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A comparative study of hype cycles among actors within the socio-technical system: With a focus on the case study of hybrid cars

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ABSTRACT

Many forms of technology cycle models have been developed and utilized to identify emergent technologies and forecast social changes, and among these, the technology hype cycle introduced by Gartner has become established as an effective method widely utilized in the field. However, if the hype cycle indeed exists in the various dimensions that constitute the socio-technical system, those who seek to analyze innovative activities using bibliometrics will be confronted with the new problem of actors' choices and the need to analyze their hype cycles. In seeking to overcome such limitations of conventional studies, this paper analyzes the hype cycles of three actors that constitute the core of the socio-technical system through the case study of the successful market entry of hybrid cars. The hype cycle of the user, the first actor, is analyzed based on the search traffic generated by their web searches, and the hype cycle of the producer or researcher, the second actor, is measured based on the data regarding patent applications. Lastly, the hype cycle of the information distributor, namely individuals constituting the market network, is analyzed by examining the exposure in news reports. The outcomes of this research showed that among the three actors, the consumers and the information distributors exhibited hype cycle patterns (bell curves) that were distinct from the market trend, and that there was a difference in time interval of around five quarters. By contrast, it was found that the hype cycle of the producers reflected a logical response, exhibiting a pattern similar to the S-curve during the market's growth period unlike the pattern found in other actors. In conclusion, this study of the particular case of hybrid cars confirmed that the two components of the hype cycle can be respectively verified using consumer search traffic and the patent applications made by the producers. If in the future, such analyses of the hype cycles of producers and consumers are expanded in application to various other industries, it will be possible to obtain more generalizable research outcomes. This is expected to contribute to determining technological life cycles or hype cycles with greater objectivity and efficacy, and furthermore to facilitate the systematic identification of promising technologies.

1. Introduction

Various forms of technology cycle models have been developed and utilized for the purpose of identifying new and convergent technologies at an early stage and of forecasting social change, in various academic fields such as management, marketing, technology management, science and technology policy development, etc. Recently, corresponding to the development of bibliometrics, there have been particularly active attempts to analyze life cycles through a quantitative analytical approach and to utilize the results in forecasting [4,5]. Among these technology cycle models, the hype cycle model has received the most notable attention for its superior explanatory power. The hype cycle model was developed by Jackie Fenn of Gartner to express the level of the technology's maturity and the degree of its adoption and commercialization, and has become an effective method that is widely used not only by Gartner but

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also in various other fields. However, in spite of the wide popularity of this model, the currently existing research literature has tended to neglect examining the main actors of the hype cycle.

It should also be noted that conventional empirical research on hype cycles has failed to provide a comparative study of the actors in the hype cycle. For this reason, this paper approaches the hype cycle as arising from the three types of actors that compose the socio-technical system [11]. The most distinguishing factor, namely the users' hype cycle, is analyzed based on the search traffic generated by their web searches, while the hype cycle of the producers (or researchers) who constitute the second actor is measured based on patent applications. Lastly, the hype cycle of the information distributors, namely the individuals who compose the market network, is analyzed through the exposure in news reports.

Selecting an appropriate subject for case study is critically important for proper analysis, and the target subject selected for this analysis must specifically be amenable to measurements of both the bubble stage (excessive increase in expectation) and the disillusionment stage (decline in expectation) which characterize the hype cycle. In other words, to examine the hype cycle, it is imperative to select a technology that requires a relatively long period to reach the growth stage following the initial stage of its introduction, and technologies which have only recently entered into its growth stage are particularly helpful in facilitating measurements. In the U.S. market, the case of hybrid automobiles was determined to satisfy these conditions. This paper analyzes the hype cycles of three actors in regard to hybrid cars in the United States, and interprets the results in linkage with the conventional product life cycle or consumer adoption models, thereby empirically demonstrating that hype cycles exist in multiple dimensions. The outcome of this research is expected to make major contributions to the utilization of hype cycles, life cycles and consumer behavior models in various efforts to analyze and forecast markets and technologies hereafter.

2. Theoretical background and preceding studies

2.1. Theoretical background

The technology hype cycle model is a model that can be implemented to explain users' expectations that differ from the conventional life cycle, which reflects users' purchasing behavior. Jun [16] has already demonstrated that this model can be empirically verified based on search traffic patterns. The socio-technical model provides a useful frame for explaining technological innovations and adoption with the inclusion of consumers, rectifying the problematic neglect of consumers that occurred in the past when technological innovation processes were presented with an exclusive focus on producers or researchers. This model also provides the basis for selecting the actors meriting attention in the adoption of new technologies and the significance of these actors within the adoption system. The major theoretical backgrounds to this study are briefly outlined in the following.

2.1.1. Technology hype cycle model

While the conventional product life cycle (or technology life cycle) constitutes a producer-oriented and outcome-oriented approach in that this cycle seeks to explain indices related to the producer such as sales, sales revenues, and operating profits, etc., by contrast, the hype cycle (or attention cycle) model is an approach that focuses more on the consumers and procedural aspects.

In general, when a new technology has been introduced, the Technology Hype Cycle Model is used to explain the process by which the expectations regarding that technology evolves and the process by which the technology becomes established in the market and utilized by companies. The phase-by-phase technology hype cycle presented in Fig. 1 yields the following observations. The Technology Trigger phase (i.e., the technology generation phase, or the incipient phase) is when the technology commodity emerges driven by the potential of the technology. In this phase, however, though the technology receives attention from the media, it may appear to be deficient in merchandising potential or it may fail to become commercialized. The Peak of Inflated Expectations phase (bubble phase) is the period of heightening interest when numerous initial success stories are publicized but not many companies participate. The media tend to report unrealistic and excessive market forecasts regarding the technological success. The Trough of Disillusionment (the disillusionment phase) is the phase when the hype rapidly declines due to falling interest regarding the results of the experiment or due to the failure of commercialization, and this is the phase in which the technology must be developed into a commodity that can satisfy early adopters if it is to secure continued investment. This is a period of realistic re-adjustment marked by a rapidly declining curve, and the media lose interest in providing coverage other than expressions of suspicion regarding the technology. The Slope of Enlightenment (the stabilization phase) is the phase in which a wider understanding can be gained regarding the specific means by which the technology in question will generate profit, and sometimes a second or third generation version that represents an improvement over the initial commodity makes an appearance. This is the phase in which conservative companies remain cautiously attentive to how the technology will proceed. The Plateau of Productivity (growth phase) is the phase in which the commercial viability is recognized, and advancement into a broad market for the technology in question can take place (www.gartner.com).

One characteristic that distinguishes the hype cycle in comparison to the life cycle is that when a new technology emerges and is evaluated to have potential for applicability (Technology Trigger), the expectations of the market and the consumers regarding the new technology rapidly rise and reach a peak (Peak of Inflated Expectation), but as in the case of the majority of new technologies, as the new technology that has reached its peak begins to be disseminated more broadly, there arises a gap between the expectation and the level of actual satisfaction, resulting in the collapse of the bubble (Trough of Disillusionment). This subsidence of the bubble and the return of the level of expectation almost back to its original point are attributed to technological problems in the new technology itself and the deficiencies in the related infrastructure that is required for the implementation of the new technology. The hype cycle has its origins in the “marketing hype,” which is a concept that explains the negative effects of

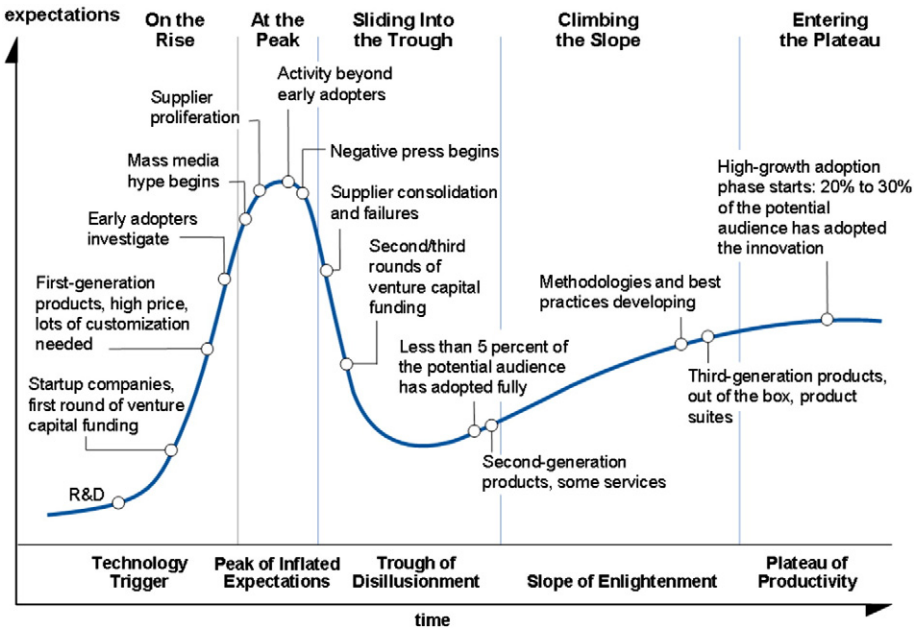

Fig. 1. Gartner technology hype cycle.
Source: [10].

excessive marketing, or in other words, excessive exposure. Therefore, the visibility in the hype cycle brings about the rapid bubble phase arising from technological vision or from the media, and such visibility becomes hyped according to the content and the amount of the exposure.

This technology hype cycle model is currently applied to almost all newly emergent informational technologies, and in the case of the Gartner Group, this type of technology hype cycle model is used to explain which phase has been reached by the new informational technologies that have been hitherto introduced, as in the following.

2.1.2. Socio-technical system

The majority of existing methodologies that embody the innovation system approach are based on supplier-centric thinking in regard to the creation of innovation. The socio-technical system, which was proposed in response to a critical awareness of this problem, distinguishes the consumer aspect in its approach (refer to Fig. 2). The socio-technical system presented by Geels [11] encompasses not only production but also the dissemination and usage of technology. This socio-technical system is composed of artifacts, knowledge,

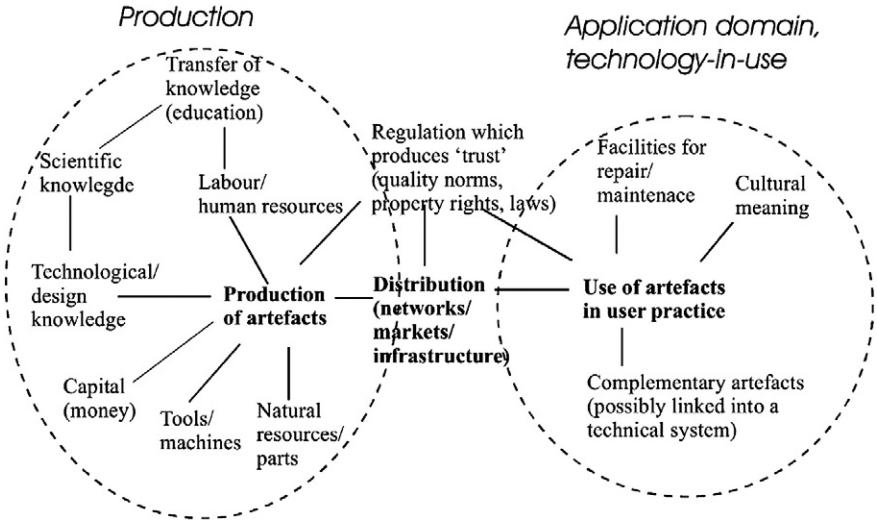

Fig. 2. The basic elements and resources of the socio-technical systems.
Source: [11].

capital, labor and cultural meaning, etc. Though this socio-technical system does not function independently, the system ultimately cannot help but be regarded as the outcome of the behavior of human actors. Also, various social actor groups (for example, consumers) that are active within the socio-technical system take actions autonomously [11,12]. This theory explains the role of various social groups including not only consumers and producers but also the distributors of technology, and this paper accordingly focuses on mass media groups in addition to users (or consumers) and producers. Information distributors (for example, the mass media) who perform the role of building social networks and generating cultural and symbolic meanings have assumed an important role in the socio-technical system, particularly since the advent of the 20th century.

2.2. A review of preceding studies providing empirical verification of the hype cycle and the differentiating features of the present study

Dahlberg and Hørlück [3] and Osterwalder [25] respectively utilized the equity value graph and the NASDAQ index to empirically define the technology hype cycle, and thereby identified patterns that were similar to the hype cycle. However, the relationship between equity values and visibility remained unclear. In particular, while it is possible to conduct an analysis of the equity values and index for a specific company or a specific industry, there are significant limitations impeding the analysis of specific technologies or products. In addition, though Romiszowski [27] has analyzed the adoption patterns for education and TV, since his analysis pertained not to the visibility of technologies but rather to their adoption (market share), his work should be considered to be rather an analysis of one type among the various conventional product life cycles. In regard to visibility, Lind [21] was able to clearly illustrate the hype cycle pattern involving the usage of the word "convergence" in IT-related articles found in the databases of news reports. Though this cannot be considered an empirical study of the hype cycle since it did not consist of an analysis of technology, Lind's work has presented the possibility for using the visibility measurement indices provided by news reports.

Such bibliometrical approaches to the hype cycle or the life cycle can also be found in the works of Watts and Porter [29], who identified the bibliometrical indices that enable approaches at each phase, as presented in Table 1. Although, according to the results of a study by Järvenpää et al. [13], the phase-by-phase categorization indicated in Table 1 cannot be regarded as the general, representative characteristics of each phase, it is certain that each index offers a valuable resource for empirically analyzing the technology hype cycle.

Järvenpää [14] actually analyzed the case of DVD technology using news articles, one of the indices included in Table 1, with the objective of identifying the technology hype cycle but failed to demonstrate a clear hype cycle pattern for DVD technology in all of the English-language newspapers examined. Järvenpää attributed this failure to the inclusion of DVD films rather than DVD technology. However, the study also achieved some progress in this area by demonstrating that the press specializing in technology and the general press have differing bubble phase peaks.

In another study conducted by Järvenpää [15], the target technologies were expanded to include MP3, Bluetooth, and Blu-ray technologies, and the indices were also modified to include both news reports and technological literature ("Compendex"). As a result, the study succeeded in identifying a clear hype cycle in the news pertaining to MP3 and Bluetooth. On the other hand, however, the study managed to detect only the decline of the bubble phase for Blu-ray. Even in the identified patterns, there were difficult challenges to interpreting the results since the study overlapped with the period of the collapse of the dot-com bubble and falling expectations.

Jun [16] conducted comparative analyses of macroeconomic indicator variables such as oil prices and GDP growth rates to demonstrate that consumers' hype cycles can be observed through search traffic. Although this study provided a more direct measurement of consumer expectations compared to previous studies, it was limited to comparing sales volume resulting from consumer behavior reflecting consumer expectations.

As examined above, there have been many efforts to empirically demonstrate the technology hype cycle up to recent times, and there have been positive developments such as the identification of indices and the various attempts at analysis, but these efforts were also beset by many limitations. In particular, because of the absence of consideration given to the technology life cycle, it has been difficult to provide an adequate interpretation of the bubble phase and the disillusionment phase. More effective interpretations will become possible when a comparison is made of the hype cycle indices in conjunction with the conventional technology life cycle, as undertaken in the research by Chen et al. [2]. Early on, Ernst [8] had argued that patent related activities undergo a period of decline during the growth phase of the technology cycle, though he did not adduce the hype cycle in his explanation. As implied in these preceding studies, it is necessary to analyze the life cycle and the hype cycle in correlation with

Table 1
Technology life cycle indices.

Factor	Indicator
R&D profile	
Basic research	Items in e.g. science citation index
Applied research	Items in e.g. engineering index
Development	Items in e.g. U.S. patents
Application	Items in e.g. newspapers abstracts daily
Societal impacts	Issues in business/popular press abstracts
Growth rate	Trends over time in number of items

Source: [29].

one another. Moreover, in order to empirically support Ernst's argument, it is necessary to expand and analyze the indices provided in Table 1. In particular, while the life cycle is regarded as a producer-centered cycle, the hype cycle by contrast has the advantage of enabling the analysis of the hype cycle for each specific actor within the diverse socio-technical system. While applications for patents or the publication of papers enable measurements of the expectations of researchers or producers as shown in the preceding literature, news articles will make it possible to measure the expectations of the opinion leader group within the market.

However, there is one index of the hype cycle that has been overlooked by Järvenpää, Watts and Porter, and this is none other than the consumer's hype cycle. This paper seeks to analyze the consumer's hype cycle using web-searching traffic, which can be defined as part of the index of information collection within the five stages outlined in the consumer behavior model. In the works of Järvenpää or Fenn, who created the hype cycle model, expectation was defined simply as the manifestation of human nature, but the project to connect the life cycle with the hype cycle must be preceded by the demonstration that hype cycles exist for multiple participants within the market including the users and by efforts to compare these cycles. This paper therefore undertakes to empirically identify and compare the three representative actors in the market.

Linstone has set a precedent for applying this method which approaches the issue from the perspective of the actors in the socio-technical system. Linstone [23] identified three multiple perspectives, namely the technological (T), organizational (O), and personal (P) perspectives, and presented their respective criteria as analysis, value, and image. Linstone argued that this perspective-based approach is useful for technology assessment and risk management. In addition, Linstone [22] also utilized the T-O-P concept to provide an insightful explanation of the complexity of the science adaptive system. What is particularly notable is that the criteria or characteristics respectably applicable to the three types of perspectives presented by Linstone [22] point to the possibility that their respective hype cycles may have differing patterns. This present research has similarities to these early studies conducted by Linstone or Geels in that it also adopts multi-perspective approach, but the unique significance of this research is that actors' behavior is simultaneously approached through a quantitative and empirical approach employing big data.

The present research also considers the possibility of lags when analyzing the relationships among the expectations or behaviors of these actors. Winthrop et al. [30] have analyzed the lag effect that occurs between the time of the producers' investments and the producers' achievement of outcomes in the course of their analysis of R&D investments and paper publications (quantitative progress), citation of published papers (qualitative progress), patent applications, and patent citations, etc. Daim et al. [6] also succeeded in analyzing the effect of lagging outcomes based on an examination of research funding and patents for emerging technology, publication of papers in academic journals, and papers presented at academic conferences. Martin and Daim [24] even progressed as far as to present a technology roadmap, predicting the technological outcome deriving from research funding based on such intelligence analyses. Such bibliometric researches are most often characterized by a producer-centered approach focusing on paper publications and patents. In this context, the present research can be regarded as distinctly significant because it performs a bibliography analysis that includes both consumers and media.

Kostoff [17–19], one of the early pioneers of research on the effects of investment in research and development, examined the issue in terms of the directionality of factors influencing scientific and technological innovation. In the present study, I analyzed the relations of influence that exist among actors through cross-correlation analysis and the Granger causality test.

Also, as in the preceding studies, analyzing visibility or measuring expectations using only quantitative data (counts or number of hits) entails the risk of reflecting changes in the media environment concomitant to the development of the internet environment in the form of noise. In other words, the concept of exposure through news, etc., can be interpreted more accurately when compared through frequencies or intensities rather than through absolute values. For this reason, this paper refrains from the analysis of simple quantities (number of counts), and instead uses frequencies or intensities to analyze the hype cycles of producers (researchers), the market, and consumers.

3. Research methodology and case studies

3.1. Variables and method of measurement

To measure the hype cycle from the user perspective, this study used the methodology of bibliometrics that measures statements and information in documents. Bibliometrics is an effective methodology for historically and systematically analyzing large volumes of documents. Bibliometrics is capable of analyzing embedded technology life cycles, and has even been utilized in linkage with consumer adoption forecasting models such as the Bass model to predict the future of technologies [7].

The subject matter of bibliometrics encompasses search traffic, news, and patents. The key target of this analysis is search traffic, which reflects the hype cycle of consumers, and news reports and patents as presented in Table 1 are also analyzed for the purpose of interpreting the hype cycle indicated by search traffic and drawing comparisons to preceding research. Because the case study under analysis consisted of hybrid cars, the bibliography was limited to documents originating in the U.S. or produced in the English language. Also, each item was respectively postulated to represent distinct actors; the contents thereof are presented in Table 2.

The categorization of actors as shown in Table 2 was founded on distinctions of the basic component factors and sources for the socio-technical system indicated by Geels [11] (refer to Fig. 2), and the operationalization of the variables of measurement for each actor was based on existing research literature and theories, as explained in Table 2.

Upon examining each respective measurement methodology in further detail, it should be noted that for the purpose of measuring the user's expectations (visibility) from the perspective of consumer behavior, measurement was made based on the

Table 2
Operationalization of variables for the measurement of the hype cycle for each major actor.

Actor	Measurement	Related articles
Production (researcher)	Patents	Watts and Porter [2] and Chen et al. [29]
Media (network)	News	Lind [21] and Järvenpää [13–15]
User (consumer)	Searching traffic	Jun [16], Kotler and Keller [20], and Rogers [26]

intensity of search traffic for searches made on a website, in contrast to the method used in other preceding studies. The site selected for analysis was Google, which provided the search statistics for this study and which occupies the highest global market share of searches, reaching 82.8% as of May 2011 (www.netmarketshare.com). The search traffic on Google was adopted as the index of consumer behavior for the reason that Google's search engine already occupies a monopolistic position in the market. Moreover, though producers also use Google searches, the majority of the Google users in this regard consist of consumers who are restricted from access to other specialized DBs.

Google's search statistics analyze a portion of web searches to calculate the number of searches for the terms input by the user within a specific time period in relation to the total number of searches conducted on Google. This is equivalent to expressing the probability that a particular individual user will search for a certain search term within a specific time period in a particular region. The search statistics set the criteria of minimum traffic for the search term and hence search terms with low search volume are not indicated in the statistics. Also, search terms that were repeatedly input by a particular user over a short time period are also excluded from the tally, preventing the possibility of artificially manipulating the level of interest through repetition (www.google.com).

Another advantage of utilizing Google trends is found in its process of normalization. Research case studies in the past used absolute values (for example, the number of hits, etc.) and hence failed to exclude environmental factors impacting consumer exposure that result from the overall increase in news volume or the number of web pages. By contrast, all of the results of the search statistics in the Google trend data undergo a normalization process, dividing them by a common variable to eliminate the influence of variables. This method makes it possible to compare the basic features of each set of data. If only the absolute values are indicated without the precaution of this normalization process, the data collected from regions or time periods with high search volume will always receive the highest score.

The frequency of all other indices for measuring the hype cycle, such as news and patents, is also measured in relation to the total data for the time period in question, and is again divided by the total average to ensure that normalized intensities are used in all comparisons. The market sales volume is also divided by the total sales volume to yield the sales market share of new products submitted to analysis. The sources for the major variables and the comparative data are listed in Table 3.

3.2. Case study: hybrid automobiles

The hype cycle has been actively utilized by Gartner in the IT industry. The elements that differentiate this hype cycle from the conventional technology life cycle are the bubble phase marked by a rapid rise in expectations (Peak of Inflated Expectations) and the phase of disillusionment marked by declining expectations (Trough of Disillusionment), which are distinguished from the market growth which occurs in the life cycle. In the IT industry, these two characteristic phases take place over a relatively short time period, and there are many problems that complicate attempts to distinguish these phases from the noise in the external environment even when the phases are actually observed. I chose the hybrid car as the target for analysis, since this case study will allow me to empirically verify whether the hype cycle exists in industries other than the established IT industry and since hybrid cars have a long-term technology life cycle that makes it relatively conducive to excluding the external environmental noise.

Hybrid cars have been developed with an almost exclusive focus on the U.S. market. In the United States, hybrid cars have grown into a market that occupied up to 2.5% of the new car sales volumes for 2010, with the cumulative sales volume reaching 2 million vehicles as of May, 2011. When estimating the cumulative maximum market to determine the growth cycle, I took into consideration that 25% of the car transactions in the U.S. consist of new cars and that the total number of registered vehicles is 250 million (as of 2007), and thereby estimated the cumulative maximum market for hybrid cars to be around 60 million vehicles (maximum potential number of cumulative consumers in the Bass model [1]). Comparing with the consumer innovation adoption model of Rogers [26], I observed that the cumulative market share since 2009 exceeded 2.5% (around 1.5 million vehicles) and

Table 3
Data sources for each major variable and index.

Variables and indices	Site	Explanation
Search traffic	Google trend	Weekly and quarterly search traffic in the United States (2004–present)
Patents	USPTO	Quarterly patent disclosures in the United States (2002–present)
News	Google news archive	Monthly and quarterly English-language news (2002–present)
Market share	Hybridcars.com	Monthly, quarterly market share rate of case study technologies among new cars in the U.S. (2004–present)

therefore concluded that the market has grown from a market for innovators into that of early adopters. In terms of the conventional life cycle, the market has passed the introductory phase and entered into the early growth phase.

3.3. Research model and statistical hypotheses

The research model adopted to explain the hype cycle of each actor and the causal relations among them are shown in Fig. 3, and this model has a dual regression analysis structure similar to Path Analysis. Path Analysis was not performed in this research; instead, I established hypotheses regarding individual relations and sought to identify the causal relations through simple regression analysis.

According to the consumer behavior model, consumers' purchasing activities and their information searching activities cannot help but exercise an influence. In particular, the stimulus–behavior model dictates that internal and external stimuli are great motivators for consumer behavior. Therefore, the behavior of the actors constituting the socio-technical system can mutually influence one another by serving as stimuli. The following is an attempt to find the factors influencing the consumer hype cycle by identifying the correlations of influence that exist among the behaviors of such actors. First, I set up a hypothesis to examine the problem of multicollinearity between media activities, which serve as the dependent variables to consumer activities or hype, and the producer's technology development activities.

H0A1. Media activities are not influenced by the producer's technology development activities.

In the above analysis, if multicollinearity is not high, or more specifically, not high enough to merge the independent variables, then the two stimulating factors can both be regarded as independent variables. If there is no multicollinearity among the independent variables, the null hypothesis for the research model explained in Fig. 3 can be established as follows according to the general consumer behavior model and the stimuli–behavior model.

H0A2. Consumers' information searching activities are not influenced by media activities.

H0A3. Consumers' information searching activities are not influenced by the producer's technology development activities.

H0A4. The proportion of hybrid car purchases is not influenced by media activities.

H0A5. The proportion of hybrid car purchases is not influenced by the producer's technology development activities.

H0A6. The proportion of hybrid car purchases is not influenced by the consumer's information searching activities.

As previously explained, in the above hypotheses, the media activities were operationalized based on the proxy variable representing news reports and the producer's technology development activities were operationalized based on the number of patent applications, while the consumers' information searching activities were considered to be the outcome of consumer hype, with search traffic serving as the proxy variable.

In addition to the correlation of causality examined above, I also needed to take into consideration the time sequence of occurrence. It is possible that the existence of a period of delay between the technology development activities or media activities and the consumers' hype may have induced the rejection of the hypotheses above, or resulted in low correlations. To examine the validity of this argument, I presented the following additional null hypotheses. If an original hypothesis that was previously adopted is rejected, or if an original hypothesis that was rejected is again rejected and the correlation coefficient increases, then it becomes possible to claim the possibility of a delayed influence among the behavior of the actors.

H0D1-1. Media activities are not influenced by the producer's delayed technological development activities.

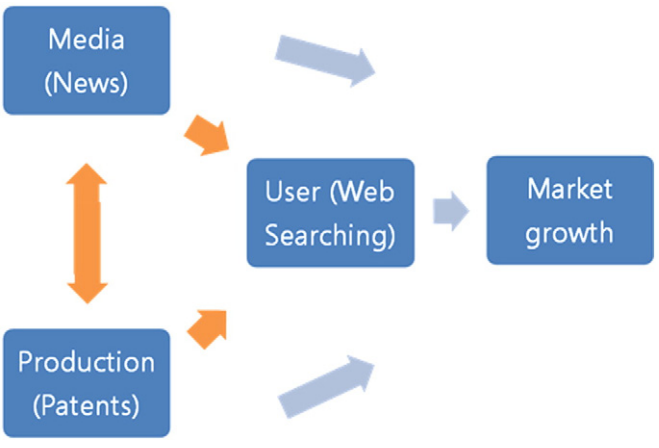

Fig. 3. Research model for investigating casual relations in the hype cycle of each actor.

H0D2-1. The information searching activities of consumers are not influenced by delayed media activities.

H0D3-1. The information searching activities of consumers are not influenced by the producer's delayed technological development activities.

4. Results

4.1. Technology statistics for each variable

4.1.1. Search traffic

Fig. 4 shows the measurement results for search traffic, which I use to assess consumer expectations. The figure shows the weekly search traffic for hybrid cars standardized by a non-dimension scale. To reduce the risk of interpretive errors that may arise due to external environmental factors pertaining to hybrid cars, I simultaneously analyzed the search traffic for electric cars, using hybrid cars as the norm. Because the intensity of the search traffic has been standardized, 1.0 was set as the average intensity of hybrid car search traffic, which I adopted as the norm, and the average for electric cars reached 1.82.

Up to the first half of 2006, there was almost no difference in comparison to the web search traffic for electric cars. However, beginning in the second half of 2006, when the sales of hybrid cars stabilized above 1.5%, the gap between the search traffic for electric cars and the search traffic for hybrid cars began to widen steadily. Rather than attributing this increasing gap to a change in the users' method of collecting information on electric cars, I deduced that the expectations of users regarding electric cars had once been focused on hybrids but gradually expanded to include other alternatives.

Fig. 5 provides information regarding the search terms selected by users when search for data on hybrid cars. Consumers searching for hybrid cars used the term “hybrid car” far more often than the term “hybrid vehicle”, and though some did use the term “hybrid vehicle,” the trend for the usage of this term was similar to the trend for “hybrid car.” For this reason, I examined only the data for the term “hybrid car” when analyzing the intensity of search traffic (Google Trends does not support multi-term searches (and, or, etc.)).

4.1.2. Sales percentage of hybrid cars

The sales of passenger cars in the U.S. reached 16.04 million new cars in 1999 but the sales of new cars thereafter entered into a recession that lasted up to 2005. Beginning in 2006, factors including the rapid rise in oil prices and the economic recession caused a period of deep stagnation in sales so that in 2009 the sales had fallen sharply to around 10.4 million cars. The sales for hybrids began with seventeen Honda Insight cars in 1999 but continued growth led to the sale of over 180,000 Toyota Prius cars in 2007 and the annual sales volume has now reached 350,000 new hybrid cars.

The annual sales volume has gradually decreased, however, as even new hybrid cars came to be impacted by the stagnation of sales in the car market in general. Up to late 2010, the cumulative sales of hybrid cars in the U.S. market had reached 1.89 million cars, and exceeded 2 million cars in May 2011. The average annual sales volume for new cars in the recent 5 years (2006–2010) has reached 12.65 million cars, while the average annual sales volume for new hybrid cars is around 300,000 cars.

The hybrid car sales percentage (market share), which is the variable obtained by dividing the sales volume of hybrid cars by the sales volume of new cars, continued to increase rapidly in contrast to the decline in new car sales volume or hybrid car sales volume. Upon entering 2010, however, the hybrid car sales percentage stagnated due to factors such as the economic recession,

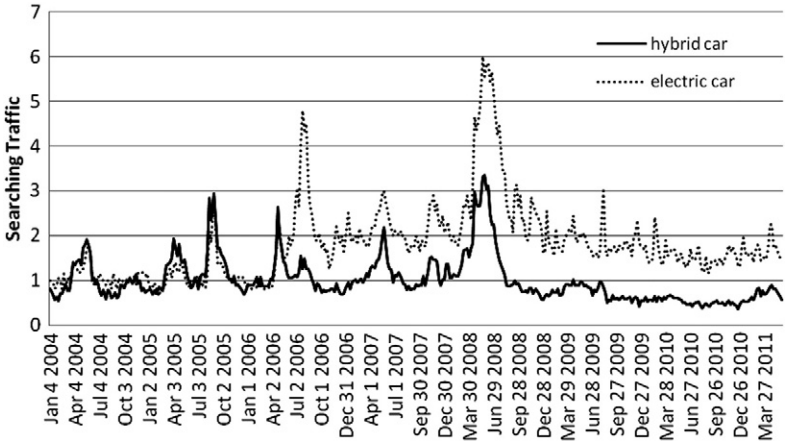

Fig. 4. Search traffic in the US for hybrid cars and electric cars (weekly data).
Source: Google trend, 2011. 6.

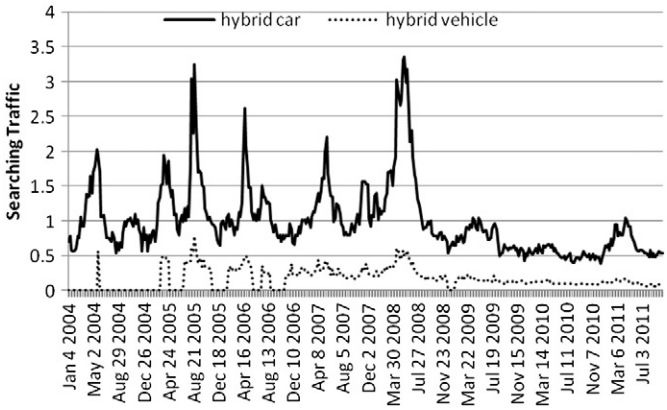

Fig. 5. Weekly search traffic in the U.S. for each search term related to hybrid cars. Source: Google trend, 2011. 10.

the quality problems that emerged in Japanese vehicles, and the obsolescence of released models. The sales percentage of hybrid cars had an average of 1.88% from 2004 to the 1st quarter of 2011.

4.1.3. Patent application percentage

When a phrase search was conducted for "hybrid car" within titles and abstracts, the results differed greatly depending on the search terminology used, a factor which had not been an issue when analyzing search traffic. In the phrase search, the number of patent applications I found increased by a large margin when the term "hybrid vehicle" was included in the analysis, compared to when only the term "hybrid car" was used. Classified based on the date of the application, from 2002 to 2010 the number of patents related to "hybrid car" totaled 1027. When the term "hybrid vehicle" was also included, however, the total reached 7855 patents, which was more than 7 times higher than the previous total. For this reason, I included not only the phrase "hybrid car" but also "hybrid vehicle" when performing our analysis of the patent application percentage.

Prior to 2001, the United States only disclosed information on registered patents, but from 2001, the patent public disclosure system entered into effect, and hence I was able to eliminate any complications arising from undisclosed patents in my analysis of all patent applications made public since 2002, as shown in Fig. 6. However, the decline in the total number of patent applications since 2010 is implicated with the issue of undisclosed patents, due to the patent public disclosure system explained above. Hence caution needs to be taken when utilizing this data. To minimize the problems arising from this complication, I undertook to analyze patents based on percentage analysis rather than on hits. As presented in Fig. 6, the total number of patent applications in the 9 years from 2002 to 2010 was 2.68 million, and the quarterly average was 74,552. Among these, the quarterly average of hybrid-related patent applications ("hybrid car" or "hybrid vehicle") was 218.

In this paper, the "patent application percentage" refers to the percentage obtained by dividing the number of patents related to hybrid cars by the total number of patent applications. The patent application percentage for each quarter had an average of 0.3%, and the overall trend showed a great increase beginning in late 2005, similar to the trend found in the hybrid car sales percentages.

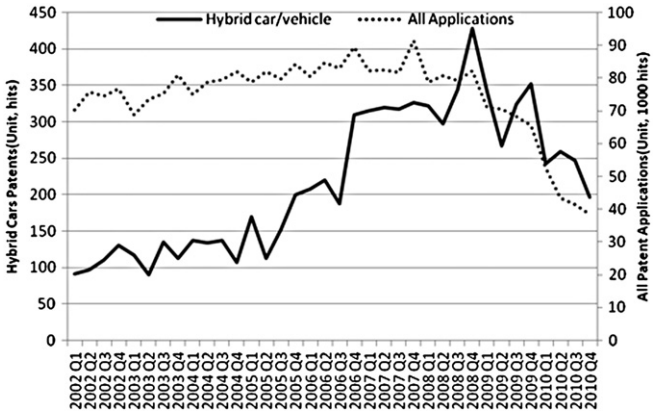

Fig. 6. Trends in the overall number of patent application and the number of patents related to hybrid cars in the U.S. Source: USPTO (2011. 10. last accessed).

4.1.4. News coverage percentage

My examination of the trend in reports and articles related to hybrid cars that received exposure in the news revealed that the trend differed from that found in the case of patents or search traffic. In the phrase search, though an analysis using the phrase "hybrid car" yielded a greater number of searches compared to analysis using the phrase "hybrid vehicle", the difference in number was not significant enough to dismiss the phrase "hybrid vehicle" as I had done in the case of search traffic. Upon classifying articles by the date of publication, I found that there were 2901 articles related to "hybrid car" between 2002 and 2010. When the phrase "hybrid vehicle" was included, however, the number increased to 2303, which amounted to 79% of the number for "hybrid car". Therefore, in the analysis of news coverage percentage, I included both the phrases "hybrid car" and "hybrid vehicle", and after searching for articles related to each respective phrase, I subtracted the number of news articles searched when using both phrases (eliminating redundant searches), so that the pool consisted of articles in which one or more of the phrases were listed.

In the nine years from 2002 to 2010, the total number of news items was 129.36 million, and the quarterly average was 3.89 million news items. Meanwhile, the number of news articles related to hybrids (searchable by "hybrid car" or "hybrid vehicle") totaled 4823, with a quarterly average of 134 articles. The peak was reached in 2008–2009, and the number of articles continually increased, and this trend was impacted by the great increase in the total number of news articles from 2007. To exclude the factor of this environmental change, I analyzed the news coverage percentage as shown in Fig. 7.

I obtained the news coverage percentage by dividing the number of news related to hybrid cars by the total number of news articles. The average was 0.0037%, and unlike the number of articles published, this percentage reached a peak in the early half of 2007.

4.2. Hype cycle observation results

According to Fenn and Raskino [9] of the Gartner group who presented a systematic understanding of the hype cycle, expectation can be defined as the human response to the new and the novel, and the hype cycle consists of two elements which can be explained by two separate curves. As shown in Fig. 8, the first curve is a bell curve, which represents the initial enthusiasm or disappointment driven by positive or negative outcomes. The second is an S-curve showing how an innovation's performance improves slowly at first, then picks up steadily, and finally yields diminishing returns.

When these two curves are combined, it is evident how the shape of the hype cycle arises from the offset timing of the two factors (refer to Fig. 1). The hype cycle is driven upward first by the collective emotional response and then, on the Slope of Enlightenment, by the logical response to an innovation's improving performance. Therefore, up to the Trough of Disillusionment phase, consumer behavior that reflects the emotional responses of the consumers can be measured by search traffic, but after the Trough of Disillusionment phase, it would be more appropriate to measure the rational response embodied in the innovative efforts of the producers.

As demonstrated in Jun [16], when the market share in the U.S. exceeded 1.5–2.0% between 2007 and 2008, the market share and the search traffic began to exhibit notably contrasting patterns. While the market share followed an exponential trend, the search traffic exhibited a polynomial (3–4 terms) trend (refer to Fig. 9).

By contrast, according to the data in Fig. 10, WTI oil prices and the market share followed nearly identical trends over the course of the entire time period, corroborating the generally held view that oil prices probably exercised a great impact on the expansion of the hybrid car market. (Meanwhile, the GDP growth rate had almost no influence on changes in the market share). Therefore, it was possible to attribute the fall in search traffic to the characteristics of the users rather than to external environmental factors such as oil prices.

The above analyses verified that the information research behavior of consumers (users) using the web exhibited the same characteristics corresponding to the bubble phase and the disillusionment phase within the hype cycle, in contradistinction to the exponential growth that takes place throughout the introductory and growth phases in the market.

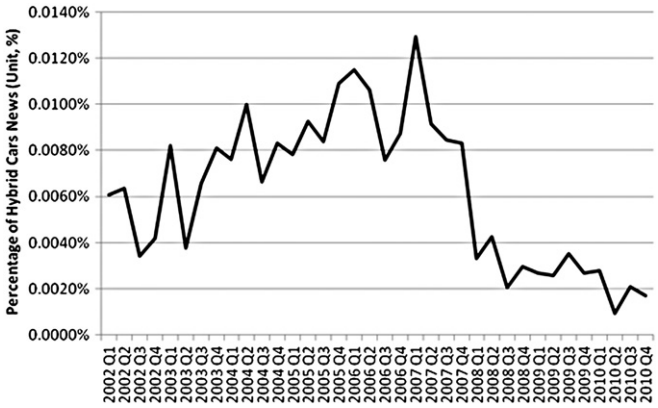

Fig. 7. Trend in the percentage of news coverage related to hybrid cars.
Source: Google news archive (2011. 10. last accessed).

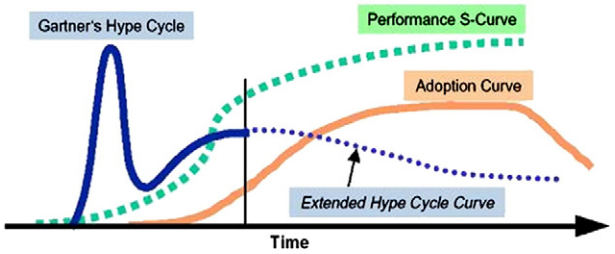

Fig. 8. Components of the hype cycle.
Source: Linden, A. and Fenn (2003).

4.3. Results of the comparison of the hype cycle of each actor

According to the five-stage model of the purchasing process provided by the consumer behavior model that helps explain the forms of searches performed by users, after the consumer (or user) is exposed to external stimulants (news or technology information) and searches for information, the consumer undergoes a process of evaluating alternatives before making the decision to buy. This consumer behavior model explains the operating mechanism behind the bubble phase and the disillusionment phase of the hype cycle. During the bubble phase, the heightening expectations among producers or in the media lead to the technology's high exposure to consumers, but as the producers or the media become aware of the realistic limitations of the technology, the technological development also normalizes in reversion from the excess, and when the external stimulants acting on the users are thus reduced, the consumers' expectations also declines.

This explanation can also be corroborated using the Bass diffusion model provided Bass, who has researched the consumer adoption model [26]. The Bass model postulates that the potential adopter is influenced by two types of communication channels, namely the mass media channel and the interpersonal channel. Cases in which the adopter selects the new product through the impact of mass media messages (news, etc.) occur continually throughout the diffusion process, but they are relatively more concentrated in the early stages of the innovation diffusion. Therefore, the mass media messages in the early phases of the innovation plays a critically important role.

The correlations among the analysis models were as follows. I have already presented my comparison between the hybrid car sales percentage and the search traffic in Fig. 9 above. Because the activities of the producers or the media may have influenced the trends in the search traffic or the hybrid car sales percentages, I compared the major variable for each actor, and Fig. 11 presents the comparisons of the changing trends in patent applications and news coverage and the changes in search traffic. Since each of these variables represented the expectation of each respective actor, the comparisons were based on normalized intensity.

Because in the socio-technical system, the activities of the producers or the media may occur in advance, I measured the intensity of the patent application percentage and the news coverage rate from 2002 to 2010, which I had not done for my measurements of search traffic. The results shown on the left in Fig. 11 indicate that though both news and search traffic exhibited patterns corresponding to the Peak of Inflated Expectations phase and the Trough of disillusionment phase of the hype cycle that is distinguishable from the life cycle (sales percentage), their respective peaks differed. The peak for news occurred slightly earlier. Patent applications did not exhibit any significant positive (+) correlation to search traffic, and instead showed a relationship closer to the negative (−) direction.

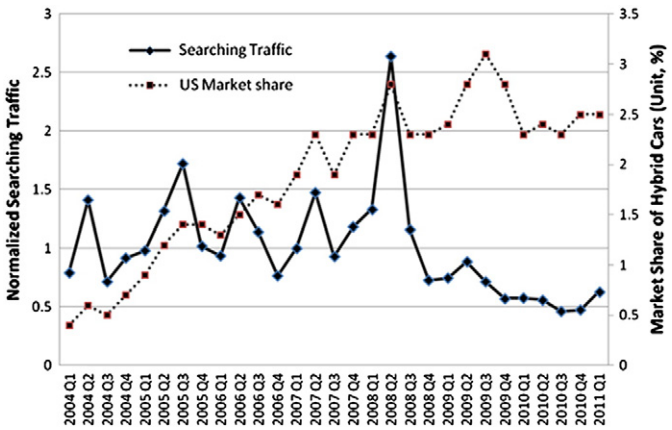

Fig. 9. Comparison of the search traffic (quarterly data) and the market share for hybrid cars in the U.S.
Source: www.hybridcars.com (market share only), [16].

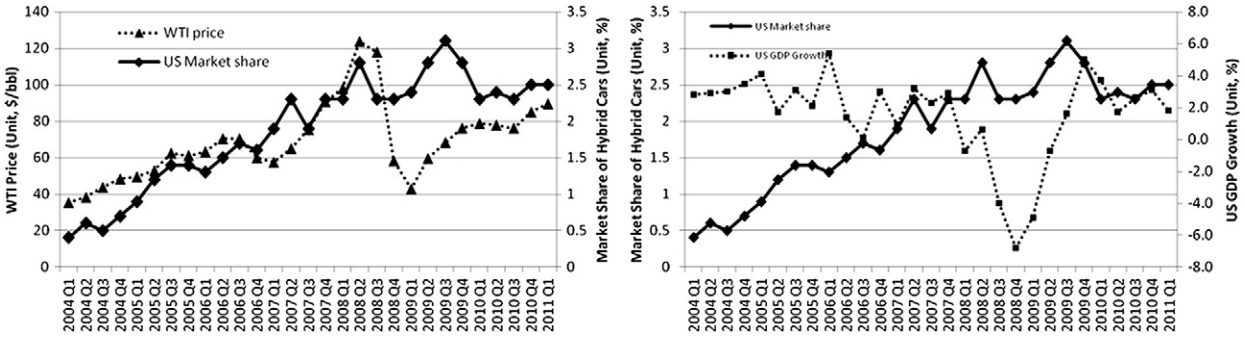

Fig. 10. Comparison of the market share of hybrid cars in the U.S. (quarterly data) to WTI oil prices (left) and the GDP growth rate (right).

The data on the right in Fig. 11 show the results of comparing the external variables consisting of patents and news to the internal variable consisting of sales percentages. In contrast to the results shown on the left in Fig. 11, the intensity of patents application percentages had tendencies similar to the sales percentages, while only the news coverage percentage shows trends similar to the hype cycle.

4.4. Model verification

Table 4 presents the results of the regression analyses I conducted on the major variables, including patent applications, news reports, and search traffic. The results indicate that the market sales percentage (market share), which had a life cycle pattern between the introductory phase and the growth phase, possessed a significant correlation to patent applications and news reports. The level of significance was high and the correlation coefficient was also relatively high. However, while the patents exhibited a positive (+) correlation and therefore could be considered to have significance, the news variable inversely exhibited a negative (−) correlation, and therefore could not be considered significant (refer to the results of *t*-test). As for the correlation between the search traffic, which had exhibited a hype cycle, and the patent applications and news reports, only the correlation to patent applications yielded statistical significant results, but the correlation was negative (−) and hence impossible to dismiss. Hypothesis H_0A1, which had been established to examine multicollinearity, also displayed a statistically significant correlation but was not dismissed since the relationship was negative (−). I was thus able to demonstrate that each individual independent variable had its own separate significance.

When using the results of the regression analysis above to examine the outcome of hypothesis verification, H_0A6 was the first to be adopted. Therefore, purchasing activities and information searching activities show divergent tendencies that cannot be explained by the consumer behavior model alone. In my verification of the other hypotheses, I rejected only H_0A5 and adopted all other hypotheses. Though hypotheses H_0A3 and H_0A4 could be statistically significant, the directions of the coefficients were not appropriate, and therefore I adopted the null hypothesis (refer to the results of *t*-test). I thus concluded that news coverage either does not influence the information searches and purchasing activities of the consumers, or inversely exercises a negative effect. By contrast, patent applications had a high correlation to the sales volume of hybrid cars. It is necessary, however, to take caution here when determining the relation of cause and effect. Though it is possible that efforts at performance enhancement such as patent

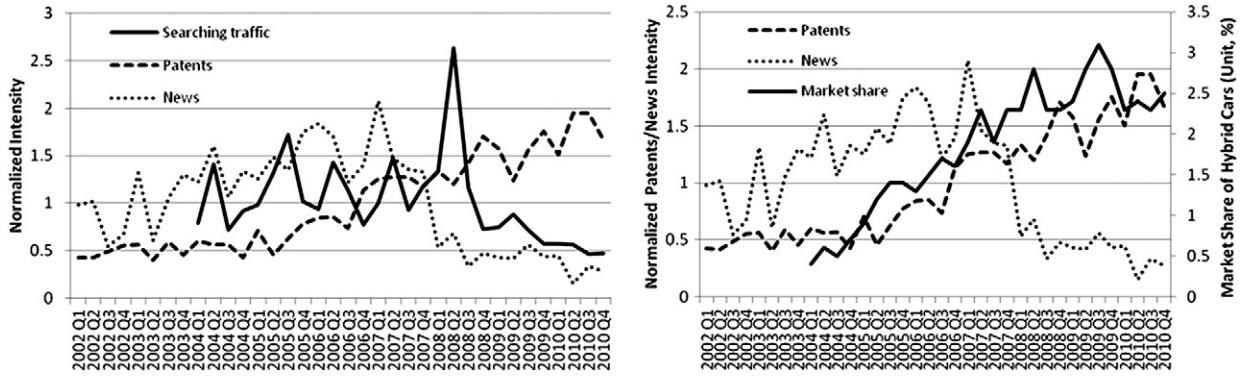

Fig. 11. Comparisons of search traffic (left) and sales percentage (right) in relation to the intensity of patents and news coverage.
Source: USPTO, Google trend, Google news archive and Hybridcars.com, 2011. 6 (modified).

Table 4
Results of the regression analyses for each major variable.

Variables	Statistics	Patent intensity	Searching traffic	Market share
News intensity	*p*-Value	**0.0007**	0.0903	**0.0003**
	t Test	**−3.7105**	1.7591	**−4.2324**
	R coefficient	**0.5369****	0.3261	**0.6390****
	(Hypotheses)	H_0A1	H_0A2	H_0A4
Patent intensity	*p*-Value		**0.0369**	**0.0000**
	t Test		**−2.1995**	**7.9121**
	R coefficient		**0.3961***	**0.8406****
	(Hypotheses)		H_0A3	H_0A5
Searching traffic	*p*-Value			0.7256
	t Test			−0.3556
	R coefficient			0.0681
	(Hypotheses)			H_0A6

* Significant at the 5% level.
** Significant at the 1% level.
Note: the items in bold are statistically significant.

applications increased sales volume, it is also plausible that the rising sales stimulated research and development or encouraged efforts to secure the rights to the related technology.

As regards the hype cycle, patent applications do influence the purchase of hybrid cars, but does not influence the consumer hype cycle or rather serves as an environmental variable that exercises a negative (−) influence. Since this outcome also fails to explain the behavior of consumers, it can be regarded as reinforcing the argument for the existence of the consumers' hype cycle.

When I took into consideration the lag effect of the environmental variables, namely news and patents, the level of significance in the correlation of the intensity of the news coverage percentage and the search traffic improved by a large margin (refer to Table 5). Between the patent applications and search traffic, there was a statistically significant correlation when the lag was not taken into account but the direction was in inverse relation and therefore meaningless. Meanwhile, when I took into consideration the lag effect as shown in Table 5, the level of significance also decreased. As for the correlation between news coverage and search traffic, the correlation lacked significance when there was no lag effect, but when the search traffic was regarded as lagging 1 year behind news coverage, there was a high level of significance and the correlation coefficient also greatly increased. The results were significant even in the case where the news was considered to be 2 years ahead of the search traffic, but the level of significance and the correlation coefficient were both lower than in the case of a 1-year lag effect. In the correlation between patents applications and news exposure, the 1-year lag effect inversely resulted in lowering the level of significance and the correlation.

In conclusion, the information distributors (market opinion leaders) exhibited hype cycle changes approximately 1 year in advance of the users, while the producers' behavior did not have a significant impact on the hype cycles of the information distributors or users (and instead only exhibited a statistically negative relation).

Table 6 presents the results of the verifications I made in the research model through the hypothesis verifications explained above. In conclusion, producers' activities do not raise the expectations of consumers, but is capable of exercising a positive impact on sales volume. Media activities do not directly influence the sales of hybrid cars, but does have a lagged effect on consumers' expectations. Media activities have an influence on consumers' behavior related to their expectations after a lag of around 1 year. This phenomenon is in clear accordance with the conceptual definition of the hype cycle, in which the rising expectation in the mass media leads to energized consumer activity, followed by continued technological innovation that creates the S-curve of the cycle in the latter half of Fig. 8. Therefore, news and patents can be seen as variables that are highly capable of explaining the consumer behavior that follows the hype cycle.

Table 5
Results of the regression analysis reflecting the lag/lead.

Div.	Div.	Patent intensity		News intensity			
	Lag/lead statistics	None	Lag 1 year	None	Lag 1 year	Lag 2 year	Lead 1 year
Searching traffic	*p*-Value	**0.0369**	0.0883	0.0903	**0.0068**	**0.0293**	
	t Test	**−2.1995**	−1.7708	1.7591	**2.9432**	**2.3054**	
	R coefficient	**0.3961***	0.3281	0.3261	**0.4999****	**0.4120***	
	(Hypotheses)	H_0C3	H_0C3-1	H_0C2	H_0C2-1	H_0C2-1	
Patent intensity	*p*-Value			**0.0007**	**0.0237**		**0.0000**
	t Test			**−3.7105**	**−2.4030**		**−7.6055**
	R coefficient			**0.5369****	**0.4263***		**0.8306****
	(Hypotheses)			H_0C1	–		H_0C1-1

To determine the lag effect between the patent application percentage and the intensity of the news coverage percentage, the possibilities of lags in each case were compared (the possibility of lead or lag).
* Significant at the 5% level.
** Significant at the 1% level.
Note: the items in bold are statistically significant.

Table 6
Summary of the results of the hypothesis verifications.

Name of hypotheses	Test results	Meanings
H_0A	Adopted	Information searching activities (consumer expectations) and purchases may show diverging tendencies.
H_0C1	Adopted	There is no correlation between media activities and producers' activities.
H_0C2	Adopted	Consumers' expectations are not influenced by media activities.
H_0C3	Adopted	Consumers' expectations are not influenced by technology development activities of producers.
H_0C4	Adopted	Sales of hybrid cars are not influenced by media activities.
H_0C5	**Rejected**	**The sales of hybrid cars and the technology development activities of producers may have a (+) correlation.**
H_0C1-1	Adopted	Media activities and the activities of producers do not have a lagging correlation.
H_0C2-1	**Rejected**	**Consumers' expectations may have a lagging (+) correlation to media activities.**
H_0C3-1	Adopted	Consumers' expectations do not have a lagging correlation to producers' activities.

Note: the items in bold are statistically significant.

5. Discussion

5.1. The producers' hype cycle

I have examined patent applications which reflect the expectations from the producers' perspective, news reports which reflect the expectations of the media (information distributor), and search traffic which reflects the expectations of the users. Among these three, the media and the users were found to exhibit hype cycle patterns. When I examined the trend in patent applications by broadening the scope to the 1990s, I found that the trend followed a similar hype cycle pattern.

As demonstrated in Fig. 12, after passing the 1st peak in 2000, it was only in 2006 that the percentages of patent applications finally managed to rise back to the level of 2000. This trend is also a manifestation of the typical hype cycle. When the public disclosure system for patents was implemented in the U.S. in early 2000, the number of patents available for my searches naturally increased, but because the figures in Fig. 12 have been normalized to reflect changes in percentage, the outcome cannot be attributed to the public disclosure system which only influences the absolute number of searchable patents. Rather, it would be more reasonable to explain the increase in the percentage in the early 2000s as attributable to the initial commercial release of hybrid cars. As indicated in Fig. 12, there were almost no differences between the percentage of hybrid car patents within the total number of patent applications and the percentage of hybrid car patents within the total number of patents for cars, which is a relatively older technology. The impact of external variables on patent applications did not diverge in any significant way in the case of cars.

The producers' hype cycle examined based on the percentage of patent applications differs from the hype cycle identified through news exposure rates or search traffic, and this can be explained by Fig. 8. Among the consumers (search traffic) and the information distributors (news coverage percentage), the escalation was led by collective emotional responses (expectations) and then subsided. By contrast, in the case of producers, after the Slope of Enlightenment, it was their rational responses regarding performance improvements through innovations that were manifested in efforts at performance enhancement as embodied in the patents applications or paper publications. This is the reason that two different types of hype cycles were formed. This phenomenon can be explained not only in terms of the components of the hype cycle but also in terms of the three perspectives referred to as T-O-P identified by Linstone [22]. The technological (T) perspective corresponding to the producers has an analytical character, while the personal (P) perspective corresponding to the consumers has an image-driven characteristic, and therefore it is understandable that their expectations will differ.

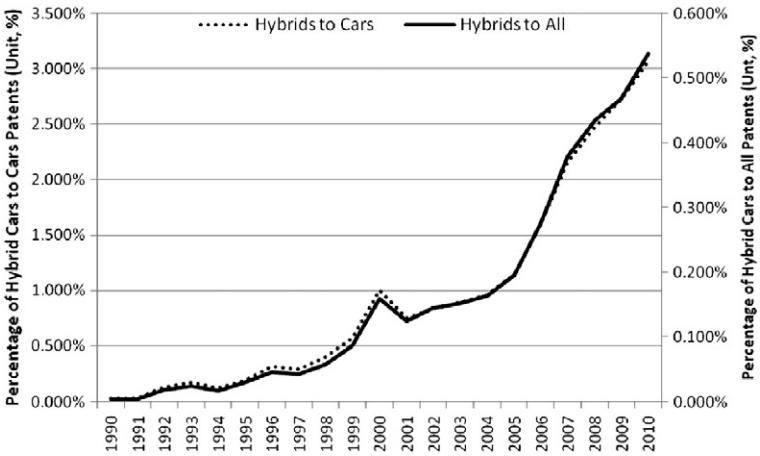

Fig. 12. Changes in the percentage of car and hybrid car related patents.
Source: USPTO (2011. 10. last accessed).

5.2. Consideration of the time lag correlation

Examining Table 5 and Fig. 11, I concluded that there may be an influence that takes place between news and search traffic over a lag of time, and in Fig. 11, I confirmed that patent applications and sales percentages may also exhibit a slight time lag. To examine these temporal relations, I presented cross-correlations in Fig. 13. First, the outcome of the cross-correlation analysis between the intensity of the news coverage percentage and the search traffic showed that the cross-correlation coefficient was the highest in the -5th quarter. Considering that in the consumer behavior model, news listings can supply stimuli in prior to the consumers' behavior, I regarded the results of the statistical analysis to be significant, and concluded that news exposure influenced search traffic after a time lag.

Fig. 13 presents the coefficient of the cross-correlation between patent applications and sales percentages. According to these results, the time lag correlation coefficient was highest in the -1st quarter for patent applications and sales percentage, but there was almost no difference in comparison to the 0th quarter. This indicates that though the patent applications and the sales percentages have a high correlation, there is no time lag.

The Granger Causality Test is a method applied to analyses of time series data such as search traffic to test how well a past value of another variable is able to explain the current value of one variable. The test thereby analyzes the relation of causality between the variables. To more rigorously examine the causal relation between the percentage of news exposure and search traffic, I performed a Granger Causality test on the relation between news coverage percentage and search traffic. The results are presented in Table 7.

The results showed that the news coverage served as a Granger cause of search traffic only in the case where there is a 5-quarter lag. Therefore, the outcome of the Granger Causality Test demonstrates that using the news coverage percentage to explain search traffic will be significant only in cases where there is a 5-quarter lag.

By examining the consumer behavior model, regression analysis, cross-correlation analysis and the Granger causality test, I was able to conclude that the expectations of the information distributors (news coverage) did have a lagged influence on the changes in expectations among the consumers. Also, I judged that the activities of the producers continually maintain a significant correlation to sales percentage once the early phase of market growth has passed.

The question of why news and search traffic may exhibit a lagged correlation can be explained based on the Bass model, purchase delay, and construal level theory. First, as discussed above, the Bass model explains not only that the cases in which the adopter selects a new product based on messages from mass media such as news exposures continually occur throughout the diffusion process, but also that such cases are relatively more concentrated in the early stages of the innovation diffusion. Therefore, the mass media messages constitute an external stimulus that plays a critically important role in the early stage of innovation, and to fulfill this role, prior media activity must have taken place significantly in advance. Regarding the issue in terms of the purchase delay effect, it should be noted that it is the nature of durable consumer goods to have a long replacement cycle, and particularly in the case of highly priced products such as automobiles, there is a difference in time between the point at which the potential consumer perceives the marketing stimulus and the point at which he or she completes the purchase, and therefore it is for these reasons that the media activities occurred significantly in advance. Lastly, another explanation is offered by construal level theory. This theory explains the phenomenon based on the desirability of the product's features and the feasibility of its purchase. When purchasing a car, comfort, safety and fuel efficiency are factors that continually influence the consumer from the moment of information perception to the moment of purchase, and constitute the factor referred to as the desirability of the product's features [29]. On the other hand, price discounts, financing (installment plan) conditions, etc. are elements that determine the degree of difficulty involved in the product's purchase and constitute the factor of the feasibility of its purchase. This latter factor only begins to impact the consumer at the time the purchase is being made. In the light of these explanations, the temporal delay between the media activities and the consumers' search activities can be attributed to the relatively long-term impact of the news coverage on desirable features such as the environmental benefits and high fuel efficiency of hybrid cars. Such differentiating features of hybrid cars constitute the desirability of the features that maintains influence even after a period of 1 year or longer.

However, when compared to Table 5, such delayed correlation did not differ greatly in significance from regression analysis without such delay, raising the possibility that the simple precedence in the media hype cycle became manifest as a weak level of

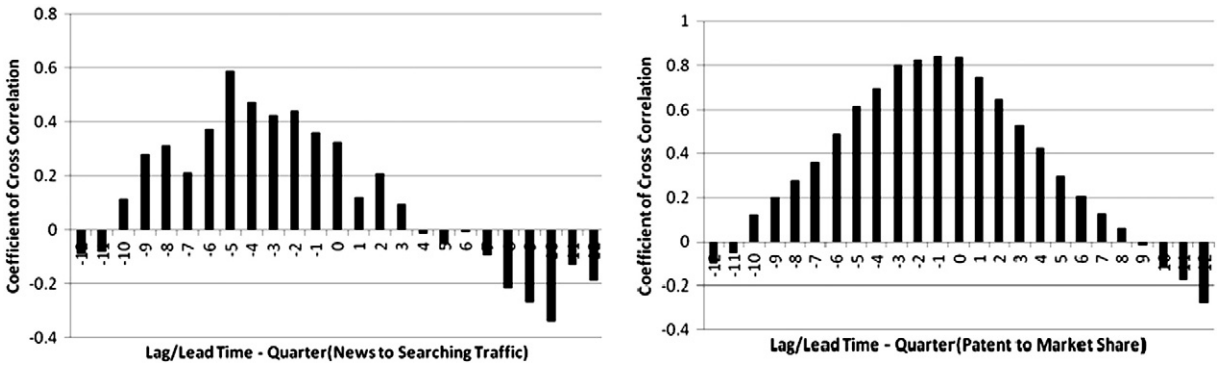

Fig. 13. The cross-correlation coefficient of between news and search traffic (left) and between patent and market share (right).

Table 7
The Granger causality test on the relation between news coverage and search traffic.

Lags	Null hypotheses	Obs	F-statistic	Probability	Test results
3	Search traffic does not Granger Cause NEWS	25	1.35244	0.2890	Adopted
	NEWS does not Granger Cause Search traffic	25	1.59073	0.2265	Adopted
4	Search traffic does not Granger Cause NEWS	24	0.79103	0.5489	Adopted
	NEWS does not Granger Cause Search traffic	24	1.41374	0.2772	Adopted
5	Search traffic does not Granger Cause NEWS	23	0.54074	0.7423	Adopted
	NEWS does not Granger Cause Search traffic	23	**2.87716***	**0.0620**	**Rejected**
6	Search traffic does not Granger Cause NEWS	22	0.46100	0.8209	Adopted
	NEWS does not Granger Cause Search traffic	22	1.87108	0.1911	Adopted
7	Search traffic does not Granger Cause NEWS	21	0.32301	0.9174	Adopted
	NEWS does not Granger Cause Search traffic	21	1.13457	0.4469	Adopted

Note: a) Significant the rejection of the null hypothesis that there is no Granger causality in $^{*}p<0.1$, $^{**}p<0.05$, and $^{***}p<0.01$.
b) the items in bold are statistically significant.

significance. In other words, further examination is needed to determine whether the temporal discrepancy between the media hype and the consumer hype could have been interpreted as a preceding causal relation.

5.3. Estimation of the hype cycle through bibliometrics

The two components of the hype cycle identified in Fig. 8 can be explained by the two separate curves derived in this paper. As seen in Fig. 8, the first is the bell curve that can be obtained based on changes in the search traffic, which reflects the positive and negative responses arising from the initial enthusiasm and disappointment (Gartner's Hype Cycle). Secondly, the performance S-curve that shows how the accomplishments of innovation gradually reveal methods of improvement can be composed based on the trends in patent applications, which reflects the rational responses of the producers. By combining these two curves, I was able to confirm the pattern of the technology hype cycle as in Fig. 14, which combines the two components which exhibit a time lag.

The trend line for search traffic presented in Fig. 14 presumes a quadratic curve, and the trend in the intensity of the patent application percentage presumes an exponential growth with an intercept of 0. There remains the need, of course, to reconsider the time point at which the Trough of Disillusionment phase of the actual hype cycle passes, but nonetheless, this paper proposes a new method for measurement and observation based on an empirical demonstration of the hype cycle using only bibliometric data such as search traffic and patent application percentage.

6. Conclusion

This study offers multiple conclusions with implications for various cases in which it will be desirable to utilize the hype cycle or the technology life cycle. Firstly, this paper demonstrates that hype cycles can exist not only in the IT industry but also in other traditional industries. Secondly, the hype cycle can emerge for each of the various actors constituting the socio-technical system, but these cycles may differ in temporal periods. Thirdly, the two distinctive curves that constitute the hype cycle can be measured by trend analyses of search traffic and patent applications. However, the conclusions must not be overgeneralized to apply to all cases. As argued by Järvenpää et al. [13], among various technologies, there have been differences in the disclosures of information that would enable estimations of the technology life cycle. This is the reason that it will be necessary to continue the study of the hype cycle in other industries and in various other forms of innovation.

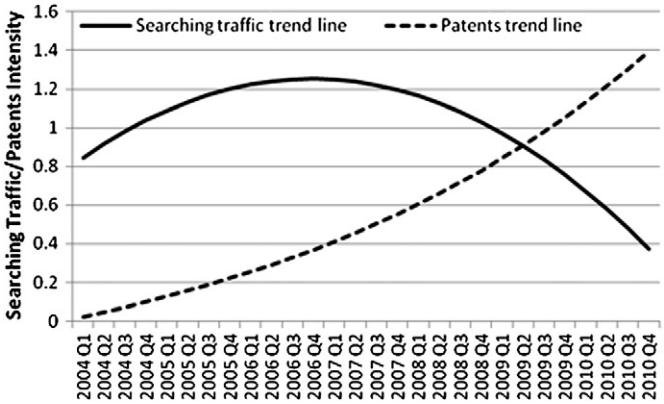

Fig. 14. Outcome of the observation of the hype cycle using search traffic and patent application percentage.

Though my case study analysis offers only a limited value for generalization, there are other significant implications that can be derived from this study. In the process of securing a more objective understanding of consumer behavior through a bibliometric approach, I raised the caveat that the promise of a particular technology should not be evaluated based exclusively on the frequency changes found in indices such as search traffic. Consumer groups are not homogenous, and therefore it is possible that the search traffic trend may inversely exhibit a decline during the growth phase. For this reason, a more objective assessment of the promise or diffusive potential of a technology can be made when the life cycle (or adoption model) is simultaneously analyzed in conjunction with the hype cycle. In particular, the hype cycle, which exhibits more dynamic movements compared to the life cycle in the early stage of the introduction of a new product, will enable these changes to be measured with greater ease, and in the same vein, I also demonstrated that from the growth phase the measurement of indices related to the conventional life cycle will provide much information.

Also, this paper has confirmed that for the purpose of estimating the speed of diffusion in accordance with innovation diffusion models such as the Bass diffusion model, various indices such as search traffic, news exposure, patents, etc. can be used as the subject of bibliometric analysis. In particular, by verifying that these indices can demonstrate the hype cycle, I confirmed the need for cautious consideration of the possibility of the existence of the hype cycle when applying the innovation diffusion model along with the bibliometric approach.

If empirical studies of various industries and types of innovations are hereafter implemented based on the results and methodology presented in this research, such studies will contribute to enhancing the objectivity and explanatory power of various analyses and forecasts utilizing technology cycles such as the hype cycle or the life cycle. Furthermore, I expect that these findings can also apply to the consumer behavior models utilized in many fields such as marketing, thereby even further extending the contribution of this study to the establishment of actual corporate strategies including marketing strategies.

One limitation of this study was that it ultimately relied on secondary data for the analysis of user hype cycles, despite the benefits of using Google, which provides a large volume of information regarding raw data and research methodologies.

Henceforth, there will need to be various additional empirical research to secure more generalizable conclusions about the hype cycle, as well as additional model research to illuminate the differences between the hype cycles of different actors within the socio-technical system as revealed in this paper. Further research ought to study the impact of decreases in patents and search traffic on the diffusion of technological innovations and new products over the mid-term and long term, as in the case of hybrid automobiles.

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