Title: Hydrogen Fuel Cells Vehicle Technology's Strategy of Toyota Mirai

Course: ETM 526/626 - Strategic Management of Technology

Year: 2015

Professor: Dr. Charles Weber

Author(s): Sudarat Poocharat

Report No.: 3

Table of Contents

ABSTRACT

In a progressively complicated economic and social environment, high technology companies are dealing with fast-track technological development and global technology-based competition. In view of the significant role of technology in a competitive environment, strategic technology management is critical for organizations. In order to achieve enduring success, companies should acquire and sustain their technological capabilities to generate internal and external effects within an uncertain socio-economic demand. The research is aimed to present in the context of new auto technology with a view to achieve understanding of strategic management of innovative technology. The chosen company and the model vehicle is Toyota Mirai HFC. Hydrogen fuel cell vehicles seem to be the substitute for more than one billion cars on the road. Once it is successfully launched in the commercial market. These vehicles work with the power generated as a result of a reaction between hydrogen and oxygen in the fuel cell, which produces the energy for the vehicle with water as the only residue. In light with the recent environmental issues challenging auto industry's development, increases in price of traditional fuel (as gasoline, etc.), regulatory control in all developed or developing nations, the efforts are on the technology across industry around the globe. Once technology is conceived for creating potential business opportunity, the immediate challenge is to make the technologist conversant with the strategy, which is a key element to turn any development into commercially viable business. The overall objective of this paper is to explain strategy management of Toyota Mirai Hydrogen fuel cells vehicles covering analyses of the structure and competitive dynamics of the industry using Porter's five-force Analysis, SWOT Analysis, PEST Analysis, Toyota's Innovation Strategy for Environmental Technology, Competitive Strategy for competitive advantage, and international & global strategy Analysis for Hydrogen fuel cells technology.

INTRODUCTION

Increasing concerns on the climatic change, quality of air and depletion of fossil fuel, there have been newer challenges emerging for auto industry and the energy sectors for transportation over last one decade. Technological innovation is necessary to come out with alternate and sustainable fuel for the auto and transportation sectors. This cannot be achieved through innovation of existing technologies of fossil fuel with higher efficiencies. The key driver is to look for alternate and sustainable energy sources to preserve fossil resources and also reduce CO2 to mitigate the climatic effect [1], [2], [3]. Thereby the radical and path breaking innovation in fuel technology needed. While number of alternate and sustainable technological innovation has come out, but the transforming them into regular commercial use, remains a great challenge. In last one and half decade there have been several theoretical frameworks came out to address the issue of understanding and supporting the transformation to sustainability [4], [5], [6]. In recent times, there are two approaches, which have become center stage for various references in both professional and academic discourses such as innovation systems approach and multi-level concept on transformation [7]. It is vital for the organization to become self-reliant on its operations and abilities to sustain the present competitive business environment of the auto industry. Therefore to stay ahead in the competition, every manufacturer invests millions of dollar into the sustainable futuristic technology to gain competitive advantage and also stay ahead with technology for the product superiority. In this study the chosen company is Toyota. Toyota is the largest producer of automobiles in Japan and the world's second largest automotive manufacturer based on production and sales. Toyota has been capable of pursuing with technological innovation and in that space; it was also one of the pioneers in the auto industry. It has one of the most efficient production processes, called the Toyota Production

System, which follows a lean manufacturing system that reduces waste and enhances efficiency (Toyota Motor Corporation). Toyota Mirai (chosen HFC vehicle for this study) works on the Toyota FCV (Fuel Cell Vehicle) concept car, which was made public at the 2013 Tokyo Motor Show. The FCV has a large grill and other openings to allow cooling air and oxygen intake for use by the fuel cell. For the full-scale market launch in 2015, the cost of the fuel cell system is expected to be 95% lower than that of the 2008 Toyota FCHV-adv [8]. In January 2015 it was declared that production of the Mirai fuel cell vehicle would grow from 700 units in 2015 to approximately 2,000 in 2016 and 3,000 in 2017.

The central question is how Toyota would be able to position its new technology product and gain competitive advantage among its own cars and the cars of other companies including cars of competing technologies. The research question would relate to the strategic management and competitive advantages that Toyota would be able to gain from Mirai after performing the strategic analysis from the point of view of the business environment. Thorough competitive analysis will be done by focusing into SWOT analysis; Strengths, Weaknesses, Opportunities and Threats. In this manner, the research paper will tend to reach its goal to identify the rational, possible success factors and the advantage compared to existing auto products by applying strategic management tools as mentioned before. It would also address as to how the research investigate the various advantage of this innovation in terms of real life usage and eliminate the disadvantages or weakness to maximize the success of this technology in billion auto car market tomorrow.

LITERATURE REVIEW

The element of ‘strategic’ was included to technology management at some point in 1980s by several authors [9], [10]. Strategic management of technology is required to provide a possible solution for managing uncertainty, intricacies and business dynamic forces that are produced by technology. Therefore, an all-inclusive notion of strategic technology management is required to give transparency for experts in the area of technology management. Accordingly, scholars should be capable of linking conventional strategic thought process and the requirements of modern high technology industries [11]. Strategic management of technology is the management of technological pursuits, working together with company’s technology infrastructure and socio-economic surroundings, in order to play a role in the design and implementation of the company’s strategy [12]. The literatures on strategic management describe the changes in approaches by shifting its underlying issues as capabilities and resources [13], [14], [15], 16]. At the same time the resources and changes in resources and capabilities are not able to explain some observations from empirical case studies of emerging technology developments. In the event, sometimes it is seen that the factors enter and exit particular system of technological innovation system but the changes in resources or capabilities are more gradual [17], [18], [19]. The other problem in this area is to describe the fact as to why the factors operating under same condition in terms of resources and institutional terms adopt different strategies. It argues that the changes and gaps are in strategy for explaining the volatility of factor’s expectation. In simpler understanding the expectation can be considered as important factor for the level of sustainability transformation processes. Thus it is advisable to assess the factor behaviour through the analysis of expectation than assessing the comparative importance

of different factors influencing the strategies such as institution, competitors, markets and technologies.

RESEARCH METHODS

This research paper would be based on a qualitative research approach. The research would contain both theoretical and case of company specific parts. The author used sources from academic literature reviews and reputed websites, which would be provided with the theoretical framework needed for the research. Toyota's specific qualitative data collection would be carried out through research. The research here will be concerned with practical application and development. The literature reviews on strategic management encourage the use of qualitative empirical methods, which inquires about the important question through research and also various phenomena in order to gain insights on the subject. It is believed that qualitative research generally provides a way of identifying the normalized pattern relating to important question on the subject. There have been several subjects that qualitative approach has contributed very widely and deeply such as innovation, top management, collaboration etc. On the flip side of qualitative research could raise major debate on various questions [20].

For example, this way qualitative research may create multiple options to develop multiple dimensions of the research. Qualitative study sometimes develops deductively for the prior work to lend a logic that subjects serves to describe and ascertain whether through interpretation, forecasting or other means of insights can be applied beyond specific area. The methodology can also work on inductive way with more open-ended question regarding unidentified issues and phenomena with an objective of providing closer observation that

provides lead to strategic management in general. In the context, qualitative study can provide rich insight about the empirical process whether expanding earlier research or open a new study.

TOYOTA'S INNOVATION STRATEGY FOR ENVIRONMENTAL TECHNOLOGY

By improving the in production efficiency and sales through advanced technology, Toyota can prove its competitiveness in the global market. The key part of Toyota's strategy is to produce many different kinds of vehicles with new advancements while emphasizing the conventional vehicles as the core technology as well. Although the new developments, technology and growth of industry has caused an enormous increase in the number of vehicles, but at the same time resulted in the massive consumption of fossil fuels. The main source of energy till now is fossil fuels. However, the further research and development is in progress to find the alternative means of energy to bring change for the future used [21].

Many countries like United States, Japan and European Union countries have achieved considerable development for producing alternative energy vehicles like electric and hybrid electric vehicles, plug in hybrid cars and fuel cell vehicles. This might resolve the energy crisis by limiting the use of carbon sources as fuel for vehicles [22].

The various challenges faced of Toyota on environmental technology include reducing the emission of greenhouse gases and preventing air solution. The automobiles with low environmental impact are important not only as an alternative but it is now an important part of the corporate strategy. Toyota has developed technology to reduce environment impact for gaining competitive advantage in exploiting them. Despite of the fact that alternative energy

sources could serve as an effective and satisfactory substitute for fossil fuels, they are associated with their own limitations and disadvantages [21].

For this research paper, Toyota hydrogen Fuel Cell vehicle (Mirai) is one of diversified types of Toyota's products that might lead its sales growth in the markets because of associated benefits with this technology such as improved living standard of the customer, profit making, high fuel efficiency and minimum pollution. Hydrogen fuel cell vehicle (HFV) are very important to reduce harmful gasses emitted by other gasoline vehicle and which are leading to the severe climate changes. However, there are various challenges, which the Toyota needs to overcome before making HFV as an alternative technology to the conventional one. In order to achieve the target of commercializing fuel cell vehicles before the other competitive industries, Toyota is investing a lot in the research and development for the full growth of this technology [21]. For reducing the cost Toyota has developed this technology in-house. The various plans to promote cost reduction efforts by Toyota include the common use of vehicle platforms, reductions in component types and the streamlining of production lines. In order to fulfill the need of customers completely which are not only bound to automobiles but other related areas as well, Toyota is developing its business strategically by effectively allocating management and other resources to its finance, information and communication businesses [24].

Considering the profitability of Toyota, making profit is a very crucial to provide an incentive for the mass production in the competitive market. In this case, Toyota sees in term of environment standpoint to get the return on a large investment. Until now Toyota Mirai is the world's first fuel cell vehicle with the pioneering development with the expectation of mass market production starting with the fuel cell manufacturing process. However, the challenges and difficulty in the implementation of this technology cannot be denied [24].

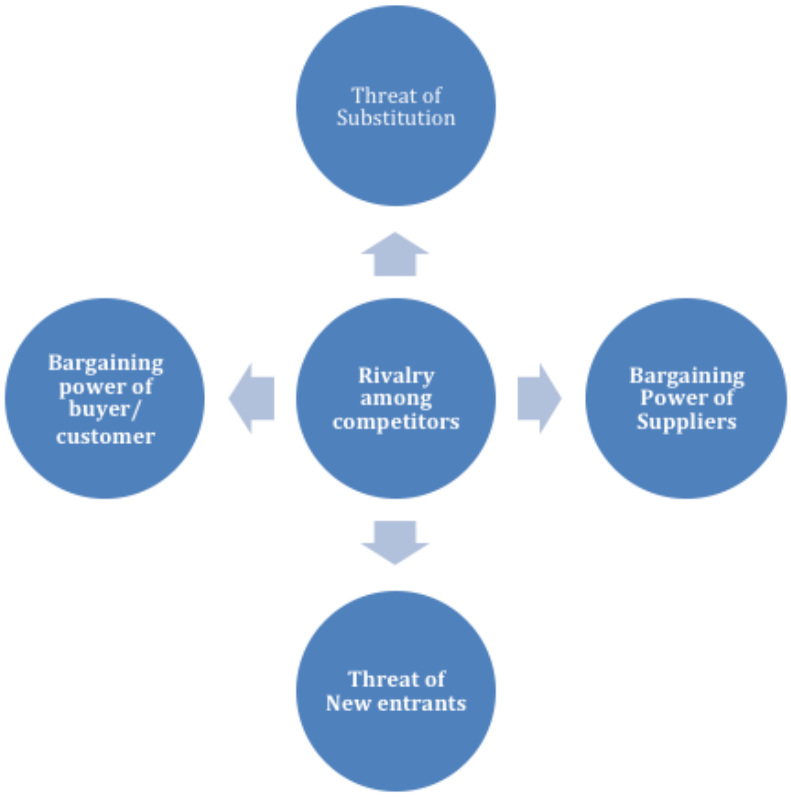
Considering the economical aspects, it is well understood that more than half of oil is used in United States that are fulfilled by importing oil from other countries. Two third of this imported oil is used in the transportation which leaves a severe impact on the economy of the country. The supply of oil and the fluctuations in the prices largely depend on the political conditions as most of the oil comes from the foreign sources i.e. Middle East countries. Various attempts have been made to free the U.S. from oil dependence on Middle Eastern since the oil crisis in 1970s but the amount of oil imported has actually increased since then [25]. The National Research Council has predicted that the cost of the hydrogen gas, on a cost per mile basis, could soon be reduced as much as 50 percent than the cost of gasoline by the year 2017 [26].

Toyota Mirai represents an attractive and new generation vehicle to the customers and investors from the Toyota automotive Company [27]. The company has the vast history of development in fuel cell vehicles since 1992. Toyota has improved the product quality a lot through continuous trial and error of 20 years and by receiving feedbacks from product testing [28]. In the year 2002, Toyota has begun the world's first limited sales of a fuel cell vehicle, the "Toyota FCHV", in Japan and the US. It has employed the hybrid vehicle technology in the development of fuel cell automobiles. There are two key areas, which are expected to make Toyota Mirai the expected future vehicle. Firstly, the energy infrastructure is such that it promotes a hydrogen society and secondly, it can overcome the global environmental and energy crisis as a result of Toyota's continuous efforts to make sustainable mobility [28]. The major challenges that Toyota needs to be overcome are the vehicle cost, hydrogen storage problem (because of storage conditions and cost of storage materials) and hydrogen infrastructure [28]. Estimation has shown that for supporting 50,000 HFC vehicles and 100 stations would require an

investment of 100-200 million dollars and this would be enough to make hydrogen competitive with gasoline on a cost per mile basis. The state of California awarded a lot of money to build many hydrogen fuel stations in order to demonstrate the development in fuel cell vehicles. Toyota is investing in the hydrogen-fueling infrastructure in this state as they are expected to hit the market next year [27].

PORTER'S FIVE FORCES ANALYSIS

Porter's competitive analysis model called "five forces of competitive structure" is an appropriate model when it comes to develop an overview in possible competitive forces around the upcoming fuel cells industry. This model actually takes into account the external forces by evaluating the nature of the market condition. Under this evaluation and analysis, a company is in advantageous condition when the five challenging forces are not very strong. These five challenging forces are rivalry among Competitors, bargaining Power of Suppliers, threat of Substitution, threat of new entrants, bargaining power of customer. It will also cover the success factors, which may contribute to a major break-through for the technology of fuel cell from niche to mass market in auto industry. To do the assessment of competitive atmosphere within the industry, Porter's Five Forces model is applied. A typical pictorial diagram of the Porter's Five Forces Model is here below



- ## Methodology

Michael Porter has designed a technique to analyse industrial structure and its competitive forces. Porter's technique is based on the "Five Forces Model" [29] as illustrated in above diagram. Here it narrates the economic environment and inter-relation among the forces. With the use of this model, the Hydrogen Fuel Cells technology's current scenario can be narrated as this is in early stage of strategic planning for the market entry. The analysis here is to attempt on the following questions?:

1) How is the financial viability of the fuel cells for auto industry?
2) How the competitive advantage can be used to introduce the fuel cells in the industry?

The competitive forces of any industry depends on the following.

i) Power of competitiveness for fuel cells manufacturers;

ii) Threats of new entry to create further competition;

iii) Customer's competitive market power;

iv) Product substitution threat;

v) Suppliers' competitiveness;

After taking into account the all five competitive conditions, it tends to provide a very good overview of the industry's competitive position. This can help the potential of the fuel cells and its profitability which is why any business exist. Therefore the model can be used to evaluate the likelihood that this fuel cells alternative can be adopted for mass usage in the auto industry globally. At the moment, it may not be appropriate to assess and perform complete competition analysis for fuel cells technology as this is more of an emerging technology and yet to taste the ground reality by entering into assembly line for mass production in auto industry. Therefore this research attempts to evaluate the market direction and the competitive forces acting for this technology [30].

In the process of fuel cells, hydrogen and oxygen are combined to generate electrical energy with only water vapour as emission. The hydrogen fuel is sourced from the hydrogen tank and oxygen is taken from the atmosphere. As the fuel cell create energy without any hazardous emission, this technology is widely considered to be a futuristic technology for use in the automotive [28]. The most critical technology part of the whole process is the proton exchange membrane (PEM) fuel cells. As a results the auto industry has focused on the PEM technology. As each fuel cell only create a small quantity of energy, therefore large number

of fuel cells are combined for creating a stack for the use in the technology for providing power to the vehicle.

- ## Porters' five competitive forces

Industry competitors of fuel cells technology are Ballard, Nuvera and United Technologies (Toyota & GM) while competitors are Exxon Mobile, Shell, and BP etc. The supplier of Platinum, membrane, bipolar plates and the companies are DuPont & J Mathey. They will have substantial influence on the development and the success of the technology when it comes to commercial production [31]. Substitution effects are very common in case of fuel cells due to the existing and alternate emerging technologies. The existing substitution threats are optimized petrol and diesel efficiency in auto industry while the natural gas, hybrid cars, electric cars are some of the emerging technologies. With regard to market entry, there is a threat from the energy giants of the globe like H-Power, Mitsubishi Electric, Plug Power, Proton Motor Fuel Cell, Siemens, Honda, Renault and Peugeot [31]. With the presence of existing substitution and other emerging technologies, the customer of this technology will highly be demanding and have massive bargaining power. The some of the major customers are Honda, GM, Toyota, Ford, DaimlerChrysler, Volkswagen, Renault and Peugeot.

The substitution condition is one of the critical area when it comes to technology innovation issues. This is because with competing technology whole of investment in the other technology may get redundant. The substitute can only be adopted by the industry when basic economics will fall in line, as favourable cost structure in comparison to the cost of existing technology. The auto industry claims that the fuel cells technology can be viable

at $40-60 per KW to become competitive. However the current cost is much higher and reflect the existence of limitation in technical area of fuel cells [32]. The PEM fuel cells manufacturer, which are active in development might get together to gain bargain power. This can happen in three sub-groups of companies who have developed prototype of fuel cells vehicle, companies, which have tested and companies, which have done the same for other companies. On the new entry point of view, it will be difficult for the transport players to do such big investment required for the research and development of the technology. This will act as barrier. As for example, Ballard-DaimlerChrysler-Ford alliance have already invested more than billion dollar in the project [33]. When it comes to customer, they will be very high on their bargain power in the process. In this, customers for auto application will be all auto major across the globe. The auto majors have four options to get the technology. They can develop cooperation with the Ballard-DaimlerChrysler-Ford alliance, produce themselves individually or in alliance with other auto companies, purchase from the supplier and produce with any other combine than Ballard. As on date, the Toyota, GM, Ford and DaimlerChrysler have created the best possibility to set up the assembly line of fuel cells vehicle. However, industry should be careful on the point of transfer cost, which is going to be very high in the beginning. This transfer cost means the cost for changing one suppliers of fuel cell to other company's fuel cell due to lack of standardisation in the industry. In case of Toyota Mirai, the progress have been quite advanced and they are ahead in the race to adopt the technology commercially. As recently announced in the Las Vegas trade show, the Toyota will allow over 5000 fuel cell patents available for royalty free licenses till the end of 2020 [34].

RIVALRY AMONG COMPETITORS	**MODERATE** • LESS GENERAL INDUSTRY COMPETITION • DIFFICULTY IN EXIT • HIGHER INDUSTRY MATURITY • CUSTOMER LOYALTY • HIGHER SWITCHING COST • INDUSTRY GROWTH
BARGAINING POWER OF SUPPLIERS	**WEAK** • SUPPLIER'S CONCENTRATION • AVAILABILITY OF SUBSTITUTE • LIMITED THREAT FOR FORWARD INTEGRATION
BARGAINING POWER OF CUSTOMERS	**STRONG** • LARGE NUMBER OF CONSUMERS • COST OF SWITCHING TO OTHER PRODUCT • LIMITED BACKWARD INTEGRATION • DIFFERENTIATION IN PRODUCT CATEGORY
THREAT OF NEW ENTRANTS	**WEAK** • LARGE CAPITAL REQUIREMENT • ECONOMIES OF SCALE REQUIRED • REQUIREMENT OF MINIMUM SCALE • HIGHER IMPORT TAX • LIMITED ACCESS TO DISTRIBUTION CHANNEL • LOW GROWTH RATE IN AUTO
THREATS OF SUBSTITUTES	**MODERATE** • BUSES OF OTHER ALTERNATE FUEL • ALTERNATIVE TRANSPORTATION MODE SUCH MOTORCYCLES, TRAINS, BUSES AND PLANES • AVAILABILITY OF SUBSTITUTES AND COMPETING QUALITY PRODUCT • LESS COST OF ALTERNATIVE TRANSPORTATION

- ## Rivalry among Competitors

The rivalry in the competitive scenario is quite high at the development stage itself. This is going to be even higher once product goes into full stream commercial production. This is all the more important due to high exit created by so much of investment in development of technology and also higher fixed cost making it more committed.

- ## Bargaining Power of Suppliers

As there are very few players at the moment there may be higher bargaining power. They may restrict the technology sharing by creating entry barrier for the new player in the supply side of the business. This could aggravate the problem in the initial stage of commercial production when lesser number supplier may become a bottleneck for the competitive supply and cost reduction.

- ## Threat of Substitution

The biggest threat for this technology is going to be how much cost reduction within what timeframe the same can be achieved. The cost of other fuel application is also on the decline as a result though the technology is very good in terms of sustainability. While the present cost is very high and the same cost is required to go down to get the viability of the technology for commercial production and this process must continue as the cost of competing existing technology are also on the decline.

- ## Threat of New entrants

This is going to be never ending threat once the technology goes into stream. Initially this is not going to be a threat due to high cost of development. But once technology becomes viable, the all auto major has to step in and with increased number of suppliers; the threat of new entrant will set in.

- ## Bargaining power of customer

When the subject is auto, everyone is aware about the industry competition in terms of customer's preference. Here customers have been always in the driver seat. There have such pressure that the auto industry has gone through major consolidation and now only major groups are commanding global auto market. As a result the power of customer in this sector is already high and going no lesser than today. New technology players have to face this demanding customer to meet the commercial aspect too.

SWOT Analysis

The SWOT analysis is a qualitative research tool and highly recommended for such new initiative especially. As it tend throw weakness and threats along with the strengths and opportunities. The most efficient way to deal with this model is to identify these issues under four buckets. By focusing on the strengths and opportunities, company tends to leverage larger benefit from the beginning of the business. On the other hand, by identification of weakness and threats, company plans to eliminate weaknesses and manage the risk of threats within controllable limit.

- ## Strengths

  The fuel cells technology has several strengths, which makes this technology as major futuristic alternate energy sources especially in automotive sectors. The major strengths are the progress where it has passed the stage of trial. It has entered into the stage of making it viable options for commercial exploitation. In an automotive industry where it will require PEM fuel cells, the key issues would be cost, durability and consistent performance. Other strength is the continuous increase in the supplier community show larger commitment for the technology evolution and commercial potential. The generic advantage, Toyota Mirai emerges as major strengths and those are like environmental friendly nature of this energy, no emission, never ending source of hydrogen and numerous applications as potable, stationary etc.

- ## Weaknesses

The key weakness in the fuel cells technology development is the lack of focus on the development by the supplier companies especially to address the reduction of cost and material content. There have been vision deficiencies in coordination between universities, national labs, suppliers and end users. This needs to be driven better than actually happening in the industry. But the same is much better in case of Toyota and Japan. At the governmental level, the readiness and encouragement is lacking across globe though Japan provides better environment but much more need to be done.

- ## Opportunities

Opportunities for the fuel cell technology are multifold. There are significant opportunities for the developmental work in the area of material, fuel cell stack, membrane, diffusion media, catalyst and plates. These also bring sufficient business opportunities for many. As the major application is being developed for auto industry, as a natural process, the auto component companies would be one of the biggest beneficiaries. At the end the universal benefit of the planet that the world be energy independent.

- ## Threats

The biggest threat in the project of Toyota Mirai and HFC technology is the cost of material and also development in one country. As major development is taking place around US, the countries in future may not be US alone. The major threat from the consumer side is the low gasoline price in the US. Until and unless the HFC technology brings about the cost competing with the existing price of the substitutes, the consumer pull will be difficult to create. The other area of challenges is cost of fuel system, which is again dependent on material cost.

With the above analysis, in case Toyota, though they are one of the front-runners in the development of HFC technology, the commercial viability still to come in reality. Toyota is trying to be pioneer in the technology and to stay ahead in the race. Toyota Mirai will be lauchned $57.500 in the next year in California because there is a refuelling station available for public to get the hydrogen fuel filling [35].

PEST ANALYSIS

The development of Toyota Hydrogen Fuel Cell technology is essential for today's market due to the energy crisis and global warming issue. PEST analysis is a market analysis tool to consider the impact of external factors that is used to help an organization in assesses actual and future strategic contexts [36]. Therefore, understanding macro environment could help the Toyota's organization take benefits of the opportunities and reduce threats. According to this research paper, the author will discuss PEST analysis of Toyota Mirai by focusing on the State of California, which is one of the largest hydrogen fuel networks worldwide. There are now 11 hydrogen fueling stations that are already in operations and another 45 hydrogen stations are under development [37].

- ## Political Factors

  - Global warming has become one of the greatest concerns of California government in recent years. The state authority is focusing on persuading local Californian drivers to switch from conventional vehicles to non-carbon dioxide vehicles. In the Governor's Office Summit on Zero Emission vehicles, which was organized in May 2015, more than 100 mayors, city councilmembers and other local state leaders support the Governor Brown's pioneering goal to have 1.5 million clean vehicles in California's streets by 2025 [38].
  - In 2013, in order to increase air quality and tackle global warming problems, Governor Jerry Brown signed Assembly Bill 8 into law, which included a provision to give up to $20 million funding every year to support the construction of at least 100 hydrogen stations in California [39].

- According to the report on the development of fuel cell electric vehicle and hydrogen fuel station network published by California Environmental Protection Agency in June 2014, 51 new hydrogen fuel stations, which are funded by California Energy Commission, are predicted to come into operation by the end of 2015 and to produce up to 9400 kilograms of hydrogen per day [40].
- The corporate income tax in California is 8.84% that is considered as an unfavorable factor for Toyota Mirai as well as other companies [41].

Economic Factors

- In 2013, California was ranked as the world's eighth largest economy. Also, the state's GDP reached $2.2 trillion in 2013 [42]. Hence, California sounds a promising market for multinational manufacturers and corporations.
- Although California has high average household income, the unemployment rate in the state is 6.3%, which is a little bit higher than some other states in the US [43]. This means it is quite competitive to get a high-paid job in California, so switching to a new innovative car at high price is not a good option to many Californian people.
- California's purchasing power is 140.26%, which implies that Californian citizens have great ability to buy products and services [44].
- California ranked the second fastest growing state economies in the United States with a 9.5% increase in auto sales, indicating a positive tendency in the market for carmakers [45].

- ## Technology Factors

  - California is one of the most innovative states in the US. The state has 4 cities (San Diego, Santa Cruz, San Francisco, San Jose), which are among top 20 most innovative cities in America [46].
  - The State of California issued some policies, which support to foster innovation activities in the area. The local authority gives tax credit for companies and organization to increase R&D expenditures [47]. As mentioned above, the local government is willing to give funding to equip a strong hydrogen fuel station networks throughout the state.
  - According to the latest statistics published by Broadband Now, 94% of Californians use different broadband Internet services. More interestingly, 97.9% of Californian population has access to wire-line internet services and 99.7% of Californians get access to mobile broadband services, resulting in great opportunities for companies to accelerate mobile advertising strategies [48].

- ## Social Factors

  - California is the most populous state in the country.
  - California's life expectancy is 80.8 in general [49]. The figure proves that Californian locals are really concerned about life quality and health care conditions, meaning Toyota Mirai as well as other zero emission vehicles can win attention of those who strongly care about better living.
  - The annual median household income of California is approximately $60,190, which is relatively high compared to other states in America [50]. According to

Forbes, American people spend nearly 20% of their annual income on transportation on the average [51]. Toyota determines California as their target market to put on sale the majority of 3000 Toyota Mirai, which is produced for US market. Not to mention that the company offers $5000 discount for California citizens and everyone can buy by installments with $499 per month [52]. More interestingly, each Californian drives 13636 miles annually, resulting in the demand of 168 hydrogen kilos, which cost only $100 [53], [54]. Therefore, to Californian locals with high income, it sounds completely a cheap and economical option to drive with Toyota Mirai.

- Cities in California, which have high percentage of population reaching high annual income, are: San Francisco, Oakland, Fremont (13%), San Jose, Sunnyvale, Santa Clara (15.9%), Los Angeles, Long Beach, Santa Ana (7.9%) [55]. Those can be target market segment of Toyota Mirai.

COMPETITIVE STRATEGY FOR COMPETITIVE ADVANTAGE

The hybrid, electric and hydrogen powered vehicles are entering the mainstream. There are several fuel alternatives such as natural gas, propane and coal, alcohol fuels such as methanol and ethanol, and from hydrogen compounds such as ammonia or borohydride [56]. On top of that biomass, methane, landfill gas or anaerobic digester gas from wastewater treatment plants can also be used as fuel substitutes and are also treated renewable energy. Compared to every one above, hydrogen produced via electrolysis gives the cleanest fuels and can be supplied through grid, nuclear, solar, or wind power [57]. The biggest challenge today in the trial stage is who will invest the money in fueling stations. There is excitement in this space but the infrastructural readiness from government side is still missing. One nation among all the others is making their intension very clear is Japan. It appears that Japan is all set to go all out for most precious found on the earth. They believe that hydrogen is the alternative source for the future fueling. Although HFC has been doing the round over decade now in auto industry of the world, but Toyota is the first and till date is the only auto company that shown higher level of commitment. This is clear from their plan. Toyota is committed to make HCV new Mirai Sedan. This is also the first auto company that jumped behind the hybrid and electric technology. They are also first in the race to come out with commercial production plan. The company has really made a difference in competitive space in this technology. It is very apparent that Toyota has carefully managed to hedge its risk on the consumer and the market where people will move towards the sustainable fuel and HFC vehicle. The introduction of Mirai Toyota is definitely achieving a lot, as it deserves too. On the other hand, Japan government is also providing appropriate ecosystem around the HFC technology by committing to build self-service hydrogen fueling stations, a much-needed ecosystem for the HFC vehicle to popularize. The government

commitment is not limited to support the auto sector of Japan by providing self-service station. As Bloomberg says that the Japanese government is looking at hydrogen power beyond auto industry. They believe that Hydrogen power can be adopted as energy source for homes and office buildings. As a result government is increasing its investment in Hydrogen technology innovation to the tune of $9.8 billion by 2030 and $75 billion by 2050 [58]. From this, it is clear hydrogen is viewed by Japan as strong substitute to fossil fuel.

INTERNATIONAL AND GLOBAL STRATEGY ANALYSIS

Mirai is the Japanese word for "the future" that definitely stands out today in terms of potential for the future auto market and sustainable energy alternatives. This now registered for released and already started in Japan in the beginning of the year, Mirai will set a standard for a whole new class of vehicles having a 300 mile range for a full tank with the fill time of less than five minutes and a clean exhaust system gives a whole new meaning to HFC vehicles [59]. In 2016 Toyota Mirai will be the first hydrogen fuel cells car to participate in NASCAR race at the Richmond International Raceway. Toyota is considering that Mirai version will be the first global auto company and model to go in its regular course of auto business though in limited manner [60]. The biggest advantage is the major support and commitment from the Japanese government. The Mirai is a four-door mid-size sedan. The cars will be available first time in commercial market in California later this year. Toyota has finalised its plan for 2016 about the Mirai fuel cells vehicle with the fleet of customer, a strategy to make the vehicle with the commercial and government fleet users. It has launched in Japanese market by giving its first car to Japanese PM in January this year. Toyota Mirai will go on sale to Europe and US in the fall of 2015. The vehicle will be sold in north-eastern US in 2016. The tentative retail price would be

$57,000 and will be offered on a lease price of $499 per month [59]. Toyota has developed one unique plan with the Mirai to showcase by using the vehicle in the hands of potential fleet users in 2015 and will bring Mirai to its annual Toyota Fleet Executive Business Meeting each June at Ritz Carlton Laguna Niguel in southern California. Fleet attendees will be having opportunity to test drive the car. The car will be able to meet the zero emission standard mandated in California as well as New York, Massachusetts, Connecticut and Rhode Island. The vehicle will also fall in the compliance car category to help meet the requirement. As we have seen before California has started building the hydrogen fueling station and government has sanctioned $200 million from the state's energy commission. On contrary, Honda's plan for the same HFC vehicle sells is delayed to now 2016 [61].

CONCLUSION

In line with this priority, the subject is chosen for research here as "strategic management of technology" in the context of development of Toyota HFC vehicle "Mirai". With the study of strategic management of technologies, this technological innovation will achieve much better business success in real commercial world. Toyota Mirai is considered one of the best emerging vehicle with respect to sustainability that is expected to unfold big opportunity in terms of "People, Profit & Planet".

The above analysis and study provide outline of the hydrogen fuel cells Totoya Mirai technology and the brief about the technology with the benefit iin term of environment issue. The discussion was focusing mainly into the area of competitive advantage and its strategy to make the success of the technology in the emerging world. It is a belief of the Japanese that this fuel or alternative energy source will be necessary in the future.

The subject area of discussion was the strategic management of Toyota Mirai HFC technology innovation with in-depth research and discussion through Porters' Five forces, SWOT analysis, competitive advantage analysis etc. The study could attempt to provide insight how the technology innovation can be linked to strategic management area to derive maximum benefit from the technology advantage. It is clear that Toyota is racing ahead on the subject by not only readying themselves on technology front, but they started preparing the commercial production in favour of the product long before the launch. Needless to say the support and motivation from the governmental side could make whole strategy of the company around Mirai, a better success. With this Toyota Mirai will bring about the major impact in the socio-technical landscape and initiating an era of factoring decision on certain technological trajectories.

REFERENCES

[1] IPPC, Climate Change 2007: Synthesis Report Summary for Policymakers, An Assessment of the Intergovernmental Panel on Climate Change, 2007, (Valencia).

[2] N. Stern, Stern Review on the Economics of Climate Change, HM Treasury and Cabinet Office, London, 2006.

[3] UNFCCC, Copenhagen Accord, 2009, (Copenhagen).

[4] F. Geels, M. Hekkert, S. Jacobsson, The dynamics of sustainable innovation journeys, Technol. Anal. Strateg. Manage. 20/5 (2008) 521–536.

[5] G. Dosi, Technological paradigms and technological trajectories: a suggested interpretation of the determinants and directions of technical change, Res. Policy 11(1982) 147–162.

[6] R.R. Nelson, S.G. Winter, An Evolutionary Theory of Economic Change, Harvard University Press, Harvard, 1982.

[7] J. Markard, B. Truffer, Technological innovation systems and the multi-level perspective: towards an integrated framework, Res. Policy 37 (2008) 596–615.

[8] Millikin, M. (March 11, 2014). Toyota continues to prepare the market for fuel cell vehicle in 2015. *Green Car Congress*.

[9] I Ansoff, Strategic management of technology. *The Journal of Business Strategy*, 1987, 7(3), 8–39.

[11] F. Betz, *Strategic Technology Management*. USA, McGraw-Hill, 1993.

[10] K. Sahlman, *Elements of Strategic Technology Management*. University of OULU, 2010. http://herkules.oulu.fi/isbn9789514262500/isbn9789514262500.pdf.

[12] K. Sahlman & H. Haapasalo, Elements of strategic management of technology: a conceptual framework of enterprise practice. *International Journal of Management and Enterprise Development*, 2009a,7(3), 319–337.

[13] D. Teece, G. Pisano, The dynamic capabilities of firms: an introduction, Ind. Corp. Chang. 3 (1994) 537.

[14] J. Barney, Firm resources and sustained competitive advantage, J. Manag. 17 (1991) 99.

[15] J. Barney, D.J. Ketchen, M. Wright, The future of resource-based theory: revitalization or decline? J. Manag. 37 (2011) 1299–1315. doi:10.1177/0149206310391805.

[16] O. Furrer, H. Thomas, A. Goussevskaia, The structure and evolution of the strategic management field: a content analysis of 26 years of strategic management research, Int. J. Manag. Rev. 10 (2008) 1.

[17] F. Alkemade, C. Kleinschmidt, M. Hekkert, Analysing emerging innovation systems: a functions approach to foresight, Int. J. Foresight Innov. Policy 3 (2007) 139–168.

[18] J. Farla, F. Alkemade, R.A.A. Suurs, Analysis of barriers in the transition toward sustainable mobility in the Netherlands, Technol. Forecast. Soc. Chang. 77 (2010) 1260–1269.

[19] S. Negro, F. Alkemade, M. Hekkert, Why does Renewable Energy diffuses so slowly? A review of innovation system problems, Innovation Studies Utrecht (ISU)—Working Paper Series, 2011.

[20] Pervez Ghauri, *Designing and conducting case studies in international business research*. Handbook of Qualitative Research Methods for International Business. Edward Elgar: Cheltenham, UK, 2004.

[21] Toyota, "Toyota's Strategy for Environmental Technologies," [Online]. Availble: http://www.toyota-global.com/innovation/environmental_technology/strategy_environmental_tech.html

[22] H. Liu, "Value Chain Model and Analysis of New Energy Vehicle," vol. 10, p. 5503, 2013.

[23] F. Aaron, M. Gary, P. Tony, W. Grace, "Toyota Paper," *the MIT Sloan 2001 Japan/Korea Trip Toyota Team Paper,* 2001.

[24] D. Michael and S. Varley, "HYDROGEN FUEL CELLS : POWERING A NEW GENERATION OF," pp. 1–10.

[25] C. Lampton, "What are the Benefits of Hydrogen-Powered Vehicles?," *How Stuff Works*, September 2008, [Online]. Available: http://auto.howstuffworks.com/fuel-efficiency/alternative-fuels/hydrogen-vehicle-benefit2.htm.

[26] N. Bianco, K. Meek, R. Gasper, M. Obeiter, S. Forbes, and N. Aden, "Seeing is Believing: Creating a new Climate Economy in the United States," The New Climate Economy - The Global Commission on the Economy and Climate. October 2014, [Online]. http://newclimateeconomy.report/united-states/.

[27] K. Kerlin, "Will Hydrogen Cars Finally Hit the Road?" *Futurity*, August 2014, [Online]. Availble: http://www.futurity.org/hydrogen-fuel-cell-vehicles-752732/.

[28] Toyota, "Powering the future," [Online]. Availble: http://www.toyota-global.com/innovation/environmental_technology/fuelcell_vehicle/

[29] M.E. Porter, Competitive strategy techniques for analyzing industries and competitors, The Free Press, New York, 1998a.

[30] M.E. Porter, Competitive advantage creating and sustaining superior performance, The Free Press, New York, 1998b.

[31] G. Carle, K. W. Axhausen, A. Wokaun, and P. Keller, "Opportunities and Risks during the Introduction of Fuel Cell Cars," *Transport Reviews*, vol. 25, no. 6. pp. 739–760, 2005.

[32] Verzeichnis von Veröffentlichungen, Fraunhofer, Institute System and Innovation, 2000.

[33] P. P. Steinemann, "R & D Strategies for New Automotive Technologies : Insights from Fuel Cells," p. 53, 1999.

[34] Toyota US NEWSROOM, "Toyota Open the Door and Invites the Industry to the Hydrogen Future," January 2015, [Online]. Available: http://corporatenews.pressroom.toyota.com/releases/toyota+fuel+cell+patents+ces+2015.htm.

[35]. K. Reynolds, '2016 Toyota Mirai First Drive - Motor Trend', *Motor Trend Magazine*, 2015. [Online]. Available: http://www.motortrend.com/roadtests/alternative/1412_2016_toyota_mirai_first_drive/viewall.html.

[36] Williams, B., Figueiredo, J., “Strategy and technology management: An innovation-leader case study,” Technology Management Conference (ITMC), 2011 IEEE International, vol., no., pp.806-811, 27-30 June 2011

[37] South Coast AQMD,"SCAQMD Opens One of the Largest Capacity Hydrogen Fueling Stations in California," South Coast Air Quality Management district, 2015, [Online]. Available: http://www.aqmd.gov/home/library/public-information/2015-news-archives/hydrogen-station-opening.

[38] Michelle Kinman, “Over 100 Mayors, City Councilmembers and Other Local California Leaders Say “Yes” to Clean Vehicles,” 2015, [Online]. Available: http://www.environmentcalifornia.org/news/cae/over-100-mayors-city-councilmembers-and-other-local-california-leaders-say-%E2%80%9Cyes%E2%80%9D-clean.

[39] Ben Xiong, “Governor Brown Signs AB 8,” Sep 2013, [Online]. Available: http://cafcp.org/getinvolved/stayconnected/blog/governor_brown_signs_ab_8.

[40] Air Resources Board, “Annual Evaluation of Fuel Cell Electric Vehicle Deployment and Hydrogen Fuel Station Network Development,” June 2014, [Online]. Available: http://www.arb.ca.gov/msprog/zevprog/ab8/ab8_report_final_june2014.pdf.

[41] Merrill Matthews, “Four Reasons Why Toyota Will Be Looking at California In Its Rearview Mirror,” April 2014, [Online]. Available: http://www.ipi.org/ipi_issues/detail/four-reasons-why-toyota-will-be-looking-at-california-in-its-rearview-mirror.

[42]Justin Garosi and Jason Sisney, “California Is the World's Eighth Largest Economy,” Dec 2014, [Online]. Available: http://www.lao.ca.gov/LAOEconTax/Article/Detail/1.

[43] Jeanne Mejeur, “State Unemployment Rates,” May 2015, [Online]. Available: http://www.ncsl.org/research/labor-and-employment/state-unemployment-update.aspx.

[44] “Cost of Living in Los Angeles, CA, United States,” [Online]. Available: http://www.numbeo.com/cost-of-living/city_result.jsp?country=United+States&city=Los+Angeles%2C+CA.

[45] Andy Kiersz, “Here's How All 50 State Economies Are Doing,” Ranked From Slowest To Fastest, Aug 2014, [Online]. Available: http://www.businessinsider.com/state-economic-growth-rankings-2014-8?op=1.

[46] Max Nisen, “The 20 Most Innovative Cities In The US,” Feb 2013, [Online]. Available: http://www.businessinsider.com/the-20-most-innovative-cities-in-the-us-2013-2?op=1.

[47] Price water House Coopers, “Government's many roles in fostering innovation,” 2010, [Online]. Available: http://www.pwc.com/gx/en/technology/pdf/How-governments-foster-innovation.pdf.

[48] Broadbandnow, “Broadband in California,” [Online]. Available: http://broadbandnow.com/California.

[49] State Health Facts, “Life Expectancy at Birth (in years),” 2010, [Online]. Available: http://kff.org/other/state-indicator/life-expectancy/.

[50] Department of Numbers. “California Household Income,” [Online]. Available: http://www.deptofnumbers.com/income/california/.

[51] Laurence H. M. Holland and David M. Ewalt, (2006, Jul) “How Americans Make And Spend Their Money,” July 2006, [Online]. Available: http://www.forbes.com/2006/07/19/spending-income-level_cx_lh_de_0719spending.html.

[52] Kenneth Chang. (2014, Nov) “A Road Test of Alternative Fuel Visions,” November 2014, [Online]. Available: http://www.nytimes.com/2014/11/18/science/earth/hydrogen-cars-join-electric-models-in-showrooms.html?_r=0.

[53] Alan Kandel, “Annual per-capita California driving 1.5 times the national average,” February 2014, [Online]. Available: http://alankandel.scienceblog.com/2014/02/07/annual-per-capita-california-driving-1-5-times-the-national-average/.

[54] Hydrogen Energy Systems LLC, “Hydrogen Fuel Cost vs Gasoline,” 2014, [Online]. Available: http://heshydrogen.com/hydrogen-fuel-cost-vs-gasoline/.

[55] Charles Adam Bee, "The geographic concentration of High-Income Households: 2007-2011," American Community Survey Briefs, pp. 11-23, February 2013, [Online]. Available: https://www.census.gov/prod/2013pubs/acsbr11-23.pdf.

[56] The leading independent fuel cell resource, Fuel Cells 2000, Article February 2015, [Online]. Available: http://www.fuelcells.org/base.cgim? template=articles.

[57] A. Friedemann, "The Hydrogen Economy - Energy and Economic Black Hole." *Culture Change*, [Online]. Available: http://www.democraticunderground.com/discuss/duboard.php?az=view_all&address=389x521368.

[58] B. Sam, “Japan Is Betting Big on Hydrogen Vehicles,” *Auto Cheat Sheet*, January 2015, [Online]. Available: http://www.cheatsheet.com/automobiles/japan-is-betting-big-on-hydrogen-vehicles.html/?a=viewall.

[59] Auto blog, “2016 Toyota Mirai starts at $57,500, lease for $499/month with free hydrogen fuel,” November 2014, [Online]. Available: http://www.autoblog.com/2014/11/17/2016-toyota-mirai-starts-at-57-500-lease-for-499-month/.

[60] E. Stephen, “2016 Toyota Mirai First Fuel-Cell to Pace a NASCAR Race Tonight, ” *Green car report*, April 2015, [Online]. Available: http://www.greencarreports.com/news/1098001_2016-toyota-mirai-is-first-fuel-cell-car-to-pace-a-nascar-race-tonight.

[61] Automotive Fleet, “Toyota Discusses Fleet Strategy for Fuel Cell Vehicle,” November 2014, [Online]. Available: http://www.automotive-fleet.com/news/story/2014/11/toyota-discusses-fleet-strategy-for-fuel-cell-vehicle.aspx.