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Green Car Manufacturing and Stock Market Performance

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Abstract: The quest for sustainable economic development alternatives is revolutionising the automobile industry toward a more economic and sustainable products. This paper examines the relationship between green (electric) vehicle products and stock market performance. The prior work inclination is on the innovation and diffusion theories, which provides a lens to examine green innovation in auto industry. The paper adopts a fusion of review and quantitative approach. Data were from the International Energy Agency and Investing databases. A fixed effect panel analysis examine how the stock market reacts to two main types of electric vehicles – the Battery Electric Vehicle (BEV) and Plug-in Hybrid Electric Vehicle (PHEV). The result adds to new knowledge namely, the BEV product relates to the stock market significantly at P=0.00002 but negatively. However, the PHEV has a positive and significant relationship with the stock market at a P=0.00001. The results offer practical implications including inter alia, manufacturers' introduction of more PHEV products into the consumer market has a high propensity to improve the stock market performance; this provides a useful information for stock market analysis and auto industry strategic planning. It also offers a good innovation case material for business schools. This paper contributes the first modelling of two main types of green car on stock market performance.

Keywords: Electric car sales; stock market price; large economies; green economy

JEL Classification: M21; M2; G1; O31

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1. Introduction

The automobile manufacturing industry continues to experience enormous pressures to change. Some of these pressures are as a consequence of low and variable financial performance because the industry embodies a mature technology in a market that has reached maturity and has become more competitive (Orsato & Wells, 2007). The industry also continues to experience increasing demand from customers, governments and global communities to reduce large amounts of greenhouse gas emitted from road vehicles (Whitmarsh & Kohler, 2010). Responding to these current challenges and pressures the automobile industry has in recent years focused on the incremental development and improvement of the energy efficient compulsion engines to the green cars. The green cars are referred to as "vehicles that use alternative fuels (other than petrol or diesel) and/or alternative types of propulsion (other than the conventional internal combustion engines). Alternative fuels include biofuels, natural gas, hydrogen and electricity from the grid. Alternative propulsion systems include hybrid and electric engines"(Beltramello , 2012, p. 10). The development and transition to new car technologies are influenced by factors such as global warming and it has become inevitable that the adoption of new green car innovation is no longer an option. All major car manufacturers are becoming active in the development of particularly one technology, that is, the electric drive car with various types such as hybrid internal combustion engine (ICE) and battery cars, the plug-in hybrids with batteries that can be recharged from the electricity grid, or pure battery electric vehicles (Riley, 2019).

Literature has indicated that there are systematic barriers and market failures that constrain accelerated development and diffusion of green vehicles. These barriers include (1) inertia – which is the resistance to change attitude and slow tendency to adopt economic, human and physical systems. (2) Network externalities that may contribute to inertia in the development and diffusion of green cars. For example, a customer may be reluctant to purchase a green car influenced by uncertainties such as the deployment of recharging and refuelling infrastructure that may not be extended further enough to cover and meet transport needs. Sceptics and critics continue to be doubtful whether the newly innovative green vehicles currently introduced in the market place will ever meet the needs of the customers and have an influence to the stock market performance. Hence, the purpose of this paper that assesses how the potential adoption of the innovative green cars has an effect on the stock market performance. Prior research studies show that green orientation is not purely altruistic, however it can be a profitable endeavour for sustainable business growth and may impact on the stock market performance. This paper makes a contribution to existing research by engaging on how adoption of green orientation has an effect to business performance.

1.1. Problem of Paper

Electric vehicles are innovation by car producers in direct response to global demand for green cars to assist with carbon reduction. There are two main brands of electric vehicles, namely the Battery Electric Vehicles (BEV) and Plug-In Hybrid Electric Vehicles (PHEV). Both the producers and inventors need to know which of these brands yield the highest impact on stock market to align product diversities with market demand. Thus far, no existing research has provided distinctive research information regarding which of these electric car brands yield a better impact on stock market. An attempt by Younis et al (2020)to investigate stock market impact of electric cars on stock markets yielded inconclusive results. This therefore constitute a knowledge gap in the prevailing research. Accordingly, this paper bridges this existing gap in knowledge.

1.2. Objective of Paper

Therefore, the aim of this paper is to understand if the production and sale of a combination of two genres of electric cars (BEV and PHEV) has an effect on the stock market price performance in four major economies (USA, China, Japan, and Germany). The paper will thus extent previous research and provides information for the industry and stock markets regarding which brand of electric cars (or both) provide a significant impact on stock markets when jointly examined.

2. Theoretical Framework

2.1. Diffusion Theory on Innovation Theory

Diffusion of innovation is referred to as “the process by which an innovation is communicated through certain channels over time among the members of a social system” (Rogers, 1962, p. 150). The initiator of the model of diffusion was Rogers (2003) who indicates that the diffusion process comprises four essential elements. These elements include innovation, the social system that is affected by innovation, channels of communication in that social system and also time. The theory is regarded as a critical and valuable change model that is presented to guide technological innovation. It became valuable in communicating how a new idea and/or product (innovation) is accepted and spreads (diffuses) through a social system. It is through the diffusion process that the population becomes part of the social system that adopts a new idea, behaviour or a new product. It is thus vital to understand it considering that a new idea or new innovative product that is developed affect a number of stakeholders including, individuals, organisations, industry sectors and many other countries disregarding the type and form of the innovation (Chang, 2010). Rogers’ theory provides a context to understand the extent of

innovation and the propelling forces that influence acceleration of the rate of adoption that affect business performance. While Rogers' model is considered to be classic and broadly established, Bass (1969) identified various limitations concerning its predictive power that is linked to the dissemination of innovation. As a consequence Frank Bass proposed the Bass model to describe the adoption of new products as it relates to the interaction between early adopters and those regarded as the potential adopters. He explained that the number of adopters at a specific time period is almost similar to the sales figures measured during the diffusion process (Chang, 2010). Expressed differently, the number of adoptions achieved during a specific time period may be regarded as a representation for sales that relates to performance of a company. The Bass model was further refined and applied in various fields and used as forecast innovation diffusion tool (Mahajan, Muller & Bass, 1990).

2.2. Path Dependence Theory

This paper is also inclined on the path dependence theory propagated by W.B. Arthur and various other colleagues during the 1970s and also early 1980s (Arthur et al., 1987). The work of Arthur and Paul David in particular relied on the results from various historical studies such as the typewriter, electrical light and many others indicating that the technological trajectories of firms and industries explains the economic and technological change. Their view state that technological change is path dependent because it evolves from the previous and earlier technological development. Also it is critical to transit to the current path dependent models, while assessing the forces that are influencing changes in the rate and direction of technical change. The technological advancement that drives and restricts the direction of firm and industry development can generally be explained by the economic inducements, technical limitations and organisational constraints. The technological advancement creates a path which influence industries to innovate the functional performance of a technology (Dosi, 1982). In this regard the transition from the conventional ICE vehicle developed from the end of the 18th century to the current all electric vehicle (AEV) is particularly a dramatic change. There is a growing global move by scientists to research on the use of renewable energy systems in the automotive industry due to ongoing depletion of crude oil based energy resources and their negative impact to the environment (Wilberforce *et al.*, 2017). Thus the environmental global concerns of global warming, now contribute towards rapid transition to green cars.

3. Literature Review

3.1. Green car Innovation and the Environment

The transition from steam powered to ICE in the early 1900 revolutionised the road transport industry (Baki *et al.*, 2004). While the invention of ICE cannot be attributed to one individual, literature tend to honour the German engineers and inventors Karl Benz and Gottlieb Daimler as the pioneer contributors to the petrol-engine vehicles. Environmentalist attributes petrol-engine vehicle innovation with high levels of emission of greenhouse gasses to the environment contributing to global warming. Projections indicate that there are about 1.4 billion to reach 2 billion vehicles by 2025 and will continue to contribute high levels of carbon monoxide pollution (Voelcker, 2021). The US Environmental Protection Agency (EPA) (2020) reports that the USA transportation sector alone accounts for (28%) which is the largest portion of total United States greenhouse gas (GHG) in 2018. While within the sector, light-duty and medium and heavy-duty trucks vehicles contributed 82% and passenger cars and light-duty trucks were by far the largest category with 59% of GHG emissions. In the European Union countries cars account for around 12% of total of carbon dioxide (CO2) - the main greenhouse gas (European Union, 2021). Currently the major car manufacturers are in a race to develop zero-emission vehicles and as such committing large amounts of research and development funds to electric vehicles (EV) development. For example, Volkswagen (VLKPF) plans to launch 70% pure electric vehicles by 2030, General Motors (GM) hopes to market their only zero emission vehicles by 2035 while Ford by 2030 (Isidore, 2021, Ford, 2021). The transition to green car is bound to have an impact to the financial performance of the manufacturers.

3.2. Green Innovation in the Car Manufacturing Industry and Stock Market Performance

Empirical evidence indicate that there is a relationship between stock prices and successful innovation having a positive impact on high stock returns (Dindaroglu & Takim, 2013;Grieco, 2018). While some studies indicate that the impact of the implementation of green orientation on stock market performance is still inconclusive (Younis *et al.* 2020). OECD (2012) as well as Hsieh, Pan and Green (2020) indicate that "the market outlook for green cars is uncertain", citing that the development of the green cars is still faced with a number of daunting challenges slowing down the fast development of the market. Some of these constraining factors include; high vehicle price when compared to the conventional petrol and diesel cars, supporting refuelling/charging infrastructure and restrictive driving range (Beltramello, 2012). Further, conventional engines (diesel and petrol fuel) are increasingly achieving much fuel efficiency such that the gap of CO2 emissions of

conventional vehicles compared to the green cars (hybrid and plug-in hybrid electric vehicles) is becoming narrower (EPA, 2021). This phenomenon creates uncertainties in predicting future technology trajectory which has critical implications for car makers' strategies and for governments. The uncertainties impact on the green car manufacturers' projections on profitability and stock market performance. The McKinsey of 2019, indicates that electric vehicles (EV) are considered more costlier to produce, and consumers have limited willingness to pay a premium for EVs (Baik *et al.*, 2019). Further, "the result: apart from a few premium models, original equipment manufacturers (OEMs) stand to lose money on almost every EV sold, which is clearly unsustainable"(Baik *et al.*, 2019, p. 5).

A recent study conducted by Irawan *et al.* (2018) in Indonesia indicates that 81.22% of the car customers reject to purchase a hybrid car. It is projected that the hybrid car market share will only reach .58% during the next decade. While the global EV sales are projected to reach 12 million vehicles in 2025 and increase on average by 21% per year to about 23 million in 2030 (Voelcker, 2014). The projected growth appears to be miniscule compared to that of conventional petrol and diesel cars. Unless the governments incentive the purchasing of the (green cars) EV in particular, the growth of this market will in no uncertain terms affect the stock market performance of the green car manufacturers investing in the research and development to develop eco-friendly vehicles. The plug-in electric vehicles market penetration projection remains uncertain since it is considered to be an emerging technology that is still highly affected by changing government policies (Hsieh, Pan and Green, 2020). Conversely, some studies indicate that the adoption of green orientation by manufacturing companies does not only improve environmental and economic performance however also the general organisational performance (Green et al., 2012). For example, in 2020 Tesla the electric car manufacturer reported its first full year profit of US$721 million since it was founded in 2003 (Boudette, 2021). The profits earned were attributed to the rising sales in China, Europe and the United States. McPeak and Guo (2014) conducted a five year study from 2009 - 2013 comparing annual stock return performance between the automotive industry and consumer goods companies that have adopted a "go green" orientation. The study revealed that if an investor would have held a stock portfolio of the 10 automakers understudy from Dow Jones Sustainability Index (DJSI), except in 2011, the investor would have gained much more stock returns when compared to holding a stock portfolio of consumer goods companies. Further, if the investor would have only purchased Tesla stock, the investor would have achieved better return of stock than any other automaker in 2011 (ibd). The 2020 report indicated that Telsa shares outperformed all other major stocks by a wide margin in 2019, rising 743% making it to become one of the USA companies highly valued in the world(Isidore, 2021)**.**British Broadcasting Corporation (BBC) (2020) indicates that Tesla's share price is rising and Tesla has overtaken its rival Toyota to become the most valuable

automotive company in the world. Nio Limited a Chinese Tesla rival also reported great success in 2020. The company's share price increased from $3.24 during early 2020 to achieve a high of $50 at the end of the same year (Cision, 2020; Isidore, 2021**).** Notably, the transition to EV in particular appears to be steadily gaining traction in the international green car market and it is projected that they will outsell the traditional petrol and diesel cars by 2040. China which is one of the fastest growing economies in the world is fast transitioning to the alternative fuel vehicles – plug in electric vehicles (PEV). The PEV include the pure battery vehicles (BEVs) and plug-in hybrid vehicles. Kandi Technologies Group Inc., Li Auto Inc., NIO Inc. are some of the Chinese largely pure-play electric vehicle manufacturers. The Chinese government is also playing an important role in providing some incentives for this change. It is estimated that the PEV will account to 21% - 37% of the private passenger vehicle passenger market in 2025 – 2030 respectively. In the USA the Biden administration is prioritising a national electric vehicle national network under the US$ 2 trillion bill projecting to install 500 000 devices by 2030 (Wayland, 2021).

4. Method

Given the type of variables that apply to this paper, namely electric vehicle sales and stock market price index, the paper applied a relational analysis. The research data were on electric vehicle sales for four major world economies being USA, China, Japan, and Germany. The authors collected data on quantity of electric car sales from the International Energy Agency, and data for stock market price were from the Investing database. In order to accommodate the years that has experienced a boost in electric cars, the authors collected data for a period of ten years covering 2011 to 2020. Furthermore, since the research examined four major economies, it was pertinent to apply a panel data approach as these countries provide four cross-sectional units. Therefore, a ten-year time series by four cross-sectional units amount to forty observations. The notable advantage of fixed effect panel-data regression is that it enables time-specific or individual effects to have a correlation with the explanatory variables, in doing so; it becomes needles for the researcher to investigate the variables patterns of correlation (Hsiao, 2007). Given the absence of prior research examining exactly stock market relation with a combined two electric car types, this paper provides the first modelling of Battery Electric Vehicle (BEV) and Plug-in Hybrid Electric Vehicle (PHEV) interaction with the stock market price index. Hence, the paper used the following analysis model:

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \varepsilon$$

Where: Y = stock market price

α = intercept

β_1. β_2 = regression coefficients

X_1 = Battery Electric Vehicle (BEV)

X_2 = Plug-in Hybrid Electric Vehicle (PHEV)

5. Results

Table 1 provides the results of the panel data fixed effect between Battery Electric Vehicle (BEV), Plug-in Hybrid Electric Vehicle (PHEV) and stock market price of four large world economies (USA, China, Japan and Germany). The results bridge a gap in existing literature given that this is the first finding that relates to a combination of four large global economies and portends electric car business implication for these countries. Closely, the results show two divergent outcomes – namely the Battery Electric V ehicle (BEV) is significantly but negatively related to stock market price for these countries at a P value of 0.00002 with a negative coefficient of -0.00472642. On the other hand, the Plug-in Hybrid Electric Vehicle (PHEV) significantly and positively relates to stock market price of these countries – this implies that increase in PHEV sales and usage drives a positive stock price performance with a P-value of 0.00001 and with a positive regression coefficient of 0.0171737. Figure 1 shows a pictorial view of how closely the variables are related. The findings of this paper supports previous research, which finds that successful product innovation may have a positive impact on stock price (Dindaroglu & Takim, 2013;Grieco, 2018). Furthermore, the findings of this paper clarifies and extends previous research findings which found that green cars have an inconclusive result on stock market performance (Younis *et al.*, 2020).

Table 1. Model 1: Fixed-Effects, using 40 Observations Included 4 Cross-Sectional Units Time-Series Length = 10 Dependent Variable: Stock-Price

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	5298,32	272,416	19,4494	<0,00001	***
BEV	-0,00472642	0,000961588	-4,9152	0,00002	***
PHEV	0,0171737	0,00288776	5,9471	<0,00001	***

Mean dependent var	6540,905	S.D. dependent var	4662,284
Sum squared resid	47188134	S.E. of regression	1178,086
R-squared	0,944336	Adjusted R-squared	0,936151
F(5, 34)	115,3626	P-value(F)	2,56e-20
Log-likelihood	-336,3730	Akaike criterion	684,7460
Schwarz criterion	694,8793	Hannan-Quinn	688,4099
rho	0,455051	Durbin-Watson	1,015138

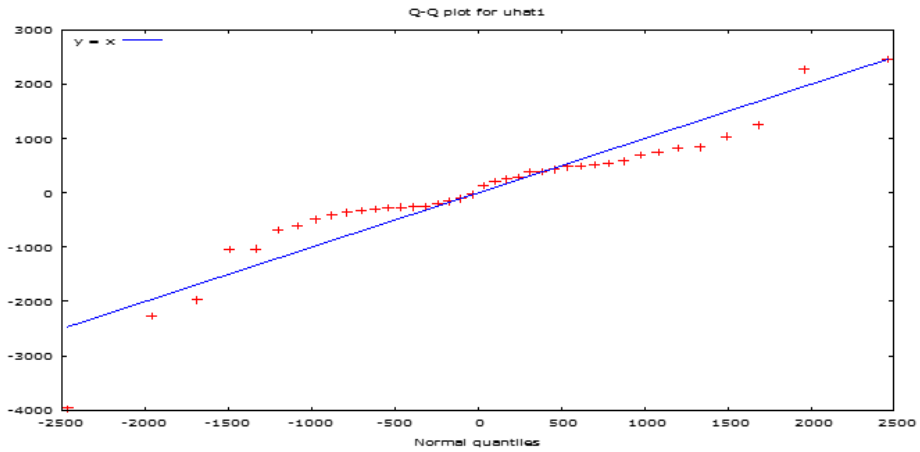

Figure 1. Q-Q Plots Indicating Close Relationships

5.1. Implication

Manufacturers' introduction of more Plug-In Hybrid Electric Vehicles (PHEV) products into the consumer market has a high propensity to improve the stock market performance. However, the introduction of more Battery Electric Vehicles (BEV) product into the market has a degree of propensity to reduce stock performance. This indicates that the consumers and the stock market welcome the hybrid electric vehicle as it has a combination of both gasoline and electric battery usage options open to the users. However, the market is negative to the Battery Electric Vehicle (BEV) as it contains only electric batter usage option – users may be stuck if they run out of battery power distance away from charging stations. However, users of PHEV option can convert to gasoline when they run out of battery power. This is a practical information for stock analysts to be able to forecast likely impact of more electric vehicles into the stock market. It is also useful for automakers in their strategic planning to balance their economic gains with sustainable product alternatives. This paper provides a good case study material for university business schools on economic implications green car innovation; it also provides an avenue for future research to expand the study in other global stock markets and to add other brands of green cars as they emerge.

5.2. Value

This paper provides the first modelling of relationship two electric car types (BEV, PHEV) and stock market performance using the four world largest economies – USA, China, Japan, and Germany. It therefore makes an original contribution to the literature, practice, and education regarding the economics of green cars; it is therefore a first platform for future models to emerge.

6. Conclusion

Literature evidence does show that there is little research on the economic implications of green cars, popularly referred to as electric vehicles – particularly the stock market implication relating to how the two major types of electric cars Battery Electric Vehicles (BEV) and Plug-In Hybrid Electric Vehicles (PHEV). This paper thus bridges apparent gap in this important area of research. Hence, the aim of this paper is to understand if a boost in a combination of two types of electric cars provides an impact on the stock market performance. This paper derives from a problem created by earlier researchers that found no or inclusive results between electric vehicle and stock market. In addition, the paper is pertinent as it dwells on a very current business, economic and sustainable phenomenon, which green (electric) car production and usage, which assists in global carbon reduction. Therefore, findings from this research may possess the impetus to ignite investors toward choosing the electric vehicle type that would best grow their stock market investments. Based on the foregoing findings, industries and investors are made aware of which genre of electric car to invest, the stock analyst and speculators also benefit from this paper is provides additional important information for stock price speculations, planning and stock investment decisions. This paper provides important agenda for future researchers to expand this research by studying how electric vehicles affects other countries' stock market. The findings also provide important study case for university business schools in green business, green finance, economic classes, and projects.

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