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EV Spreads and Semiconductor Convergence Study according to Price Inflection Points

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Abstract

This study aims to analyze the correlation between semiconductor innovation and market dominance in the mobility electric vehicle industry. To this end, the study presents strategies that provide low-price competitiveness along with high-value creation in the electric vehicle and semiconductor markets. The first change in the era of high interest rates is to overcome the crisis of survival for value. Furthermore, the study acknowledges the ongoing second wave of change as the digital technology's value continues to rise, and companies experience decreased productivity due to rising ESG labor costs. The study analyzed price competitiveness in the context of the increased adoption of electric vehicles and the integration of semiconductor prices, proving that Tesla and Samsung Semiconductor have developed technology to dominate the market, with appropriate low-cost strategies applied as the value of innovation declines.

Keywords: *Inflection-point, Sustainability, 2nd inflection point, Innovation, Perception-point, Electric vehicle, Semiconductor.*

1. Introduction

This study aims to maintain manpower while presenting growth plans for the semiconductor and electric vehicle industries. Currently, price competition games are taking place in the memory semiconductor and electric vehicle markets, and falling prices of DRAMs are the cause of the sharp drop in semiconductor exports. Tesla continues to develop its own chips and reduce the use of third-party chips as it orders a large number of next-generation chips for its fully autonomous computers from TSMC. FSD chips are not essential for full autonomy, but they have significantly improved performance over previous models. However, price-discount competition is necessary to gain market dominance and increase sales in the electric vehicle market. Tesla recorded an operating profit margin of 15.6% in 2022, which is nearly three times higher than other manufacturers. To maintain its leading position in electric vehicle sales, Tesla has adopted such sales policies by sacrificing some profitability. This trend of companies designing and producing their own chips to lower in price is not unique to Tesla. Apple, Google, and Amazon have started designing their own chips to power their products too. This allows them to have more control over the performance and features of their devices,

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and can also lead to cost savings in the long run. So, the development of in-house chips allows companies to optimize the design of the chip specifically for their own products, resulting in better performance and efficiency. When a company designs its own chip, it can tailor it to fit the exact specifications and requirements of its products, rather than relying on off-the-shelf chips that may not be perfectly suited to their needs. This can lead to improved performance, reduced power consumption, and better integration with other components in the product. So, the aim of the study is to analyze the potential impact of the shift towards in-house chip design on traditional chip manufacturers like Samsung and Micron. The study may aim to examine the reasons behind this shift and its implications for the market demand for traditional chip manufacturers' products. The study may also investigate how traditional chip manufacturers are responding to this Tesla FSD chip trend and whether they are adapting their business strategies to stay competitive in the changing market landscape. Overall, the goal of the study seems to be to provide insights into the changing dynamics of the semiconductor and EV industry and the potential risks and opportunities for companies operating in this market.

2. Prior research

2.1 EV expansion

Compared to previous studies, this study builds 3 scenarios of electric vehicle demand for semiconductor prices. Scenario 1, states that a decrease in the price of semiconductors will lead to a decrease in the price of electric vehicles. Scenario 2, states that an increase in the price of semiconductors can stimulate an increase in the price of electric vehicles. Scenario 3, recognizes that changes in the price of semiconductors can influence the demand for electric vehicles. A decrease in price can improve the competitiveness of electric vehicles in the market, while an increase in price may hinder demand.

Tesla is the only company that shows a positive correlation between oil prices and demand for EVs, indicating a substitution effect between combustion-engine cars and EVs[1]. This means that as oil prices increase, consumers are more likely to switch to EVs, which use less or no oil. While this statement may be true based on available research, it is important to note that there are other factors that influence consumer demand for EVs, such as government incentives, technological advancements, and changes in consumer preferences. So Tesla is the only company that shows a positive oil price sensitivity for EVs when considering other factors. EVs are expected to replace traditional fuel vehicles in the near future due to energy and environmental problems. The dynamic system of EVs has been established based on research, and the model of the pure electric car dynamic system is feasible[2].

The study found that Tesla EVs became become the world’s largest EV market about 66% of worldwide EV sales are in China. Tesla's share of China's all-electric retail car market dropped from 13% in 2021 to 8% in the first nine months of this year, according to data from the country's car association. Traditional car pricing research shows that cars as a product have enough price elasticity of demand. However, early research also shows that EVs, as a new type of car, do not have enough price elasticity of demand. The paper analyzes Tesla's Chinese pricing strategy using a theoretical model, quantitive economic tests, and case analysis. The study of Tesla's sales data through ARIMA and linear regression models showed that Tesla's product is significantly more price elastic than previously concluded. The prior research case also shows that price is a highly effective weapon for Tesla as a market entrant and price cuts have brought strong entry effects to Tesla. However, the original incumbents in the Chinese market did not capture the benefits of time and geographical location to effectively counteract the market impact[4]. The step is the introduction of low-cost and economical electric vehicles with acceptable prices and mass promotion. The process of going from high price to low price is in line with Philip Kotler and Gary Armstrong's definition of skimming pricing. The price of the new Tesla

releases ranges from high to low and from far to near. Among them, products with different release times also show some different price characteristics. Among these products, Model 3 and Model Y are made in China. These two products are the main products to open up the Chinese market and are the core of the skimming pricing strategy. The pricing strategy Tesla adopted when entering the Chinese market is skimming pricing [4]. The availability of various new features compared to conventional vehicles positively influences EV purchases. This study shows that higher government subsidies and prices are direct effects for the expansion of EVs and charging facilities, safety and performance in case of fire, and various vehicle (sedans, SUVs) are the most influential factors for EV sales.

2.2 Study on the Persistence of Semiconductors

The paper analyzes the expected growth trend of the semiconductor industry and the impact of various economic factors on semiconductor demand [7][8]. It is emphasized that the scale of mass production and the level of revenue determine the growth of the semiconductor industry, and it is also mentioned that new technologies for K-semiconductors are needed. NVIDIA provides a better solution for AI processing and parallel computing by connecting the main and intermediate servers with its own server CPU and a Grace CPU chip that integrates GPU and CPU. Platform companies and electric vehicle companies are investing in AI processor competition for autonomous driving, and it is suggested that research on the development of safety accident chip technology for autonomous vehicles is needed[9]. This paper aims to provide insight into the present and future of the semiconductor industry and its key players.

3. Study on the Age of Mobility

3.1 Innovation in Electric Vehicle Chips

Toyota's first electric vehicle (EV) model, the bz4x, is behind the technology of Hyundai and Tesla who are currently leading the EV market. Toyota's first EV was similar to typical fast followers but with design and technological differences. The platform was an unnecessary structure and added to the production costs. Currently, Toyota has 0% EV market share in 10 European countries, with projections of 40-50% EV sales market share by 2030. Toyota Toyota was behind global automakers by focusing on hydrogen cars, while Hyundai Motor was ahead of Toyota by combining hydrogen and electric vehicles. To catch up with this, Toyota is developing a platform exclusively for electric vehicles by borrowing Hyundai's electric vehicle production method. The electric vehicle market is an emerging industry in which a small number of companies operate in the form of oligopolies. Tesla is a leader in the U.S. market that controls input prices so that it can produce high-end EVs within the mid-size sedan price range[10].

3.2 Semiconductor case and inflection point

The semiconductor inventory of Samsung Electronics was 26 trillion won (approximately 22.5 billion USD) based on the 3rd quarter of 2022, while SK Hynix's was 14 trillion won (approximately 12 billion USD). This is due to the trust in South Korea's memory semiconductor. Companies like SK Hynix, Kioxia, and Micron are in the same situation. They induced a cut in supply through artificial reduction in October 2022, while Samsung Electronics did not. Samsung's failure to reduce its share of the DRAM flash market affects the global semiconductor market. Reducing supply through artificial cuts will alleviate the oversupply in the

market and ultimately stop the decline in semiconductor prices and lead to recovery. This change in the global semiconductor market is due to Samsung's strategy to gain a technological edge over competitors. However, in the future as [Table. 1], the demand for semiconductors will increase due to the establishment of next-generation advanced industries such as 6G, AI, and high-performance computing.

Table 1. Semiconductor status vs. Automotive electronics cost and semiconductors per car, source: KSIA,NIPA, Deloitte analysis

Semiconductor/year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Product(Twon)	20	21	22	26	18	19	24	32	32	35	38	36	41	61	62	65	68	72	69	66	103	143	134	159	201	-
MarketShare%	7	6	7	7	6	7	7	10	11	11	11	10	12	14	13	14	16	17	17	17	22	24	18	18	20	-
Export($100M)	172	170	189	260	143	166	195	265	300	374	390	328	310	507	502	504	571	627	629	622	979	1,267	939	992	1,280	1,292
Ex rate (%)	13	-1	11	38	-45	17	18	36	13	25	5	-16	-5	63	-1	1	13	10	0	-1	57	29	-26	6	29	1
Import ($B)	129	122	161	199	156	175	213	236	251	280	308	320	266	311	325	322	346	365	383	366	412	447	470	503	614	748
Im rate (%)	22	-5	31	24	-22	12	22	11	6	12	10	4	-17	17	4	-1	7	5	5	-4	13	9	5	7	22	22
DRAMPrice($)	6	5	5	4	2	2	2	4	4	4	3	2	2	3	2	2	3	3	2	2	4	4	4	3	3	-

	2000	2010	2020	2030
Automotive electronic cost(% of total car cost)	18%	27%	40%	45%
Semiconductor price(per car)	150	300	475	600

Competitors dramatically reduced their investments due to deteriorating performance. Samsung Electronics, with its high financial capability and semiconductor characteristics, has to pay more to restart its production facilities after interruption, rather than other competitors. Samsung prepares for the next semiconductor boom by either eliminating competitors who can't withstand the downturn or continuing with its planned investment. As [Fig. 1], the growth of autonomous vehicles and IoT appliances is driving the demand for HBM as a RAM due to the increasing use of AI and machine learning (ML). Artificial intelligence is on the rise, Companies like Google, Microsoft, and Baidu are investing in GPT, and demand for HBM is increasing. Companies like Samsung and SK Hynix are expected to benefit greatly. AI aims to replicate the human brain with complex neural networks and is divided into two functions: learning and inference. Parallel computation is the best-optimized device for AI, with GPU being the most commonly used. GPU was also widely used in. The demand for HBM has increased explosively as the leading domestic memory semiconductor companies dominate the global HBM market like autonomous driving of the second change.

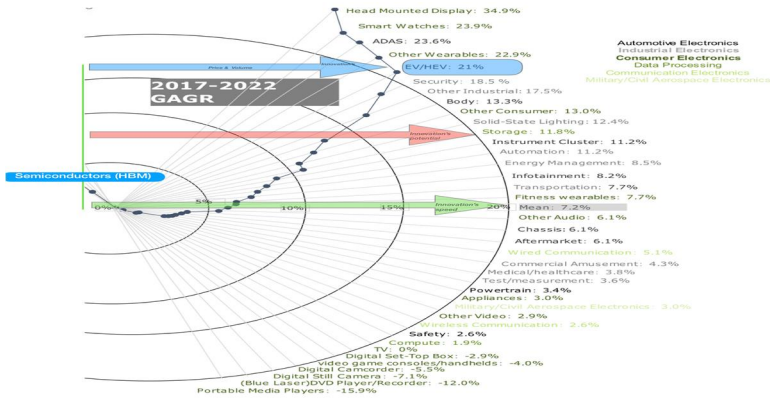

Figure 1. Semiconductor revenue growth by electronic equipment type (2017- 2022) source: Gartner, Deloitte analysis & author [6]

3.2.1 Price competition era

When it comes to the Golden Price strategy, companies that have previously led the market with low-cost supplies emphasize that a new era needs a new transformation. To this end, global automakers are seeking to offer more EVs and lower prices in competition with Chinese companies. It's called a "chicken game," suggesting Tesla should join it. In addition, Tesla will continue to lower prices and launch new models, which will be priced at around 25,000 euros, or roughly 30 million (KRW), by 2025. and Samsung emphasizes that it is competing with global competitors in the semiconductor industry and that efforts are needed to launch faster and more energy-efficient products. SDRAM is expensive but faster than DDRAM, while DDRAM is faster than SDRAM and DDR5 is faster and more energy efficient. Samsung and SK Hynix are the top two companies in the market, controlling over 70% of the market share. To this end, Samsung aims to maintain its competitive advantage and maintain a more stable point of view than other companies.

3.2.2 EV convergence with integrated chips

South Korea, once a non-existent player in the semiconductor industry, has become a leading player in the industry, beating Japan and Taiwanese companies who tried to undermine its growth. Samsung is competing with other global memory semiconductor companies such as SK Hynix, Micron, Toshiba, and Taiwanese companies. The prices of PCs and smartphones, as well as the global semiconductor stock market, are all being impacted. Therefore, to maintain the continuous growth predicted by the author, it is necessary to recognize and prepare for the second transition point in the semiconductor demand like EV convergence with integrated chips. Samsung's goal is to maintain its competitive advantage over other companies, as it may become difficult to monopolize the market in the future. This is because at a relatively stable point in time.

4. Semiconductor Analysis of Mobility

The electric vehicle market is growing rapidly. Electric vehicles have pursued the technological advancements that internal combustion engine vehicles have made over the past hundred years. Electric vehicles use a variety of semiconductors, especially power semiconductors, which are used to control and regulate the power inside the vehicle. Microcontrollers used to control various functions within the vehicle,

such as HVAC systems, infotainment systems and battery management systems, sensors, memory devices and display drivers that monitor various functions within the vehicle are also used. These semiconductors play an important role in the function and performance of modern electric vehicles, and memory semiconductors such as DRAM can also be used in infotainment systems, battery management systems, or other control systems requiring high-speed memory access. As above[Fig. 1], High-bandwidth memory (HBM) as a sort of D RAM was used in electric vehicles (EVs), including the Tesla Model 3 or other models. HBM is a type of high-speed, low-power memory semiconductor that is designed for use in high-performance computing systems and graphics processing units (GPUs). In EVs, HBM was used in various applications, such as the vehicle's battery management system, autonomous driving system, or infotainment system. HBM's high-speed and low-power characteristics make it well-suited for use in the demanding environment of an electric vehicle, where quick access to large amounts of data is required with minimal power consumption. The use of HBM and other types of semiconductors in EVs is constantly evolving, and new developments in technology and manufacturing processes may result in changes to the types and quantities of semiconductors used in future EV designs.

4.1 Correlation between EV demand and semiconductor prices

Will a decrease in Tesla's D RAM chip orders have an impact on the overall D RAM market prices? If orders for D RAM chips from Tesla decrease, it may have some impact on the overall D RAM market price, but it is unlikely to be significant. This is because the demand for D RAM chips from other industries, such as the smartphone and computer industries, is much larger than the demand from the electric vehicle industry. Therefore, the overall D RAM market is not heavily reliant on orders from Tesla, and fluctuations in their orders are unlikely to have a significant impact on the market price. But it is like “butterfly effect” on future leaders (Tesla-EV) and high-tech companies. So, The collected data on semiconductor orders and exports can be prices of both semiconductors and Tesla electric cars over a certain period, and the regression analysis results are obtained using a regression model. This is done to determine if there is a significant relationship between the two variables and to see how much the semiconductor price affects the electric car price. Then, this information can be used to predict future prices of electric cars based on changes in semiconductor prices.

Table 2. Regression analysis of the table on the Sales volume by Tesla electric vehicle price range on 2017-2023E.1 in the world [7],[8], [13],[14], [16]

Regression Statistics					
R	0.2459	***R-Squared***	**0.0605**	*Adjusted R-Squared*	-0.1274
MSE	0.0073	***S***	**0.0853**	*MAPE*	127.8981
Durbin-Watson (DW)	1.8216	*Log likelihood*	8.4794		
Akaike inf. criterion (AIC)	-1.8513	*AICc*	-1.7370		
Schwarz criterion (BIC)	-1.8667	*Hannan-Quinn criterion (HQC)*	-2.0423		
PRESS	0.0870	*PRESS RMSE*	0.1115	*Predicted R-Squared*	-1.2497

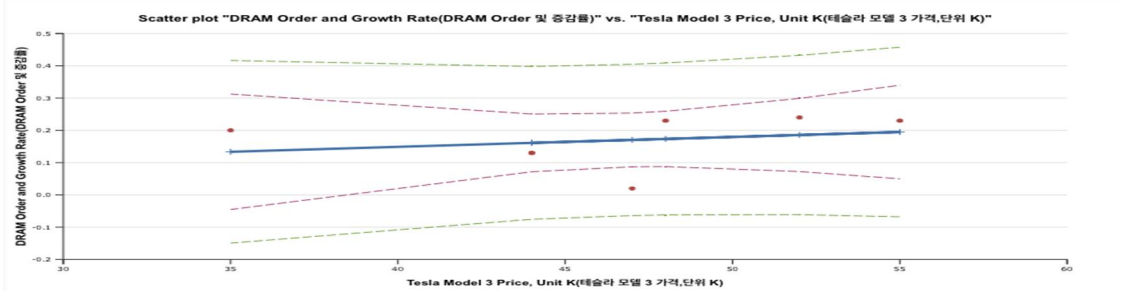

Figure 2. Scatter plot on “ DRAM order rate vs. Tesla 3 price”

Dependent variable: D RAM order & growth rate,When analyzed as an independent variable with each Tesla model 3, as using the following data[13],[14], [16].

$$R2: 0.605.\ y=-197.42+17.92x-0.60x^2+0.01x^3. \quad (1)$$

however, even if analyzed by quartic(4th) regression, R2 is 0.523, and the formula becomes as follows. The p-value of Test Statistic is :H0 (5%) (Shapiro-Wilk W) 0.830, which is significant.

As a result of the above, It is possible that the decrease in Tesla's orders could have ripple effects on the future development of electric vehicles and high-tech companies, similar to the "butterfly effect"[15].

4.2 Results and Implication Analysis

According to the research results, if the price of EVs is lowered, semiconductor prices also decrease due to price competition. In addition, if semiconductor orders and prices decrease, the price of Tesla's mass-market Model 3 will also decrease. The analysis suggests that if the prices of EVs are lowered, it could potentially lead to a decrease in the prices of integrated semiconductors as well. This is because the demand for integrated chips used in EVs is likely to increase, leading to a larger order volume from EV manufacturers such as Tesla.

The exact number of Samsung semiconductor portions used in the Tesla Model 3 is not publicly disclosed, as it is proprietary information of both companies[13],[14],[16]. However, it is known that Samsung is one of the suppliers of memory chips for Tesla, such as the central touch screen, the autopilot system, and the infotainment system. Currently even if Samsung's portion of the semiconductor content in the Model 3 would be a fraction of the total semiconductor contents, it will be more than now. With a larger order volume, the cost of production for sort of integrated chips may decrease, leading to a potential decrease in their prices. As a result, Tesla may be able to lower the price of their mass-market Model 3 vehicle, which could attract more consumers and increase their market share in the EV industry. Overall, the result suggests that there is a potential link between the prices of EVs and integrated chips, and that a decrease in one could lead to a decrease in the other, ultimately benefiting companies like Tesla.

5. Conclusions

The battery life and safety of electric vehicles are critical to maintaining customer confidence. Therefore, the battery sector needs integrated chips that prioritize battery life and safety, such as smartphones and computers. In addition, software updates can solve hardware problems, and in the technological age, it is important to maintain trust. EVs must consider advanced technologies and safety, including electronic stability control (ESC) systems and advanced driver assistance (ADAS) experiments, and electromagnetic error experiments on reduced battery fire risk. For this reason, EVs that require new integrated semiconductors as premises 1. are appropriate to change this strategy at a lower price. The price competition in the semiconductor and electric car markets is a crucial factor due to economies of scale. If the electric car market grows to more than twice its current size, companies will seek to lower prices to increase their market dominance. To survive in this game of low prices, sustainable market competitiveness is required while maintaining manpower. This is because larger companies tend to survive in markets with large scale economies. Smaller companies may struggle to compete on price and may find it difficult to keep up with the rapidly changing technology in these markets. Additionally, the study’s limitations and new areas touches on the importance of considering advanced technology and safety considerations in the development of new integrated semiconductors for electric vehicles. However, further research could be conducted to explore the specific technological innovations required to improve electric vehicle performance and safety, as well as strategies to make these advancements more accessible and affordable for consumers. Overall, future research is necessary to continue

advancing the development and adoption of electric vehicles. In an era of high interest rates and high inflation, the paper suggests on the second change to withstand the pressures of a price war.

References

[1] Baur, Dirk G.,Todorova, Neda, "Automobile manufacturers, electric vehicles and the price of oil." Energy Economics. (2018), Vol. 74, p252-262. 11p.

[2] Yunxi Zhang, Kuansheng Zou, Jiabao Wu, Zilong Cheng, Linlin Hou, and Jia Liu, Modeling and Simulation of Power System for Electric Vehicle, ICMIP 2022, Association for Computing Machinery, (2022), pp 242-246.http://lps3.doi.org.libproxy.sungkyul.ac.kr/10.1145/3517077.3517117.

[3] Hyeonjung (Tari) Jung, Mingzhou Yang, Matthew Eagon, and William Northrop, Revolutionizing electric vehicle management: spatial computing challenges and opportunities, IWCTS '22, Association for Computing Machinery, (2022), Vol 11, pp 1–4. http://lps3.doi.org.libproxy.sungkyul.ac.kr/10.1145/3557991.3567785.

[4] Shuwen Qin &, Guangzheng Wu, Research on Tesla's Price Strategy in China, Proceedings of the 2021 3rd International Conference on Economic Management and Cultural Industry (ICEMCI), Advances in Economics, Business and Management Research, (2021), Vol 203 ,https://doi.org/10.2991/assehr.k.211209.099.

[5] DaeSung Seo, "EV Energy Convergence Plan for Reshaping the European Automobile Industry According to the Green Deal Policy", JCIT, (2021), Vol.11, No.6 pp.40-48, retrieved from doi:https://doi.org/10.22156/CS4SMB.2021.11.06.040.

[6] Deloitte, Semiconductors – the Next Wave Opportunities and winning strategies for semiconductor companies, Jan 2023, retrieved from https://www2.deloitte.com/content/dam/Deloitte/tw/Documents/technology-media-telecommunications/tw-semiconductor-report-EN.

[7] The Semiconductor Industry Association (SIA). market data, Jan 2023, retrieved from https://www.semiconductors.org/data-resources/market-data.

[8] World Semiconductor Trade Statistics (WSTS), Semiconductor market forcasts, (2023), retrieved from www.wsts.org.

[9] DaeSung Seo, "A Study on the Application of AI and Linkage System for Safety in the Autonomous Driving", Journal of the Korea Convergence Society, (2019), Vol.10, No.11 pp.95-100, doi:10.15207/JKCS.2019.10.11.095.

[10] Salman, D. M., An insight for the market driving forces: Case of tesla model- S. International Journal of Business Ecosystem & Strategy, (2019), Vol 1, No2, pp 25-30. doi:https://doi.org/10.36096/ijbes.v1i2.123.

[11] Katis, C., & Karlis, A., Evolution of equipment in electromobility and autonomous driving regarding safety issues. Energies, (2023), Vol 16, No 3, pp 1271. doi:https://doi.org/10.3390/en16031271.

[12] McKinsey & Company, The semiconductor decade: A trillion-dollar industry,. April 1, 2022. retrieved from https://www.mckinsey.com/industries/semiconductors/our-insights/the-semiconductor-decade-a-trillion-dollar-industry.

[13] MarketWatch, Jan 2023, retrieved from, https://www.marketwatch.com/investing/stock/tsla.

[14] Samsung Semiconductor, Jan 2023, retrieved from https://www.samsung.com/semiconductor/.

[15] DaeSung Seo, Study on Shift of Innovation and Manufacturing Hubs to the United States, The Journal of the Convergence on Culture Technology, (2023), Vol. 9, No. 2, pp.553-560. http://dx.doi.org/10.17703/JCCT.2023.9.2.553.

[16] Car gurus. March, 2023, retrieved from https://www.cargurus.com/Cars/price-trends/Tesla-Model-Y-d3044.