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A STUDY OF ALTERNATIVE FUEL VEHICLES AND ROLE OF AUTOMOBILE INNOVATIONS PERTAINING TO THE SALES OF CARS

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ABSTRACT:

There has been a remarkable amount of innovation in the automotive industry since these vehicles were first invented. almost since a decade, a significant amount of technology has been introduced into the ever evolving automobile innovation connected to alternative powered vehicles, navigation systems, and safety top the list of automotive technology improvements. Though there have been innovations to make the car a better transporting mode, many consumers yet have not adopted those innovations. Hybrid cars have been a major part of this evolution of cars. This paper enumerates the major innovations in the field of passenger cars in the previous century. It examines the role played by innovations in automobile industry on passenger car sales. Further, the paper examines the alternative fuel vehicles. It lists various factors affecting the sales of the alternative fuel vehicles. Relative cost, convenience and availability and lack of information have been found out as major factors influencing the low sales of alternative fuel vehicles.

Key Words: *Automobile, alternative fuel vehicle, hybrid car, consumer behaviour, innovation.*

INTRODUCTION

Rogers (2003) defines innovation as an ideas, objects, and methods that are perceived to be new by consumers and users. Innovation is core to any entrepreneurial venture. Any firm owes to an novelty for its establishment, at least with regards to its competitors in the business. Innovations are the key factors for the economic growth across the globe as well as a driver for competitiveness (Vives X, 2008). Innovation has turned into significant to the survival of firms and a tool to defend competitive advantage. Innovation can make it possible for firms to improve their market share, establish the prominence of their brand, move way ahead of the competition, create breakthroughs, and attract more customers (Mu et al., 2009). Yet, it is not enough to develop technologically for a sustainable development, it also means understanding the market need, having market oriented products offering improved quality and/or supported services, arrange efficiently, producing in time keeping a check on costs. Hence, innovation becomes more and more extensively stretched phenomenon and a tool.

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significant amount of technology has been introduced into the ever evolving automobile innovation connected to alternative powered vehicles, navigation systems, and safety top the list of automotive technology improvements. the automotive industry is enormously progressive, leading some in the field to assert that the car would be the most technologically superior product that most consumers will ever buy.

INNOVATIVE ATTITUDE OF CONSUMERS

As a marketing phenomenon, innovativeness can at the very least be defined as inaccurate. Organization innovativeness, or ''creation of newness,'' represents a firm's capability to develop and launch novel products at a fast rate (Hurley and Hult, 1998). Product innovativeness, or ''possession of newness,'' is the degree of newness of a product (Daneels and Kleinsmith, 2001). Consumer innovativeness, or ''consumption of newness,'' is the inclination to acquire new products more frequently and more quickly than other people (Midgley and Dowling, 1978). In this article, the word ''innovativeness'' will be used solely with reference to consumer innovativeness.

INNOVATION RESISTANCE BY CONSUMERS

Consumer's resistance to innovations is a exceptional case of general resistance to change. Resistance can broadly be defined as an aversive motivational status, initiated while single perceives that one's preference is susceptible, and directing opinion and proceedings towards retrieval the susceptible preference (Brehm 1966; Brehm and Brehm 1981). Consumer's resistance to innovations reveals itself in varied shape. The majority of the time innovation resistance occurs passively. Consumers resist innovation exclusive of intentionally allowing for acceptance for innovations. Literature differentiates numerous drives of this passive resistance towards innovations. At first, passive resistance could be a outcome of behavior (Bagozzi and Lee 1999). Sheth (1981, p.275) terms habits "the single most powerful determinant in generating resistance." A unique human tendency is to endeavour for uniformity and status quo, comparatively than to acknowledge new behaviours (Gourville 2005). This status quo nepotism leads consumers to significance the reward of products they possess more than the payback of innovative one.

The time of automobile innovation in the 20th century

Year	Innovation
1769	Cugnot builds first self-propelled road vehicle
1789	Evans is given the first automobile patent in the US
1828-1835	First Small-Scale Electric Cars
1860	Lenoir makes a car with internal combustion engine
1873	Steam engine
1876	I C Engine
1879	Diffusion: First Marcus car runs on gasoline
1885	Benz Motorwagon is the first commercially available automobile
1898-1990	World's First Hybrid Electric Car Is Invented
1902	Standard drum brakes
1908	Affordable car – Model T
1911	Electric starters
1913	Assembly lines
1918	Hydraulic brakes
1919	Single foot pedal to operate coupled brakes
1926	Power steering

Year	Innovation
1925 – 38	Turn signal
1930	Vehicle audio
1936	Anti-lock Braking System
1939	Air conditioning
1939	Auto transmission
1946	Car phone
1951	Airbags
1950s	Cruise control developed
1957	Electronic fuel injection
1959	3 point seat belt
1960s	Effort began to reduce emission
1966	Electronic fuel injection system
1987	ESC
1990	GPS and Navigation
1997	Automatic stability control

Innovation and the passenger car sales

Although hundreds of innovative products are launched each year, many lean to be nearer to in-line extensions which at maximum would convince consumers to switch brands within a product category. The word innovation makes people to think of a new product. Innovation indeed is an effective way to strategic and competitive advantage. Significant and disruptive innovation no doubt command a premium and build the category spends from the consumers which might be buying similar product category which can be termed as category expansion. However, the innovation should highly disruptive in nature to really command a sustainable demand and increase the consumer base to have a lifelong impression in that particular category. Creating absolutely new products by considering the unmet consumer needs is indeed rewarding. Similarly the automotive industry from the second half of 20th century has seen a plethora of innovations which has shaped the automobile industry we know today. Though the innovation initially were more isolated and single in nature which eventually started to have an impact on the whole car which can be seen from a systemic point of view. Innovations though were good for mankind as well for the vehicle have not always been received with open mind. There were many factors for the late acceptance of the innovation which may be either the money involved to acquire that innovation or the habits of using the well established product easily available in the market. Innovations did play an important role in increased sales of automobile across the world. The following table of shows the number of cars registered globally with reference to that particular year. The data collected is from 1960 to 2015.

Year	Car sales in Million	Reference
1960	122	(Dargay, Gately, Sommer, & Sommer, 2007)
1968	170	(Elert, n.d.)
1970	250	(John Sousanis, 2011)
1985	375	(Elert, n.d.)
1986	500	(John Sousanis, 2011)
1997	600	(Errol A. Gibbs & Philip A. Grey, 2011)
2002	812	(Dargay, Gately, Sommer, & Sommer, 2007)
2009	980	(John Sousanis, 2011)
2010	1015	(John Sousanis, 2011)
2014	1200	(Voelcker, 2014)
2015	1272	("Sales Statistics | OICA," 2016)

Table 1

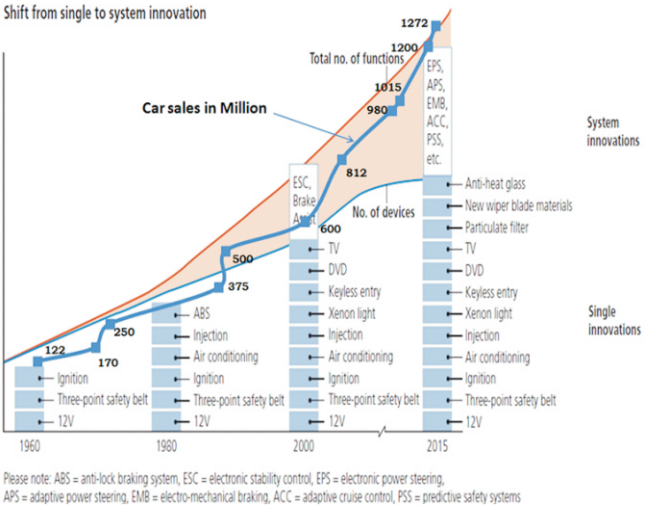


Chart 1 Source: Dannenberg & Burgard (2007)

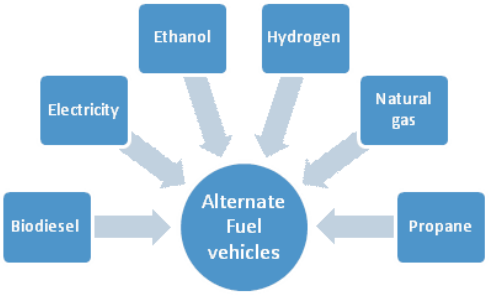
When this data of passenger cars sales compiled from various sources is superimposed on the technological roadmap given by Dannenberg & Burgard (2007) gives the clear understanding of relationship between innovation and car sales.

This chart with the sales line on it clearly shows that innovation has indeed a direct impact on case sales.

In 1960 when the cars didn't have much to offer in comparison had very little sales too. Over a period of time the sale of the cars drastically increased. Factors like safety of the passenger in the car, better comfort, a more powerful engine to drive, and hybrid engine for greener environment have lead to the boost in the sales. Consumers appreciated the entertainment available in the car may it be audio or video. However, each of these innovations has taken its own course of time to be adopted completely across the world. From 122 million cars across the world in 1960 the population of cars reached nearly 1.272 billion in 2015.

Alternative Fuel Vehicles (AFVs) and its types

An amalgamation of factors, such as ecological concerns, elevated oil prices and the prospective for peak oil, growth of cleaner option fuels and advanced power systems for cars has become a high priority for many governments and car manufacturers around the world. A rising number of people think alternative fuels will have a long-lasting responsibility in the cars and trucks of tomorrow. Such inquisitiveness has been encouraged by three important deliberations: a) alternative fuels typically have lower car emissions that contribute to smog, air pollution and global warming, b) the majority alternative fuels don't come from limited fossil-fuel resources and are sustainable, c) alternative fuels can help nations turn into more energy independent. Alternative fuels are derived from resources other than petroleum. Some are produced domestically, reducing our dependence on imported oil, and some are derived from renewable sources. Often, they produce less pollution than gasoline or diesel.



Biodiesel

Biodiesel is an alternative fuel made of renewable supply, such as soybeans or worn restaurant oil. It doesn't compose any petroleum product, but it may be mixed with diesel to produce a biodiesel mix. It can be utilized in diesel engines without any key modifications. This biodegradable is safe and creates less air pollutants in comparison with petroleum based diesel. ("Biodiesel," n.d.) Some of the advantages are that biodiesel is domestically produced from renewable resource. Most diesel engines can utilize this fuel which creates less pollution (except nitrogen) as well less greenhouse gas emissions. This fuel being degradable and non-toxic is safer to handle. However, with these all benefits, the uses of other blends of biodiesel are not yet approved by automakers. It has lesser power and fuel economy in comparison with conventional engines. It also is more expensive as of now. It is not generally used in areas with low temperature. (Consumerreports.org, 2014)

Electricity:

An electric car is a car that comprises an electric motor. The vehicle either runs on electric motor solely or in combination with some other fuel type engine. Plug-in hybrids put forward either a petrol or diesel engine along with an electric motor: the electrical motor is motorized by a battery which can be recharged by plugging in. Some plug-in hybrids have much bigger batteries and thus run on electricity much more of the time. Some are set up such that the gasoline engine kicks in with strong acceleration or at high speeds, while others only really use it when the batteries run out. Pure electrical vehicles (EVs) can produce power from a variety of energy sources, including oil, coal, nuclear energy, hydropower, natural gas, wind energy, solar energy, and stored hydrogen (USDE, 2016). These vehicles can be seen with potential for excellent fuel economy, run on existing gasoline supplies, and drive just like regular cars, requiring no change in lifestyle habits. They run quite with instant torque from the electric motor. It doesn't emit and the cost per kilometre is a fraction of that for a petrol-powered car. There are enough electric infrastructures across the world. There are some drawbacks of these vehicles too. Some hybrids cost much more than similar conventional cars. Some don't live up to the gas mileage buyers may expect, especially considering the extra purchase price. On a mass scale, they are considered too

little, too late, but big savings mean we'll see lots more of them. They take a lot of time for recharge and can travel lesser distance with each charging. The batteries fitted as costlier. Looking at environmental factor, most of the countries produce electricity using coal which is not a clean burning source. There are not many public charging points and owning a home charging point is a costly affair. (Consumerreports.org, 2014)

Ethanol

Ethanol is a renewable, domestically produced alcohol fuel made from plant material, such as corn, sugar cane, or grasses. Using ethanol can reduce oil dependence and greenhouse gas (GHG) emissions. The use of ethanol is widespread, and approximately 97% of gasoline in the U.S. contains some ethanol ("Ethanol," n.d.). Ethanol contains about one-third less energy than gasoline. So, vehicles will typically go 3% to 5% fewer miles per gallon than on 100% gasoline ("Ethanol," n.d ., USDE, 2016). Ethanol reduces the demand of foreign oil dependency. It is a better quality fuel with high octane and potentially can be produced from waste material. The carbon dioxide released when ethanol is burned is balanced by the carbon dioxide captured when the crops are grown to make ethanol. This differs from petroleum, which is made from plants that grew millions of years ago(USDE, 2016a). Some of the disadvantages of the ethanol are that twenty-five percent lower fuel economy on E85 than gasoline. Ethanol made from any food crop can adversely affect food prices. Farm equipment involved in crop production runs on petroleum, limiting the net benefits (Consumerreports.org, 2014).

Hydrogen

Hydrogen (H2) is being experimented as a fuel for cars. It can be used in fuel cells to power electric motors or used in internal combustion engines (ICEs). It is an ecologically friendly fuel that has the potential to considerably decrease our reliance on imported fuel, but quite a few important difficulties must be overcome prior to it can be extensively utilised. Hydrogen can be produced domestically from numerous sources, dipping our reliance on petroleum imports. Hydrogen generates no air pollutants or greenhouse gases when used in fuel cells; it generates only nitrogen oxides (NOx) when used in ICEs. However, Fuel cell vehicles (FCVs), which run on hydrogen, are at present more high-priced than conventional vehicles, and they are not yet accessible for sale to the common public. Hydrogen contains much less energy than gasoline or diesel on a per-volume basis, making it difficult to store enough hydrogen onboard an FCV to go as far as a comparable gasoline vehicle between fillips (fueleconomy.gov, n.d.).

Natural gas

Natural gas is an odourless, gaseous mixture of hydrocarbons—predominantly methane (CH4). It accounts for about a quarter of the energy used in the United States. About one-third goes to residential and commercial uses, such as heating and cooking; one-third to industrial uses; and one-third to electric power production. Although natural gas is a proven, reliable alternative fuel that has long been used to power natural gas vehicles, only about one-tenth of 1% is used for transportation fuel.

Two forms of natural gas are currently used in vehicles: compressed natural gas (CNG) and liquefied natural gas (LNG). Both are domestically produced, relatively low priced, and commercially available. CNG is produced by compressing natural gas to less than 1% of its volume at standard atmospheric pressure. To provide adequate driving range, CNG is stored onboard a vehicle in a compressed gaseous state within cylinders at a pressure of 3,000 to 3,600 pounds per square inch. CNG is used in light-, medium-, and heavy-duty applications. A CNG-powered vehicle gets about the same fuel economy as a conventional gasoline vehicle on a GGE basis. Liquefied natural gas, or LNG, is natural gas in its liquid form. LNG is produced by purifying natural gas and super-cooling it to -260°F to turn it into a liquid. During the process known as liquefaction, natural gas is cooled below its boiling point, removing most of the compounds found in the fuel ("Alternative Fuels Data Center: Natural Gas Fuel Basics," n.d.).

Propane

Propane is also known as liquefied petroleum gas (LPG) or propane autogas, propane is a clean-burning, high-energy alternative fuel that's been used for decades to power light-, medium- and heavy-duty propane vehicles (USDE Propane, 2016). Liquefied Petroleum Gas (LPG), is produced as part of natural gas processing and crude oil refining. In natural gas processing, the heavier hydrocarbons that naturally accompany natural gas, such as LPG, butane, ethane, and pentane, are removed prior to the natural gas entering the pipeline distribution

system. (consumerenergycentre.org, 2016)

Use of propane can result in lower vehicle maintenance costs, lower emissions, and fuel costs savings when compared to conventional gasoline and diesel. These are less expensive than gasoline and potentially lower toxic, carbon dioxide (CO2), carbon monoxide (CO), and nonmethane hydrocarbon (NMHC) (fueleconomy.gov Propane, 2016). The limited availability is the big drawback of this fuel. It is less readily available than gasoline & diesel. It also ends up with fewer miles on a tank of fuel.

Context of Alternative Fuels

-1893 First fuel cell, which combines hydrogen and oxygen to create electricity invented.
-1900 Diesel engine that can run on peanut oil invented.
-1925 Henry Ford tells the New York Times that ethanol is "the fuel of the future." Ford's Model T was originally designed to run on gasoline, ethanol or any combination of the two.
-1940-90 America's oil use triples. Two-thirds of that growth is attributed to the widespread use of gasoline-powered cars.
-1996 GM introduces the EV1, the first mass-produced electric car, for lease in California and Nevada.
-1997 Toyota introduces the Prius in Japan. The Prius has gone on to become the best-selling gas-electric hybrid in the world.
-1999 Arizona, California, Nevada and Utah work to create biodiesel filling stations for trucks.
-2003 President George W. Bush announces the Hydrogen Fuel Initiative, which has dedicated over $1 billion to hydrogen fuel cell research.
-2008 Honda and Chevorlet introduce hydrogen fuel cell vehicle to lessees((“wiki-land - Alternative Fuels,” n.d.)

Factors affecting the sales of AFVs

Despite the advantages of AFVs, there are noteworthy barriers to their expanded use. The issues and challenges connected with the use of AFVs are shared to some degree by most, if not all, AFVs.

DVRPC (2011) identified the relative cost, convenience and availability of AFVs when compared to conventional petroleum based internal combustion engines. The relative cost, convenience, and availability of alternative fuel vehicles compared to traditional petroleum-based internal combustion technology. The enlargement of supply, storage space, and refuelling/charging centres is also one of the major barriers as not many nations are very keen to invest in this infrastructure. Energy storage is an issue too which could hamper the growth of AFVs.

T. Stephens (2013) lists some of the non-cost barriers for adoption of AFVs and they are as follows:

• Inadequate car range. This results in range anxiety, thereby limiting vehicle travel options and thus vehicle utility, especially if the fuel (or electricity) is not readily available.
• Inadequate availability of fueling or charging centres. This enhances range anxiety.
• Long fueling or charging times. This is particularly significant if the car range is inadequate or if fuel or electricity is not widely obtainable.
• inadequate availability/number/variety of models. This slows down purchasing a car with a new technology even when it is wanted because it’s not accessible with other desired features.
• Lack of information on or unfamiliarity with new cars or their refueling systems. This generates ambiguity about future expenses, profit, reliability, ease, and/or necessary adaptations. Contributing to this are (1) untrustworthy sources of information (e.g., car dealerships) that may filter information accessible to clients or may be seen as suspect or undependable sources by clients, (2) ambiguity regarding future fuel prices, (3) ambiguity about the car’s life span.
• Less tangible factors influencing consumer vehicle choice behavior. These include perceived differences in performance, safety, or other attributes, as well as connotations or associations that result in a predisposition for or a dislike of certain vehicle types.
• Lack of standardization/codes. This creates vagueness concerning the technology’s compatibility with the accessible charging/refueling infrastructure and may lead to safety concerns.
• Rules that may limit operations. These are pertinent for some option fuel vehicles. These rules (e.g., tunnel restrictions) may confine the places where cars can be driven.

Alternative Fuels Industry is increasing consciousness of diverse fuels and their advantages. The majority of the public is not exposed to alternative fuels on a usual basis and consequently is cautious to consider in its competence and security. Some of the other barriers to the acceptance of alternative fuels comprise cost of the fuel, car purchase or modification cost, storage ability, insufficient subsidies, accessibility of competent technicians, a apparent decrease in comfort, and concerns about the ecological impacts of producing alternative fuels. ("Barriers & Incentives for Alternative Fuels - BIAF.pdf," n.d.)

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