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Chapter 12: Collaborative innovation, policy development, and the future direction of the automotive industry

12.1. Introduction

The automotive market has been evolving rapidly, although concurrently facing pressure from external macro-environmental factors, consumer diversity inertia and emerging disruptive technologies. Among those factors, policies are recognized as one major key driver which is expected to impact on the profitability and sustainability development of players across the market. On the contrary, firms' collaboration is another key driver whose capacity to deeply influence policies' intent, structure, governance, and compliance is relatively underestimated. Moreover, policy bench-marking and policy-driven collaborative innovation are both issue areas that haven't been covered thoroughly in the high-tech sector, and these will be explored in more detail along with empirical evidence from the world's automotive market.

This paper proposes a systematic framework to understand the interaction between collaborative innovation and policy development at three levels: the nature and knowledge-based collaborative opportunities, pathways, and networks; the impact on policy intent, structure, governance and compliance; and the driving forces of competitive markets expanding beyond national borders. This paper also employs interpretations of policy-driven collaborative innovation networks to reveal their governance structure in the world's automotive industry through initial theoretical propositions and in-depth case studies.

This paper further elaborates on the methodology based on four core propositions and detailed analysis and discussions of the automotive industry from a consideration of collaborative innovation maturity, process benchmarking and policy-driven collaborative innovation networks development perspectives. A case study of 20

countries' policies is preferred for the awareness and implementation of policy-driven collaborative innovation networks design and leading in the automotive industry, and a summary of findings is emphasized on an implication to related concerns. This paper concludes with a discussion on certain limitations of the study and points of future endeavours.

Fig 12.1: Research on collaborative innovation

12.1.1. Research design

This research is designed to identify how collaborative innovation and policy development is perceived on partners, and what is their importance for policy makers. An explorative qualitative research strategy was adopted and semi-structured interviews were selected for data collection. However, an analytical research design was thus developed, consisting of a qualitative explorative phase followed by a quantitative confirmatory phase. This research used a mixed case study design since it incorporated in-depth single case studies and a broader multiple case study in a sequential manner to take advantage of a combination of both types.

This research followed a sequential explanatory design. A sequential explanatory design consists of two phases. The first phase is qualitative and is followed by a quantitative phase. This type of design is mainly used to explore, explain, and understand a phenomenon better. In this research, it was decided to explore the perspective of tenants on collaborative innovation and policy development as it does not have a firm registration in literature. However, since qualitative research provides a shallow understanding of a phenomenon, the second phase of this design type is also executed which is quantitative research to obtain a richer insight. Therefore, an explanatory

sequential design was selected for this research. Both quantitative and qualitative data collection methods were employed. However, surveys, or questionnaires primarily based on scales were used for the quantitative data collection whereas everything was otherwise designed and conducted for the qualitative phase prior to the quantitative phase.

12.2. The Importance of Collaborative Innovation

Many nations around the world are experiencing rapid development of the automotive sector, which is particularly notable in emerging regions such as India and China. It is well recognized that development of a rich automotive industry requires location of global vehicle manufacturing facilities which depend on a key set of local capabilities. The talk emphasizes the importance of collaborative R&D of smaller and domestic firms for development of larger, diversified, and branded firms. These research findings have significant policy implications for developing economy governments as well as international firms. This transformational aspect of the channel of influence has hitherto largely escaped research, but cannot be neglected in a global automotive industry undergoing significant change across the globe.

This xhapter investigates co-evolution of policies and technological capabilities in the Indian automotive industry 1970s-2009. Influenced by earlier development studies, the paper emphasizes that government policy plays a crucial role in firm capabilities development. The findings show that government policies in India had two phases characterizing differential understanding of policy makers regarding their role in influencing firm level technological capabilities nurturing. After initial emphasis on local action, sectoral barriers were lifted. A phase of collaboration between emerging domestic firms and appropriate multinationals began in which domestic firms were nurtured to be international competitors. On the other hand, planned market policies putting restrictions on economic agents have inherent limitations in implementing. This emphasizes the need for governments to perform proper cost benefit analysis of policies.

It is concluded that the policy measures proposed are fundamental from the viewpoint of overturning path dependencies in the automotive industry which impede the diffusion of alternative vehicles, with respect to business models and consumer attitudes. Carmakers' business models are generally characterized by risk aversion and by return optimization through continuous improvement and cost cutting. New entrants as well as incumbent carmakers need to embrace radically new business models, characterized by an offer of services and cooperation with other stakeholders. In other words, the traditional automotive business model should be changed and the relationship between producers and users should continue over time through the offer of services. Most consumers are satisfied with the fact that the internal combustion engine performs as

they expect it to, and at a predictable cost. Furthermore, again in agreement with previous studies, it is found that those who prefer clean and fuel-efficient engines represent only a niche market. In sum, consumers favour internal combustion engine innovations over alternative vehicles, and consumers care a great deal about fuel consumption but very little about vehicle emissions. Therefore, consumer attitudes as well as business models must be tackled by means of carefully designed and properly targeted policy measures.

12.2.1. Defining Collaborative Innovation

The automobile as part of the transportation system has continued to be one of the most influential, innovative, and complex technological artifacts in society (Brown et al., 2022; Kim et al., 2025; Ng et al., 2024). It has fulfilled vital technological needs for surface transportation and unveiled important dimensions of relevance for social, institutional, psychological, cultural, and ethical aspects of transformation. In this complex of technology and society, the development and implementation of automobile technology have had intense interactions with local stakeholders, industry players, and policymakers in a variety of historical and spatiotemporal contexts. The automobile industry and market, its players, and the vehicles it offers, as well as cities, roads, railways, and bus systems, have rendered cities and urbanized agglomeration a new configuration of transportation, society, and urban structure in the age of the automobile. More recently, concurrent with, and as a consequence of, the pervasive use of the internet, wireless connectivity, and smart mobile devices, new information and communication technologies (ICTs) have emerged as new factors of technological change that have begun to transform the transportation systems.

12.3. Current Trends in the Automotive Industry

The dramatic rise of new technologies is changing the automotive industry and fabricating new technologies, which is a solid basis for automobile innovation in commercialized scenarios. AI, EVs (Electric Vehicles) and MCVs (Multi-brand Connected Vehicles) are discussed as growth opportunities for the automotive industry in particular. With the rise of EVs, automobile industrial player's opportunities have been open to industry participants, which have been consortiums, original equipment manufacturers (OEMs), and service providers. Regarding this, a strategy for capturing a share of the future growth opportunities of EVs is an analysis of scenario-based strategy planning methodologies of automotive-industry related companies for responding to cooperation with diverse players.

New automobiles and technologies create disruption that may lead to new entrants. The automotive industry is a rapidly changing environment where three interesting trends are

automobile digitization, electrification, and diversification. Competing on pricing cars in emerging countries will fail. Instead, local intelligence plays an active role in the definition of the distribution of digitization. As there are products that fit each specific market, revenues are to be managed through distribution. Understanding the power train function of customers and maximizing it with scale products must commence redefined. The effects on the emerging countries will be diverse and nuanced whose consideration of customs and strengths or weaknesses is necessary for specifying strategies. However, feeding an uncontrolled society of generous free data for a price on an egocentric society of marginal free data questioning a price is complicated. Local data regulation is fundamental and deals with the question of pricing data. Traditional European partners may notice the trend of electric engines needing fewer specialized machineries. Present OEMs will be squeezed from both ends and must combine highly cost-limited vehicles tailored with local taxes and a full smart range to maintain a market position.

Fig 12.2: Latest Automotive Industry Trends

12.3.1. Technological Advancements

Since the last decade changes have been taking place with high dynamics and impact in all sectors of the economy. Therefore many industries are doing efforts adapting to these changes and also redesigning their markets and value chains. Last year's new entrants in the automotive industry demonstrate that automotive firms are living in an environment of disruption and uncertainty where the traditional concept of integrated car-manufacturing firm is changing to the notion of a product-service system. Information and communication technology can create a large volume of new innovations, e.g. novel automotive services like parking. This is why many ICT companies start entering the automotive market. Their resources and proficiencies enable them to raise new and competitive on-road businesses. As time goes by, automotive original equipment manufacturers (OEMs) on the other side not only feel threatened by these new entrants

but also accommodate them towards their operation strategies. OS integration as a way out helps legacy manufacturers' preparedness to collaborate with ICT companies and cope with the pressure on digitalization.

Digitalization of the automotive industry has already altered the competition landscape and created challenges to LMs. The emergence of both internet of things and vehicles is re-inventing vehicles into M2M service platforms while making it an extensive channel with large user footprints. A competitive environment is coming into place that features a growing number of service providers, dramatically enlarged incumbents, and access-holding agency stakeholders. For instance, more than 10 millions of people are currently using mobile service maps which also concerns route-planning, traffic-icon, and inquiry. Such big data whose ownership is not clear creates an environment where scalability is far higher than automotive OEMs and service developers, against OEMs' traditional notions that information needs to be kept confidential and disclosed on a vehicle-basis. Standardization also becomes hard as there are multiple industry players. Tension is raised between traditional LM's control-basis business model and supporting-player's platform-basis model. This tension manifests in disagreements in standard and governance scheme or control as well.

12.4. Policy Development in the Automotive Sector

Policy measures to stimulate automotive car demand by means of environmental impact reduction are proposed within the framework of the close interaction between manufacturers' business models and consumers' attitudes towards vehicles (Williams et al., 2023; Young et al., 2023). Business models in the automotive industry are generally conservative, characterized by risk aversion and a readiness to accommodate only incremental changes in design and technology. As a result of these business models, car body styles and vehicle propulsion technologies and fuels have not changed substantially for decades. Attempts to stimulate alternative vehicles, such as strategies and proposals to set research and development priorities and host public-private partnerships, are often neglected. Of note, mistrust of the remedies provided by carmakers' business models arises, stemming from the perception that they are merely a pretext to continue selling internal combustion engines. Ultimate users decide the transition pathways and technologies. By means of a consumer survey, an analysis of consumer attitudes towards vehicles is performed. A generalized preference for internal combustion engine vehicles is found, construed as a path dependency that no other vehicle type can currently overturn. Therefore, policies capable of overturning path dependencies in the automotive industry are proposed. This is fundamental for the promotion of competitive mechanical engineering and energy technologies and the long-term sustainability of European economies at large.

12.4.1. Regulatory Frameworks

The regulatory framework consists of environmental-related directives that must be taken into consideration when an electric vehicle (EV) design is performed. Specifically, the directives that target components and relevant implementation machines must be considered in the preventive design. The automotive regulations are considered and described to highlight the possible grounds for car manufacturers to optimize a design proposal and to comply with the relevant directives.

The initial situation of the automotive environmental protection gaze is the prevention of environmental disturbance already in the product design phase. The regulations for passenger vehicles and their components and the respective test standards have been selected for a more representative overview of the framework. The design itself is described in a generic manner to not influence the car manufacturer's internal development with specific disclosures.

The environmental directives were translated and catalogued according to the product definition of a passenger vehicle. The Passenger Car Directive and the new car assessment program suggest functional considerations for the regularities on the tests and the indicators, but not on the implementation of the tests in a specific automotive or calculation tool. The passenger car component directives describe remnants and possible environmental impact of these components but not on the automotive standards themselves. The environmental protection directives describe the framework for vehicle component certification but do not state any case-related metrics, measurement equipment or categories. The vehicle components for which standards exist are marked with a star in the respective description table. The automotive standards specify the impact and grounds for certification for components and emissions. Without compliance to standards no component certificate can be obtained. The design and kind of test procedure depend on the manufacturer's need in consideration of its position in the vehicle project, chassis type, power levels, etc. With the regulations keywords environmental protection and prediction the generic design proposal focuses on implementation for engineering simulation of the component and indicator design on the numerical modelling basis.

12.5. Challenges to Collaborative Innovation

The automotive industry is currently undergoing a transformation towards software defined vehicles (SDVs), implying that the vehicle architecture can vary from the hardware to the whole software stack . Vehicles become machines constructed from parts capable of remote updates. With vehicles needing to be constantly updated, like smartphones or PCs, a paradigm shift from development under certain configurations to

development as a product type is required. These demands pose a challenge to the automotive development cycle due to the complex behaviour resulting from larger design spaces with tight interaction between components. To cope with such challenges, the main players along the value chain, OEMs, suppliers and software companies, have increased interest in collaborating and aligning their development efforts along joint roadmaps underpinning the cooperation. Roadmapping is a strategic tool capturing product aspects along a time horizon with the intention of aligning the product development process among competing countries, regions, or companies. In the automotive industry, the aim is to give concrete shape and speed up informal cooperation on joint ASAM standards, development processes, and tool chains. However, the automotive industry faces challenges to these roadmapping activities, such as declining global competitiveness, increasing competitive pressure from other countries, a lack of know-how and standards, fair treatment of all value chain participants, and the fear of over-promising. For instance, in regard to the treatment of third parties in the development of ASAM standards, it is desirable that these developments are either accessible for free or via an index-based approach. In addition, stakeholders contributing content to the standards want to ensure that they are not used for proprietary purposes. Otherwise, it is feared that participation in the efforts goes back to where it was previous to the compound effort, in this case, to a slow and cumbersome standardisation procedure that relied on cooperation and therefore lacked the strength to compete. As the proposed standard is a competitive advantage for China, Europe needs to be fast and robust.

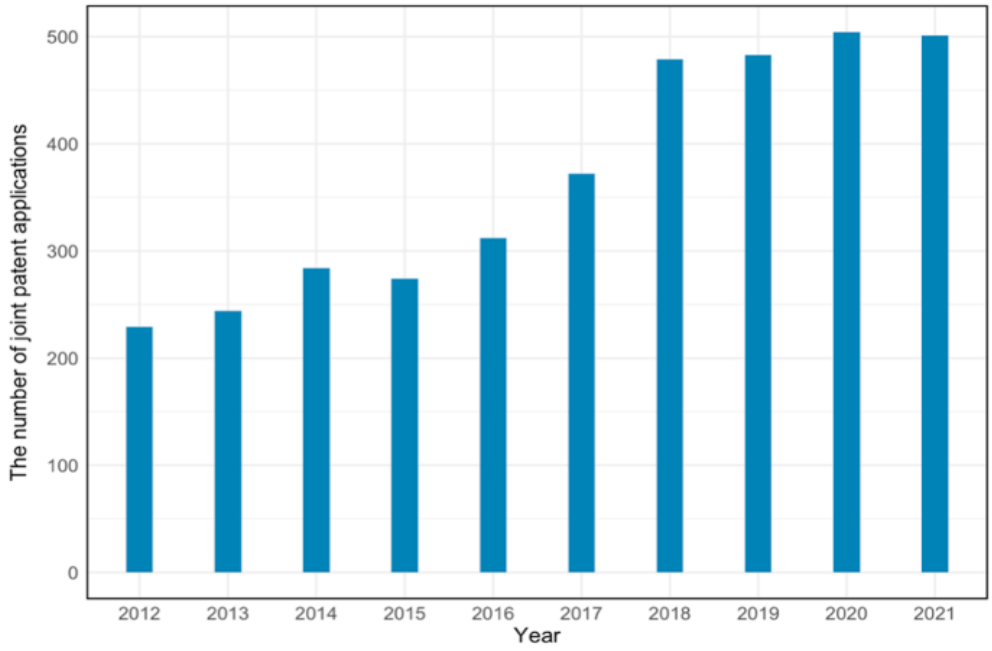

Fig : An Evolutionary Analysis of Higher-Order Interaction Collaborative Innovation Networks

Collaborative innovation is a process of innovation in which government bodies, enterprises, higher learning institutions, and research institutions reciprocally and cooperatively innovate revenue-sharing market competitors to achieve a win-win situation. The government, enterprises, research institutions, and universities build a multi-party collaborative innovation alliance. The government formulates support measures, and the innovative technical road index of cars to encourage enterprises to jointly explore IP feasibility. The influence of enterprise cooperation degree, patent analysis capability, and patent pool establishment degree on the collaborative innovation performance of new car IP mentions is explored, paving the way for subsequent solutions.

12.5.1. Intellectual Property Issues

Intellectual property issues in collaborative innovation and policy development in the automotive industry are critical because the automotive industry uses collaborative innovation to develop more intelligent new energy vehicles to realize the low-carbon transportation industry development roadmap guidelines. Collaborative innovation can promote the implementation of government policies by using the innovation resources from enterprises, educational institutions, and research institutions. Scholars have studied theoretical and empirical research on standards, but much of the literature on patent pools is limited to how various pool structures are required to ensure patent pool profitability. Recently, the analysis of cross-licensing agreements has received extensive attention from scholars. The feasibility of constructing and operating patent management and patent pools in autonomous vehicle R&D collaborative innovation.

12.6. Conclusion

Collaborative innovation plays a fundamental role in encounters between policy professionals, engineers and scientists involved in the fields of carbon capture, hydrogen and batteries. Both local policies and specific technologies for innovation policies affect collaborative innovation in low-carbon technologies in the automotive industry. In each specific technology domain, policies implemented in each country become vehicles that condition collaborative innovation between policy professionals, engineers and scientists of different types of production technology between countries. Local policies co-evolve with technology in a mutually supportive way: technologies help to implement policies while policies develop and shape technology; policy developers find ways to ‘line up’ local policy with specific technologies. Technology-domain specialists and

policy professionals gather different views, perceptions and understandings of problems to deploy specific collaborative technologies, effectuating understanding of local policies in line with policies in other countries and regions. Afterwards, technologies based on large scale demonstration and collaboration are developed among policy professionals, engineers and scientists of different countries to realize collaborative innovation. Attitudes towards technologies, tastes and preferences of users and consumers (including car manufacturers) differ among countries, which affects collaborative innovation. It is important for policy developers and engineers to know the specific attitudes, tastes and preferences among countries in deploying technologies across countries and changes in them in collaborating on the development of specific technologies.

Policy developers and technology developers benefit from interaction and exchange. Collaborative developments of products, business models and policy measures on a specific domain create shared knowledge of each other's language and fields of expertise. This shared knowledge becomes a basis for cross-domain collaboration, when adopting a specific new technology affects topics, actors and networks of the existing collaborative policy processes. It is the need to assure low-risk use, safety, security, etc., while stimulating innovative manufacturing processes. Cross-domain interaction between policy developers and technology developers can be affected by mutual enmity, competition and opposition, blocking collaborative innovation and policy development.

12.6.1. Future Trends

The auto industry's strategic future choices with respect to manufacturing technologies and information and communication technology (ICT) to be used in combination with these technologies were explored. Based on engineered scenarios, significant differences in the pursued technology components were analyzed and resulted in different kinds of production systems. Today automotive manufacturing systems are challenged by vast changes of the automotive industry and a rethinking of future production strategies is needed. Challenges comprise global market changes leading to product variety, regulation in terms of change of quality in the products resulting in pressure for new technologies in body and powertrain, as well as fierce competition by new entrants consisting of non-automotive companies (especially huge ICT companies). Car companies tackle these issues very differently or put different focuses on them. The question is which automotive value chains will most probably arise in the future based on automotive original equipment manufacturers (OEMs) strategic choices with respect to their ICT use building the manufacturing systems.

The scenario technique was applied therewith creating a picture of the future car production landscape. Automakers are confronted with vast changes in the environment

significantly impacting their value chains and production systems. These changes comprise, inter alia, a shift of demand from Western countries to China. The value chain of production moves not away from Germany, but there is the perception that mega cars made of steel are not only produced by established large players in the future anymore. Instead, large OEMs are marginalized and unable to hold volumes, value added, or prices in one part of the industry as the power moves to players with totally other business models compared to today. The well-known value chain shifts from OEM to tier suppliers to equipment suppliers collapses, new players become critical. Products and manufacturing processes are more virtual than physical and non-geographic. Development is more in the focus than manufacturing which is often a disguise activity.

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