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Strategic Competition in the Electric Vehicle Industry: A Game Theoretic Review of Global Trade and Supply Chain

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Abstract. The electric vehicle (EV) industry is becoming more important in global economic competition. It is shaped by strategic decisions in international trade, resource competition, and industrial development. This paper will apply game theory as an analytical perspective, exploring how countries and firms interact within the EV supply chain. This paper examines the approach of competitive behavior, such as pricing strategies and cooperation methods. Rather than create a new theoretical model, this study will focus on summarizing, comparing, and reflecting on the strategic decisions that have been discovered. Finally, this paper will identify the potential affective factors that might not have been discovered and suggest the future direction of combining theory and practical relevance in the evolving EV field. A creative point of this paper is combining the theoretical model and reality cases of the EV industry. It will fill the gap between reality strategies and theoretical study by using case analysis and research summary. Unlike other studies that focus on building models, this paper highlights reality factors such as market uncertainties, policy changes, complexity of supply chain to reveal the influence of reality factors in the strategic interactions, and focuses on the potential of game theory in dealing with challenges in reality.

Keywords: Game Theory, Electric Vehicle Industry, Strategic Competition, Supply Chain Dynamics, Policy Incentives.

1. Introduction

Nowadays, transportation shifts globally towards electrified transportation, bringing the EV industry to the forefront of international trade and strategic supply chains. As the competition for resources becomes intense and governmental strategies change, the EV market is no longer just a technological race but also a complex field of interaction of different strategies.

Game theory offers the tool for simulating strategic decisions in the condition of interdependence and providing a practical approach to understanding these dynamics. Previous studies used game theory to analyze pricing strategies, Investment in green technologies, and policy incentives across different EV market structures[1]. For example, some models examine how suppliers and manufacturers negotiate under uncertainty or how governments influence the market with subsidies. Although there are increasing studies about the EV market and its strategic competition, current research often emphasizes theoretical assumptions, ignoring the complexity of reality. Simplified models might neglect information asymmetry, rapid changes in markets, etcetera.

The EV market is not only the interaction of technology development and environmental discussion, but also the core field of policy battle and industry strategies among countries. According to the International Energy Agency (IEA), global electric vehicle sales will exceed 14 million in 2023, and it accounts for 18% of total vehicle sales. This number is expected to keep increasing in the future. At the same time, more and more countries introduce subside policies, limitative tariffs, etc, making the firms have a stronger relationship with the government. In this case, the game theory can provide theoretical evidence for the interaction between firms, governments and markets, and it becomes an important tool for understanding the policy making, pricing strategies, and resource utilizations.

This paper will provide a structured review of current research on EV supply chains and trade strategies. It organizes previous studies from macro and micro perspectives. A case study of Tesla and BYD illustrates how theoretical models align or misalign with actual strategic outcomes. This study contributes to a deeper understanding of competitive dynamics in the EV field and offers direction for future strategic analysis.

2. The Overview of Previous Studies

2.1 Macro Perspective - Strategic Supply Chain and Subsidy Effects

Previous studies often use macro perspectives to analyze strategic interactions in global EV trade, especially regarding tariffs, subsidies, resources, etc. Game theory models how governments make trade decisions while predicting others' strategic decisions. For instance, Cheng, Wang, and Gong (2020) model the pricing and production game between EV supply chains in the case of subsidy reduction and find out that the demand and the pricing strategy are closely interconnected. Besides, Wang and Huang [2] investigate how companies that collaborate closely with their suppliers tend to invest more steadily in clean energy solutions. Besides, under the background of the global supply chain is affected by the covid, wars, and geopolitics, the problems about trades and resources monopoly makes the strategic behavior more complex. For example, some countries limit the batteries exports, making the game between firms and their suppliers not only reflected in price negotiations, but also non traditional strategies such as long-term cooperation and the technology exchange market. These new trends tell us that the strategic interactions at the macro level is not static, instead, it is affected by external changes.These studies emphasize the importance of aligning the supply chain with cost efficiency and green innovation incentives in competitive markets.

2.2 Micro Perspective - Firm Behavior and Strategic Advantages

The game theory model has been used at the micro level to explore how firms compete for market advantages through resource acquisition, technology innovation, and pricing strategies. Rasti-Barzoki and Moon [3] construct a model in which electric and gasoline vehicle producers compete under sustainable strategies and reveal how tax and cost incentives change firm behaviors in the supply chains. Adnan, Chakraborty, Bag, and Wu [4] also analyze how green investment strategies change under different supply chain structures. They show that the dominant players in the game determine the investment equilibrium and market outcomes, whether manufacturers or suppliers. Concepts such as Stackelberg leadership and Cournot competition are used to capture this interaction. These models provide practical insights, revealing how decision-making at the firm level is shaped by the prediction of competitor actions, especially in the EV industry. Recently, research has also begun to explore "behavioral games" or bounded rationality models, which consider the strategic decisions made by corporate executives due to irrational factors such as cognitive bias and empiricism, in addition to the traditional assumption of complete rationality. Especially under pressure of technological transformation and rapid market changes, companies may make predictions based on memories of previous opponent behaviors or past experience, instead of strictly based on mathematical prediction. Future research that incorporates these behavioral factors into the analysis may be closer to the dynamics in the real world.

2.3 Modeling Limitations and Areas for Improvement

Many existing models offer important theoretical contributions, but many of them are limited by simplifications that accuracy in real-life decision-making. Some common assumptions are made in these models, such as complete information, rational expectations, and symmetric payoff structures, etc. These assumptions might not reflect the complexity of the EV market. For instance, Chakraborty and Kumar [5] propose a model for EV adoptions under varying market structures, but the model model is static and is limited in the aspect of ability to interpret technological disruption or consumer behavior changes. Furthermore, few models can capture the differences of internal strategic preference, scales, and so on. Zavvos, Gerding, and Brede [6] admit that the difference between investors and uncertainty of localized demand is hard to represent in a single model. These limitations show that future studies should develop more flexible, adaptive game theory methods that can reflect the dynamics of the modern EV market. All in all, future research on electric vehicle games should develop towards the direction of dynamic models that are driven by multiple factors, and combine

data-driven and behavioral modeling to more accurately capture the interaction between companies and countries.

3. Case study: Tesla and BYD

Tesla and BYD are two global leaders in the electric vehicle market. Tesla is known for its technology innovations and its influence in the U.S. and Europe, and BYD is known for efficient manufacturing and low cost (especially in China). As both of these firms expand globally, their strategies influence each other increasingly.

This competitive relationship can be viewed using game theory. A point is, BYD entering European markets can be viewed as Tesla's strategic decision to gain market share, because it has to use aggressive pricing strategies to get advantages. This makes Tesla adjust their own production and price correspondingly. According to game theory, this is like a Cournot competition. Every firm will consider the reaction of their competitor when they are choosing their production level. The game is dynamic, since their competition expands in more than one market, so both firms will learn from each other's action.

Compared to the previous models that study the production quantity competition under the change of subsidies by Cheng et al. [7], Tesla and BYD reflect similar patterns like output and pricing adjustment, but in a more complex, real-life environment. Decisions in the real world involve not only production and pricing, but also technologies development, regulation, etc.

Additionally, the strategic differences between the two companies are also reflected in the degree of integration of their supply chains. BYD adopts a vertical integration model. They independently control core components such as batteries and motors. However, Tesla relies on external suppliers and partners. This difference not only affects its cost structure, but also determines the two companies' response strategies of the dynamics of the global supply chain. An example is the global chip shortage in 2021, BYD was relatively less affected, but Tesla had to adjust the production strategies of some models. If we analyze from the perspective of game theory, this stability of the supply chain can be regarded as the initial advantage of the company in the dynamic game, which will influence its pricing strategy and market layout.

One question worth discussing is whether the long-term competition of Tesla and BYD can lead to an equilibrium, which means both firms can stabilize their strategies based on their expectation. If so, the continuous competition of Tesla and BYD might provide a beneficial interpretation of understanding how game theory is used in the EV market, and how the theoretical model reflects that.

4. Discussion

The case of Tesla and BYD raises several questions for future research. One important question is, whether long-term competition will lead to relatively stable strategic actions. As both firms adjust their price, production, and market strategies, do their actions eventually stabilize and come to an equilibrium? If so, what conditions are required?

Another question worth exploring is the flexibility of the supply chain. Tesla changes their suppliers frequently, but BYD manages most of its own production. This difference in supply chain might affect the long-term competition methods of both firms, especially when the cost or policy changes.

Additionally, current studies usually focus on internal factors such as firm strategies or external factors such as politics, but not both. Future research can explore how factors like geographical location, fundamental facilities, and sources acquisition influence the competition. These limitations might influence the result in a way the theories don't capture.

In addition, future research can also use the perspectives of behavioral economics and organizational behavior to study the irrational factors of managers in strategy making, such as overconfidence and path dependence. In real competition, the judgment of corporate leaders is not

always completely rational, which may lead to deviations from the equilibrium in game theory. For example, a company may make aggressive actions based on historical experience instead of purely based on the optimal solution derived from the opponent's strategy. Therefore, incorporating these deviations into the model will help to simulate the response mechanism of firms in a rapidly changing environment more accurately.

In conclusion, the case of Tesla and BYD shows that combining real-world examples with game theory can lead to new insights and help reveal the weaknesses in current models. These cases remind us that real competition involves changing markets, unexpected decisions, and strategies that don't always follow theory. We can better understand what current models miss and how future research can improve by looking at how companies behave in global trade.

5. Challenges and limitations

Although game theory provides a practical tool in the studies of strategic behaviors in the electrical vehicle industry, there are several limitations. A common issue is the dependence on the simplified assumptions such as perfect information, rational decision-making, etc, and these assumptions might not reflect the actual behaviors in real-world competitions [8]. In reality, the firms always face uncertainties, which means they have limited knowledge of competitors' actions and their shifting internal priorities.

Another limitation is lack of empirical foundation. Although models constructed by scholars like Cheng, Wang, and Gong [9] or Adnan et al. [10] offer useful information in theoretical prediction, they are usually based on stylized scenarios, not real-world data. This makes people doubt if the model matches the actual behavior of the EV supply chain. Besides, volatilities are introduced by real-world factors such as changes of material cost, disruptions of supply chains, or changes of consumers' demand. The volatilities are difficult to capture in a static model [11], and they reflect that traditional frame might oversimplify the dynamics of global EV competitions. Another challenge that is easy to ignore is the adaptability across different cultures. The policy environment, regulated system and customer preference will deeply influence the behavior of a firm. For example, the way that Chinese firms facing subsidies or exporting limitations might be completely different than European or American firms. This difference has not been fully reflected in current models, which makes the prediction less efficient in the environment that is made up of multiple markets. If future study can combine the adaptability into models, they will make more accurate and reasonable predictions.

In order to improve future analysis, researchers should combine formal models with real-world data, explore more flexible and adaptable strategies that better reflect the operations of the firms.

6. Conclusion

This paper explores how game theory explains strategic behavior in the EV industry, focusing on important decisions such as pricing, production, market expansion. The case of Tesla and BYD illustrates how firms compete through dynamic and dependent strategies, which reflect the concepts of quantity competition, long-term adjustment, etc. Although theoretical models provide useful frames, they always simplify the complexity in real-world situations, ignore the uncertainties of the market, flexibility of the supply chain and changing demand of consumers. The competition between Tesla and BYD shows that firms will make adjustments based on competitor's actions in order to take advantage in the market, which will create patterns that might not align with static models or theories. This means that future models need to better reflect the global market, since it is changing fast, so that researchers can understand how models or theories need to be changed to align with reality better. To sum up, game theory is still a useful tool, but its relevance depends on how well it captures reality.

Moving forward, it would be helpful for future studies to combine these models with real-world data and observations based on cases. Instead of relying only on assumptions, researchers could

explore how companies actually behave when they are facing uncertainty, competition, or sudden changes in the market. This could make game theory more practical and relevant, especially in an industry like electric vehicles that changes rapidly. Future models might better reflect the actual strategies used by firms like Tesla and BYD by focusing more on how decisions are really made. In conclusion, connecting theory with practice is key to making game theory more useful for understanding real-world business competition in the EV industry.

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