the upper-class and have restricted policy in brand expansion into more segments (for example, Land Rover is producing only SUVs all in all). I consider that a startup choosing MFR is able to reach the level of product variety of the groups that have got "0" in this characteristic, due to the principal differences in the organization of MFR-production, where original powertrains and traditional all-steel body components are eliminated in favor of purchased components and simplified modular technology which allows for dramatic cost reductions in the most significant area of production and R&D costs [4], and hence for launching more new models in the same time period compared to a non-MFR startup.

Customer service. I have selected Flagships, the Flagship Candidate and Premium as the groups with the best customer service. So it's only them who can replicate competitive advantage of a startup in this characteristic. However, MFR startups will still win in this situation because of the ultimate proximity of the integrated production, sales and service facilities to customers.

Innovation rate. Groups 1 to 4 are especially strong in innovations, having ability to replicate competitive advantage of any innovative startup. Groups 5 and 6 are considered to be unable to do that in the 3 years perspective. This means that in the context of this work Startup/Player 1 (regardless strategy chosen) will win over groups 5 and 6 in this characteristic.

Pricing model. Flagships, Volvo and the premium brands have more value-based pricing models, that is, they never set prices for their cars lower than customers want to pay for them. This means that they will be unwilling to participate in price wars. Groups 3, 4 and 5 will more likely do so, because of their market-oriented pricing. MFR startups are considered to pose no threat to any of the Cluster players, because of the theoretical difficulty

of the MFR concept to allow for competitive pricing, which takes origin from much higher labor intensiveness of MFR car production compared to the traditional one.

Promotion strength. Startups will be able to compete with Clusters in this characteristic since adequate promotion is the routine task of every entrepreneur. I consider only groups 1 and 2 to be able to replicate the competitive advantage in the short time perspective, because of their (supposedly) higher price margins, resulting from value-based pricing.

3.4 Static games

In the static games players make their moves simultaneously without ability to cooperate. Payoff profiles are defined based on Table 6.

Game outcome	{"MFR"; "Fight"}		{"MFR"; "Accept"}		{"No MFR"; "Fight"}		{"No MFR"; "Accept"}	
Characteristic	Startup	Cluster	Startup	Cluster	Startup	Cluster	Startup	Cluster
Brand strength		×		×		×		×
Product variety		×	×			×		×
Customer service	×		×			×	×	
Innovation rate		×	×			×	×	
Pricing model		×		×	×		×	
Promotion strength		×	×			×	×	
Payoff profile	X_1	Y_1	$4X_1$	$0{,}4\ Y_1$	X_1	Y_1	$4X_1$	$0{,}4\ Y_1$

Normal (strategic) game representation		CLUSTER (market share 18,5%)	
		Fight	*Accept*
STARTUP	*MFR*	$\boldsymbol{X_1; Y_1}$	$4X_1; 0{,}4Y_1$
	No MFR	$\boldsymbol{X_1; Y_1}$	$4X_1; 0{,}4Y_1$

Table 7.1. Game 1 "Startup vs. Group 1 (Flagships)".

Game outcome	{"MFR"; "Fight"}		{"MFR"; "Accept"}		{"No MFR"; "Fight"}		{"No MFR"; "Accept"}	
Characteristic	Startup	Cluster	Startup	Cluster	Startup	Cluster	Startup	Cluster
Brand strength		×		×		×		×
Product variety	×		×			×		×
Customer service	×		×			×	×	
Innovation rate		×	×			×	×	
Pricing model		×		×	×		×	

Promotion strength		×	×			×	×	
Payoff profile	X_2	Y_2	$2X_2$	$0{,}5Y_2$	$0{,}5X_2$	$1{,}25Y_2$	$2X_2$	$0{,}5Y_2$
Normal (strategic) game representation			CLUSTER (market share 1,9%)					
			Fight			*Accept*		
STARTUP	*MFR*		***X_2; Y_2***			$2X_2$; $0{,}5Y_2$		
	No MFR		$0{,}5X_2$; $1{,}25Y_2$			$2X_2$; $0{,}5Y_2$		

Table 7.2. Game 2 “Startup vs. Group 2 (Flagship Candidate)”.

Game outcome	{“MFR”; ”Fight”}		{“MFR”; ”Accept”}		{“No MFR”; ”Fight”}		{“No MFR”; ”Accept”}	
Characteristic	Startup	Cluster	Startup	Cluster	Startup	Cluster	Startup	Cluster
Brand strength		×		×		×		×
Product variety		×	×			×		×
Customer service	×		×		×		×	
Innovation rate		×	×			×	×	
Pricing model		×		×		×	×	
Promotion strength	×		×		×		×	
Payoff profile	X_3	Y_3	$2X_3$	$0{,}5Y_3$	X_3	Y_3	$2X_3$	$0{,}5Y_3$
Normal (strategic) game representation			CLUSTER (market share 22,6%)					
			Fight			*Accept*		
STARTUP	*MFR*		***X_3; Y_3***			$2X_3$; $0{,}5Y_3$		
	No MFR		***X_3; Y_3***			$2X_3$; $0{,}5Y_3$		

Table 7.3. Game 3 “Startup vs. Group 3 (Technology Mainstream)”.

Game outcome	{“MFR”; ”Fight”}		{“MFR”; ”Accept”}		{“No MFR”; ”Fight”}		{“No MFR”; ”Accept”}	
Characteristic	Startup	Cluster	Startup	Cluster	Startup	Cluster	Startup	Cluster
Brand strength		×		×		×		×
Product variety		×	×			×		×
Customer service	×		×		×		×	
Innovation rate		×	×			×	×	

Pricing model		×		×		×	×	
Promotion strength	×		×		×		×	
Payoff profile	X_4	Y_4	$2X_4$	$0{,}5Y_4$	X_4	Y_4	$2X_4$	$0{,}5Y_4$
Normal (strategic) game representation			CLUSTER (market share 21,6%)					
			Fight		*Accept*			
STARTUP	*MFR*		***X_4; Y_4***		*$2X_4$; $0{,}5Y_4$*			
	No MFR		***X_4; Y_4***		*$2X_4$; $0{,}5Y_4$*			

Table 7.4. Game 4 “Startup vs. Group 4 (Technology Candidates)”.

Game outcome	{“MFR”; ”Fight”}		{“MFR”; ”Accept”}		{“No MFR”; ”Fight”}		{“No MFR”; ”Accept”}	
Characteristic	Startup	Cluster	Startup	Cluster	Startup	Cluster	Startup	Cluster
Brand strength		×		×		×		×
Product variety	×		×			×		×
Customer service	×		×		×		×	
Innovation rate	×		×		×		×	
Pricing model		×		×		×	×	
Promotion strength	×		×		×		×	
Payoff profile	X_5	Y_5	X_5	Y_5	$0{,}75X_5$	$1{,}33Y_5$	X_5	Y_5
Normal (strategic) game representation			CLUSTER (market share 23,9%)					
			Fight		*Accept*			
STARTUP	*MFR*		***X_5; Y_5***		***X_5; Y_5***			
	No MFR		*$0{,}75X_5$; $1{,}33Y_5$*		*X_5; Y_5*			

Table 7.5. Game 5 “Startup vs. Group 5 (Budget Mainstream)”.

Game outcome	{“MFR”; ”Fight”}		{“MFR”; ”Accept”}		{“No MFR”; ”Fight”}		{“No MFR”; ”Accept”}	
Characteristic	Startup	Cluster	Startup	Cluster	Startup	Cluster	Startup	Cluster
Brand strength		×		×		×		×
Product variety	×		×			×		×

Customer service	×		×			×		×
Innovation rate	×		×		×		×	
Pricing model		×		×	×		×	
Promotion strength	×		×		×		×	
Payoff profile	X_6	Y_6	X_6	Y_6	$0{,}75X_6$	$1{,}33Y_6$	$0{,}75X_6$	$1{,}33Y_6$

Normal (strategic) game representation		CLUSTER (market share 2,7%)	
		Fight	*Accept*
STARTUP	*MFR*	$\boldsymbol{X_6; Y_6}$	$\boldsymbol{X_6; Y_6}$
	No MFR	$0{,}75X_6; 1{,}33Y_6$	$0{,}75X_6; 1{,}33Y_6$

Table 7.6. Game 6 “Startup vs. Group 6 (Premium)”.

4.0 Discussion/analysis

4.1 Comments and explanations

The results of the games show the following tendencies:

- Nash equilibria are always located in the quadrant “MFR”-“Fight”, however more than one equilibrium exist for some of the games.
- MFR startups will find it more rational to establish in the groups with lower level of innovative technologies.

4.1.1 Game 1 “Startup vs. Flagships”

Game 1 appears to be the least attractive game for a startup to play. Companies of the cluster (Flagships) have high incentives to fight, because they get only 40% of customer preference if they accept the startup. Therefore, I believe that any resources they will put into improvement of their competitive advantage, will be justified. In both outcomes where the cluster chooses «Fight», the startup gets customer preference in only category of five. The Nash equilibria are [“MFR”;”Fight”] and [“No MFR”;”Fight”] – the startup is indifferent to the choice of strategy from the game theoretical viewpoint.

What could motivate a startup to go for MFR or traditional model in reality? Incremental principle of investments in the MFR model reduces risks of investments. An MFR-startup can begin with establishment of a car plant with capacity of 5-10 thousand cars per year and expand production by means of more car plants according to the market response. At the same time, higher labor intensiveness of the MFR model restricts the competitiveness of delivered cars in terms of pricing. All else equal, the cluster’s counterstand to the startup will include price competition against MFR model and investments in customer service against the traditional model. In case of price competition against an MFR-startup, the cluster has good chances to win, given brand strength of Flagships and their corporate financial power. Even though they are able to consolidate the counterstand with improvements of customer service, they may find it a redundant measure since pricing is considered a definite weakness of the MFR model in this game, and therefore they may have no need in any more effort than challenging the MFR-startup with price competition. By price competition here, I do not mean price war, because Flagships have limited possibilities of using this tactics. But some elements of customer relationship management in form of attractive offers for additional equipment, or other actions allowing

to additionally attract customers choosing between cars of two competing companies, should work well. To start a micro factory with low chance to expand the capacity or to survive at all, wouldn't look as an acceptable alternative for a new car company on the market.

On the contrary, in case of startup choosing the traditional business model, price competition would not appear as effective measure for the cluster as investments in customer service, along with innovations and promotion. This case involves more freedom for the startup in terms of market strategy. For example, ultimate differentiation in innovations ensures good market position for a startup with traditional business model, but for MFR less attractive prices for cars and their additional equipment, all else equal, would undermine this advantage. In the long term, customers may well enjoy lower total costs of ownership in case of the MFR model, but at the initial stage, one micro-factory or even several of them will likely meet hard price competition from the Flagships, and this may restrict inflow of customers for the startup. In Group 1 the standard of product differentiation is the highest, so to succeed among the Flagships, a new company on the car market wants to ultimately differentiate itself in terms of product variety, customer service, innovations or promotion, and to use a traditional model rather than MFR.

There is one brilliant example of successful establishment in this group and it is Tesla. By claiming its strategy to be production of market's most prestigious and innovative electric cars, Tesla created the barrier that Mercedes-Benz, BMW and Audi were simply not willing to overcome (because they wouldn't want to produce only electric cars) and by this means secured high and stable customer loyalty in less than 10 years since it entered the world car market. It's however interesting that Tesla uses direct sales in its business, which is one of the key elements of the MFR concept. The fact that Tesla originates from the USA, where laws in some states prohibit direct car sales from manufacturer to end customer, gives greater significance to the argument that abandoning of dealerships can greatly benefit a car company in the long run. Tesla owns all its physical and virtual sales outlets and puts its stakes on viral marketing as the main sales channel [16].

4.1.2 Game 2 "Startup vs. Flagship Candidate"

Game 2 is the game of a startup against only one established car brand – Volvo, and it's interesting for this reason alone. The Nash equilibrium here is strict, and it is ["MFR";"Fight"]. The outcome ["No MFR";"Fight"] is not preferable for the startup, because in this case the player gains customer preference only in one characteristic – pricing model, while if MFR is chosen, the startup is preferred in product variety and customer

service. The difference with Game 1 is due to narrower product range of Volvo compared to the Flagships. Therefore, product variety becomes a weak side of Volvo, which an MFR-startup is theoretically able to outperform, because of eliminated need in costly all-steel body elements production and powertrain production, which in its turn yields much less R&D expenses for launching new models [4]. I estimate that in short-time perspective (3 years) a new MFR car company will be able to introduce one car model per each segment where Volvo gains most of the revenue: middle class, compact SUV and full-size SUV. Still, Volvo can powerfully confront the startup by having its brand strength and leveraging advantageous position in innovations, pricing and promotion. Volvo is a brand which is additionally differentiated by its commitment to car safety, so in order to distinctively compete with Volvo an MFR-startup must work out a strategy for gaining customers adhered to the idea of safety from the competitor. So long there is additionally a threat of price competition remaining, this game appears to be no easier than Game 1. Volvo has high incentives to fight so that it could maintain its unique brand image. To succeed in Game 2 will be difficult for the startup because of the high required level of differentiation, both within safety and overall innovation.

4.1.3 Game 3 “Startup vs. Technology Mainstream” and game 4 “Startup vs. Technology Candidates”

Games 3 and 4 have absolutely identical outcomes due to almost similar profiles of customer preferences. I have assigned lower brand power to Group 4 (Technology Candidates) than to Group 3 (Technology Mainstream), however a new company on the market is always unable to win customer preference by means of its brand power in the short-time perspective, and therefore the difference in this characteristic has no meaning here. The Nash equilibria are [“MFR”;”Fight”] and [“No MFR”;”Fight”]. If Cluster choose strategy “Accept” it cedes its superiority in customer preferences to Startup, and therefore the clusters in both games have high incentives to fight. Both equilibrium outcomes are equal in terms of the characteristics that the startup is best at – advantage in customer service and promotion is not likely to be replicated by Cluster in the short-time perspective. However, Cluster’s brand power, product variety, pricing and innovation rate are estimated to be beneficial whatever strategy is chosen by Startup. Again, in order to succeed, Startup must take a highly differentiated position, preferably in area of customer service. The MFR model with its excellent car lifecycle management and physical proximity of sales and service

outlets to customers, could provide such a differentiation by itself. There are of course certain risks in this choice too. Because the difference between playing against Group 3 compared to Group 4 have turned out to be insignificant, it is important to remark that Startup is actually going to play against a large unified group. Taken together, groups 3 and 4 cover 44,2% of the market. Therefore, an MFR-startup should make a thorough estimate regarding how high expansion of the production (how many new micro-factories) would be safe for its competitiveness in a longer perspective. Strong brands included in large corporations, that belong to this group, will likely intensify their counterstand after a growing startup will take over some certain market share, but may stay passive as long as the innovator doesn't pretend on too much of their sales.

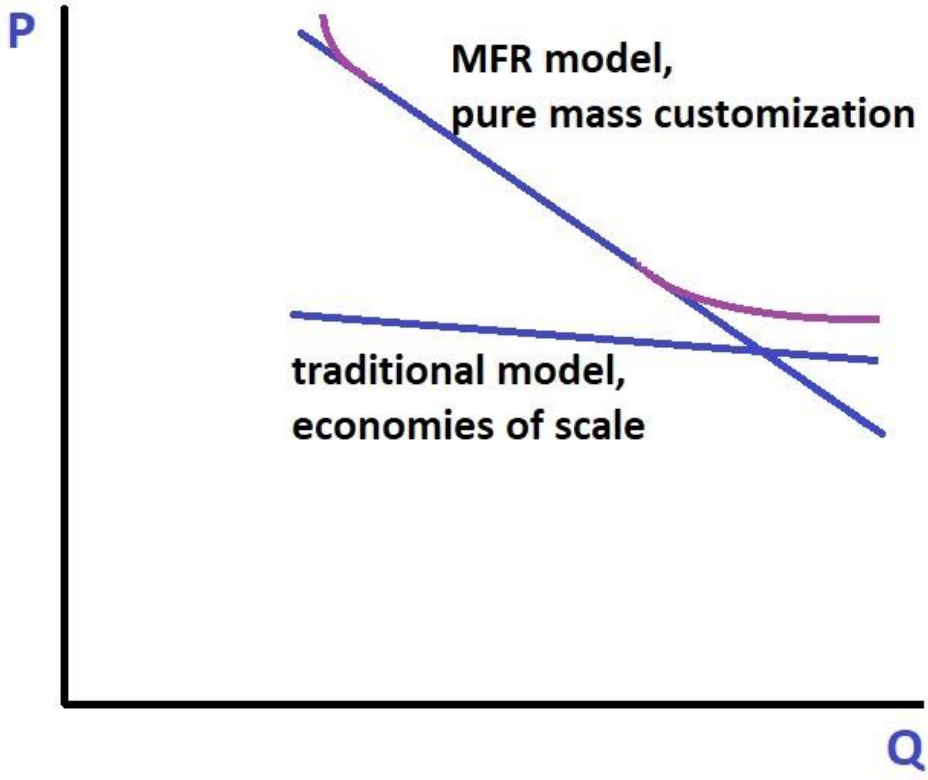

Fig. 7. Inverse demand function.

In my opinion the methods of competition will vary between two outcomes. One of the way to improve willingness to pay is to hold in dealers' stock the most popular versions of cars, so that end customers with not very sophisticated preferences can buy immediately. Since manufacturers in lower prestige groups (3, 4 and 5) must hold significant inventory at dealer net level, they get high fixed costs. Due to high numbers of their production and the fact that the traditional car industry has been developing in the direction of production cost

saving, they also have low marginal costs. On the contrary, MFR production is based on the pure "pull" principle, so the stock of cars at retailing facilities is eliminated. However, MFR is more labor-intensive than the traditional model. So that's why an MFR car production, compared to an existing car brand, will have lower fixed costs and higher marginal unit costs. Plotted on the standard P-Q coordinate system, the inverse demand functions for a traditional car production with economies of scale and an MFR production will in simplified form look as Fig. 7 shows.

A flat inverse demand function allows for insignificancy of price variations under quantity adjustments, while a steep function gives much price change if quantity is a subject to changes. Based on that, the following assumption should be made: a traditional car manufacturer, having economies of scale, is better off being engaged in output (Cournot) competition, while for an MFR manufacturer price (Bertrand) competition is better. This means that a traditional manufacturer prefers to set quantities to be produced during a period of time first, and adjust product prices after that, and in the MFR model, the price is set first, and the quantity adjusted according to that [17]. That's why the market situations for equilibrium outcomes in this game will be different.

In case of ["No MFR";"Fight"] Startup should invest in large production facility allowing for lowest possible marginal unit cost, and focus on market penetration in order to gain influence on Cluster in terms of production numbers, and hence, price setting. The Cluster under this outcome is better off using its initial advantages in product variety and innovations to emphasize superiority in "value for money" over the newcomer.

In case of ["MFR";"Fight"] Startup should use differentiation advantages provided by MFR business model, while Cluster's most effective way enter into competition will be making special offers for complete and customized packages of its models that directly compete with those of the Startup, in order to undercut it by price. The purple elements of the plot for MFR model on Fig. 7 illustrate the effect of defense of an MFR-startup by means of differentiation: willingness to pay is decreasing slower with increasing quantity because there are loyal customers.

It's interesting that these strategies of both players provide them with different roles in each outcome. A non-MFR startup will act rather than react with its strategy of market penetration, while an MFR startup will react rather than act with the strategy of differentiation, limiting loss of new customers due to price undercuts from Cluster. Likewise, for Cluster the strategy of segment price competition will look proactive and the

“value for money” strategy rather reactive. The real outcome is a subject to the mission and capabilities of Startup, which will imply either traditional way of development or MFR.

4.1.4 Game 5 “Startup vs. Budget Mainstream”

Game 5 signals transition of the Nash equilibrium into the right part of the game matrix along with shift of the power balance to the startup side. There are three outcomes with equal payoffs: [“MFR”;”Fight”], [“MFR”;”Accept”] and [“No MFR”;”Accept”]. From the game theoretic viewpoint, since the startup is getting lower customer preference only in the outcome [“No MFR”;”Fight”], it will naturally choose strategy “MFR”, to ensure higher payoff regardless strategy of the cluster. This way, [“MFR”;”Fight”] and [“MFR”;”Accept”] become Nash equilibrium outcomes. This is one of two games where Startup gets the most desirable outcome for adopting the MFR business model. Due to identical patterns of customer preference distribution in both outcomes of this game, Cluster is indifferent to the strategy choice. In reality, a real market situation will not be the same if the cluster chooses to fight by leveraging its competitive advantage in pricing, as if it chooses to accept and not use this advantage.

Group 5 features high production volumes, and the pricing model is the closest to the market-oriented by contrast to value-based, compared to other groups [16]. Implementation of the strategy “Fight” will develop much the same market situation as in the outcome [“MFR”;”Fight”] of the previous game. However, Startup will have more possibilities to differentiate and protect itself from price undercutting in this case, because of Cluster’s lower product variety than in the previous game; as said in Section 3.2. Group 5 manufacturers are represented mostly in budget segments. In case of the outcome [“MFR”;”Accept”] Cluster wants to adapt to the situation by means of measures, reducing the gap in terms of customer service and total cost of ownership (for example by focusing on quality improvement), while Startup takes the advantageous position. There can be many details about both players that will play role in the choice of strategy by Cluster. The real outcome will depend on details provided by a specific case study.

4.1.5 Game 6 “Startup vs. Premium”

Game 6 shows the same Nash equilibrium outcomes and distribution of customer preferences in them as Game 5, but the market situations will likely not develop in the same way due to high differentiation level of the Premium car brands.

Under the [“MFR”;”Fight”] outcome, the undercutting tactics of Cluster will be ineffective, because competition in the Premium segment entails buildup of high level of customer loyalty in order to succeed, so Startup will still have much market power. Instead, Cluster will do better by leveraging its advantage in brand power. This can include any value-added activity, that simply cannot be copied by competitors because of the brand uniqueness, for example special “heritage” editions of car models as well as identically branded accessories and events for established customers are common practice in this segment.

The outcome [“MFR”;”Accept”] doesn’t definitively benefit Startup as in the previous game, but neither does it restrict its progress too much. Under this outcome the players continue to develop with minimum impact on each other, thus Cluster gets the most value from its brand power and Startup leverages advantages in customization capabilities provided by MFR model (in premium market segment total cost of ownership is not something that end customers tend to think much about). This way, strategies “Fight” and “Accept” appear like one strategy applied with different intensiveness, and it won’t cost much for Cluster to switch between them, which in fact forms a mixed strategy equilibrium. Switching can be rational under changing market conditions, for example overall fall in sales figures for luxury cars may lead to revitalization of the competition in this segment. However, given the fact that the Premium segment (at least nowadays) is not the most affected by fluctuations in the world economics, one can draw the conclusion that Group 6 is the most comfortable environment for a new establishment in the car industry, especially for MFR companies.

4.2 Expected and unexpected outcomes

Now the hypotheses claimed in 1.4. can be verified.

H1. MFR is more suitable for custom production, than for mass production: confirmed.

All of the car brands examined in this work utilize mass production and the MFR model is suitable for competition with them to some extent. The most comfortable competitive environment for an MFR startup is Group 6 “Premium”. The most important criteria for chances for MFR startup to succeed are differentiation in innovation and prestige. Differentiation in innovations can often be hard to replicate because of practice of high protection of technological information by the manufacturers. Technologies that allow companies to stand out are tangible values and cost a lot to develop. Differentiation in

prestige is much easier to replicate because it is based on intangible concepts, a good portion of which is related to customer care. Since MFR model by itself is strong in customer care, it has the best opportunities in Group 6, and since a startup needs time and large investments to gain momentum in the ever-changing world of car technologies, MFR has worst opportunities in Group 1. By this I mean not that cars of the premium segment are technologically unadvanced, but that the premium manufacturers may need more time to replicate technological features of a startup, compared to Flagships that have more significant corporate power, and that time can be used by the startup to consolidate its position by prestige differentiation. So, the characteristic of innovation rate works as an entry barrier for new companies in the car industry. Groups 3 and 4 can be unified for consideration as a competitive environment and I have estimated chances of an MFR startup to succeed as limited and lower than those of a non-MFR startup, because of the reactive action profile in the competition. Group 5 is less complicated to compete with for an MFR-startup due to better opportunities to differentiate and keep customer loyalty high enough.

In the examined model of inverse demand functions specific for MFR and traditional car production it has been noticed that traditional manufacturers tend to set the production volume and adjust prices accordingly, while for an MFR firm to define price that customers are willing to pay for a car, and then calculate how many cars will be possible to sell would be a better way to act. This places manufacturers of groups 3, 4 and 5 in the beneficial position in that sense that for them it's easier to control and expand market share than for an MFR manufacturer driven by pure "pull"-principle. It correlates with the sound judgement that not all new car buyers are keen on personal configuration of the car package when they choose which car to buy; in fact, many people are satisfied with cars that they find in dealer stock, even if the option list is not identical to their wishes. Therefore, an MFR car brand will inevitably be qualified rather for those who can call themselves car enthusiasts to some extent, which limits possibilities to extend production numbers. This restriction in its turn benefits the MFR brand in the sense that market incumbents are not expected to spend much effort on fighting competitors that take insignificant share on the market.

The abovementioned concludes that the MFR concept naturally fits into the custom car industry without typical production lines and with high participation of end customers in the production process (make-to-order). However, a purely customized car production meets restricted market need. The MFR concept, having mission of bringing sustainability into the automobile industry, is theoretically designed to compete in mass production market as well. However, uncertainty, related to the entry into a such competition, have apparently

lead to the lack of penetration of MFR-based car brands on the conventional car market as of today.

H2. Existing players will find it more rational to fight newcomers that apply MFR business model, rather than accept: confirmed.

It has been found that Cluster finds rational to definitively choose strategy “Fight” only in games 1 through 4; thus, in games 1, 3 and 4 Startup is indifferent to the choice of strategy from the game theoretical point of view. However, in games 5 and 6 it’s Startup that definitively chooses one strategy “MFR” and the equilibrium payoffs are the same regardless strategy chosen by Cluster. This correlates with stronger market position of an MFR-startup in competition with Budget Mainstream and Premium manufacturers, compared to competition in other segments. In the analysis it has been suggested that conditions under which Cluster will choose to accept Startup are likely to appear in the game 5, and they are even more real in game 6.

H3. MFR startups will be unable to affect actions of other players in case of active rivalry: rejected.

MFR startups need to adjust to the actions of the group of existing car manufacturers that implements strategy “Fight” in the competition. However, according to the performed analysis, in game 5 an MFR company will have significantly more market power than in games 1 through 4, while in the game 6 the market position of Startup is passive to the least extent under this outcome.

4.3 Limitations of the study, unanswered questions

The Cluster player is considered an aggregated player, without allowance for different viewpoints on the Startup player as a competitor within the groups. This interpretation simplifies formation of outcomes. To see how accurate are the forecasts of market situation provided by this study, one should design a more detailed game landscape with multiple players, representing separate car manufacturers, and then analyze and compare results of the games to the present ones. The resulting competition on the real market will then have a more complex structure than examined in this work, because a car brand or at least a particular car model may also be involved in competition in other segments. Extent of this involvement obviously negatively correlates with customer retention rate for a particular brand or model. Finally, aggregation of the market incumbents into groups removes possibility to analyze how actions of a new player affect competition that takes place within these groups

Characteristics of the players that define game outcomes are simplified, with no quantitative data provided. More precise characteristics of the car brands can include surveys and elements of business intelligence with analysis of downstream operations. There are certain barriers in getting real financial figures, so the study can instead rely on simulated data.

Dynamic game models are not examined; however, they would give a more real perception of market development. Introduction of a new company on the market represents a disruption to a greater or lesser extent, and there must be some time gap between the introduction and the response of market incumbents. Proactive measures would be of a greater help for the existing market players, but some knowledge validating such measures may simply be unavailable before the new player is already on the market for some period. Therefore, it's safer to expect that on the real car market games of this kind are played consequently: one player always reacts to an action of another one. As a simple example, the action profile of an incumbent player can include strategies "Fight", "Cooperate" and "Accept", and a new player can respond on these actions with the strategies "Investments in R&D" and "Investments in production expansion". The players and their action profiles can be of greater variety than examined in this work, but one should estimate how much the increased complexity of the analysis will add to its accuracy. This is supposed to be one of the subjects for further research.

The work considers MFR as the only possible way to make the industry more sustainable but doesn't provide more suggestions on what else it could be. It also doesn't encompass the term "competitive environment" from the viewpoint of the classic five competition forces by Porter. This approach would be a useful tool to divide traditional and innovative business models by categorizing them respectively as potential new entries and substitutes. The issue of interaction of car manufacturers with their suppliers is left untouched, and the internal processes of existing rivalry between manufacturers are not identified.

The question that stays completely unanswered by this work is: "What are incentives of changing the business model towards higher sustainability for existing car manufacturers? How significant they are going to be?". The MFR business model in this work is taken as the standard of sustainability in the industry. One can suggest that MFR haven't yet captured any interest of the important players on the car market because of high costs of reorganization, uncertainty of market response and lack of clear market signals for this change. Still the need for sustainability is increasing, even though it is happening in an

unregulated manner so far. At the same time the vast majority of car manufacturers today exploit unsustainable business model, and they have high market power. The possibilities of the directly opposed scenarios of market development, where existing manufacturers either block any further progress in sustainability or completely disappear under pressure from disruptive innovators, are considered by me to be very low. Therefore, the topic of real prospects for existing car brands to be sustainable is also very relevant for building a complete picture of the future standard of the industry.

5.0 Conclusions

The problem statement of this work is clear and covers the purpose of encouraging research of sustainability in the automobile industry. Furthermore, the work addresses the topic of prospects for practical application of sustainable business models in the real competitive landscape. Even though the analysis is based on simplified concepts of customer preferences, its main finding is well defined: The MFR model meets several barriers on the way to implementation, but an MFR startup is able to have market power under certain conditions. The consistent patterns of formation of the most MFR-friendly competitive environments for a new market player are observed: the implementation of MFR is more justified in the segments where customer expectations for customer service or total cost of ownership are high, and expectations for innovation rate are relatively low. This statement can set the stage for more detailed kinds of research in this area, which I find very necessary. So, the significance of my graduation work is that it makes an effort in setting the direction for future business analytical works concerning practical application of sustainable business models in the automobile industry.

The methodology used in the work has proven itself to be relevant for the subject. The use of game theory makes the work quite different from most of the previous researches in the field of business model transformation. Finding an appropriate game model was the hardest part of working on results, and I have mastered it primarily by generalization and simplification of potential market development scenarios.

There is a number of limitations, resulting from the scope of master graduation work as well as shortage of quantitative data about the market players. The limitations can be summarized by categorizing them into simplicity of the used game model and incompleteness of the value chain analysis, which defines my expectations from subsequent studies. By development of more sophisticated game models and performing ultimate industry and value chain analyses one would significantly add to the accuracy and therefore, importance of conclusions.

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