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The hype cycle model: A review and future directions

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ABSTRACT

The hype cycle model traces the evolution of technological innovations as they pass through successive stages pronounced by the peak, disappointment, and recovery of expectations. Since its introduction by Gartner nearly two decades ago, the model has received growing interest from practitioners, and more recently from scholars. Given the model's proclaimed capacity to forecast technological development, an important consideration for organizations in formulating marketing strategies, this paper provides a critical review of the hype cycle model by seeking evidence from Gartner's own technology databases for the manifestation of hype cycles. The results of our empirical work show incongruences connected with the reports of Gartner, which motivates us to consider possible future directions, whereby the notion of hype or hyped dynamics (though not necessarily the hype cycle model itself) can be captured in existing life cycle models through the identification of peak, disappointment, and recovery patterns.

1. Introduction

There are many uncertainties associated with technological development. Application realms, customer groups, technical feasibility and performance potentials, and related economic attributes remain hidden from the knowledge of actors that provide input, including innovating firms, governments, research institutions, and finance providers. Stylized depictions such as the diffusion of innovations (e.g. Rogers, 1962), product life cycle (e.g. Klepper, 1996), industry life cycle (e.g. Agarwal et al., 2002), and technology life cycle (e.g. Abernathy and Utterback, 1978) models aim to reduce these uncertainties through the repeated patterns of developmental trajectory they portray. Using these models, multiple actors can make forecasts to assist their resource investment decisions in the absence of complete knowledge of future technological prospects (e.g. Gao et al., 2013). Notwithstanding, forecasting the development of nascent technologies and products, in other words the very early stages of life cycles, remains difficult, given the technical, economic (e.g. supply and market demand), and political barriers that require circumvention, which serve to significantly delay or perhaps even prohibit market penetration (e.g. Kurawarwala and Matsuo, 1998; Ortt et al., 2007; Dismukes et al., 2009; Feng, 2015).

An attractive framework that has recently been introduced to enhance the analysis and forecasting of technologies during the early period of their development is the 'hype cycle model'. Developed by Gartner Inc., this model explains a general path a technology takes over time, in terms of expectations or visibility of the value of the technology. The model proposes that technologies progress through successive stages that are pronounced by a peak, followed by disappointment, and later a recovery of expectations (Fenn and Raskino, 2008). In this manner, the model depicts what has been dubbed the First Law of Technology, stating that "we invariably overestimate the short-term impact of a truly transformational discovery, while underestimating its longer-term effects" (Collins, 2010).

The hype cycle model has gained substantial attention from practitioners, and although its dissemination has been relatively limited in academic circles, there is burgeoning interest within the TIM (technology and innovation management) literature over the past decade as well (evident especially in the Technological Forecasting and Social Change journal). Indeed, the attention afforded by scholars has led to the model's growing maturity as quantitative methods focusing on specificity (e.g. with content analysis) have been combined with qualitative methods to ascertain the emergence of hype in TIM contexts (e.g. Konrad, 2006; Alkemade and Suurs, 2012; Jun, 2012a). Given these recent trends and the importance of forecasting the trajectories and life cycles of new technologies from an organizational standpoint, to which end the hype cycle model has been proposed, the objective of this paper is to review the operationalizability of the model through empirical examination. For this purpose, we seek evidence directly from Gartner that technologies progress through the sequential stages of the hype cycle model, thus providing confidence of the model's repeatability, a characteristic of already established life cycle models. Using a two-step approach, we firstly undertake a longitudinal study of 46 technologies analyzed by Gartner in one of their report series — "technologies for utilities and the energy sector". We secondly examine the hype cycle conforming behavior of three technologies from this collective – tidal power, IGCC (Integrated Gasification Combined Cycle), and

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photovoltaic generation – by comparing Gartner's reported progression of these technologies along the hype cycle curve with real empirical data obtained from Google News and Google Insight.

The results of our empirical work show incongruences connected with the reports of Gartner, thus questioning the reliable applicability of the hype cycle model. Notwithstanding, the notion of hype or hyped dynamics, though not necessarily the hype cycle model itself, presents an important addition to existing life cycle models in the TIM research field, which are important tools for understanding and forecasting the adoption of technological innovations by consumers. In this regard, to attain a comprehensive understanding of the over-enthusiasm that may (or may not) eventuate in relation to a new technological innovation we believe that Rogers (1962) diffusion of innovations framework presents a fruitful starting point. From the elements that constitute this framework, and in alignment with Jun's (2012a) recent work, we propose that hypes in TIM contexts should be sought with respect to the media, social system, and the innovation itself, which experience change over time. We additionally suggest that an understanding of hype dynamics in the industry, product, and technology life cycles (e.g. Phillips, 2001; Ortt and Schoormans, 2004; Routley et al., 2013) can provide valuable information for organizations while extending the existing, stylized theoretical models.

2. The hype cycle model

Introduced in 1995 by Gartner Inc. the hype cycle model explains a generally applicable path a technology takes in terms of expectations or visibility of the value of the technology (y-axis) in relation to time (x-axis). It is formed by merging two distinct equations/curves that, after Hubert Delay from Gartner, explains the hype curve shape for new technologies, as shown in Fig. 1. The first equation is human centric and describes expectations in the form of a hype level curve. The second equation is a classical technology S-curve aiming to depict technology maturity (Fenn and Raskino, 2008).

The bell shaped curve of expectations/hype is firstly based on a sudden, overly positive and irrational reaction on the introduction of a new technology. Fenn and Raskino (2008) argue that three human nature phenomena are responsible for the curve's shape: attraction to novelty (and the love for sharing), social contagion, and heuristic attitude in decision-making. Together, these phenomena lead people to assess a new technology's potential with overenthusiasm. The media additionally tend to focus on potentially big stories and the resulting collective hypes the number of supporters over a critical mass. Once a technology begins to hype, decision makers in organizations may follow the trend rather than carefully assessing the technology's potential themselves. This is potentially a dangerous tactic as the sharp peak of enthusiasm of the new technology is often followed by disappointing early results of the first generation of applications, causing the hype to suddenly ebb and collapse into a trough.

The second equation that forms the hype cycle is the S-curve, which describes technological maturity based on the notion of technical performance. Technology S-curves can be traced back to the findings of Dosi (1982) who distinguished between continuous or incremental changes, where technologies follow a trajectory defined by established technological paradigms, and discontinuous or radical changes sponsored by the emergence of new technological paradigms. By comparing the changes in a single technological performance parameter with respect to exerted R&D efforts, Foster (1986), in turn, has suggested that these trajectories are S-curve shaped. He showed that the maturity of a technology develops slowly in the beginning as its fundamentals are poorly understood and investments into pilots and early adoptions may result only in minor performance gains. Notwithstanding, at some turning point technological performance takes off until a plateau is reached, defined by the limitations of the technology with an upper limit due to physical barriers or cost-prohibitions.[1]

As indicated in Fig. 2, the hype cycle can be divided into five distinct phases: innovation trigger, peak of inflated expectations, trough of disillusionment, slope of enlightenment, and plateau of productivity (Fenn and Raskino, 2008). Each phase is marked by indicators that allow the assessment of the stage of development of a given technology.

Innovation trigger: A public announcement or demonstration triggers the cycle. Awareness about the technology starts to spread and attracts first media coverage. Venture capitalists and adopting companies aim to capitalize on possible first mover advantages.

Peak of inflated expectations: This phase is characterized by high expectations boosted or hyped further by media coverage. Following a bandwagon effect, companies invest without having a clear strategy or sound business case.

Trough of disillusionment: The overenthusiasm and hyped investments result in commercial adoptions that fail to meet performance and/or revenue expectations. Public disappointments spread and are again hyped by media, this time negatively.

Slope of enlightenment: Some early adopters who continued working with the technology begin to experience net benefits and regain motivation. With more investments, the contextual understanding of the technology grows, resulting in increasing performance. The technology begins to be socialized.

Plateau of productivity: The technology is realistically valued. Following successful market place demonstrations, the adoption accelerates.

The time between the peak of inflated expectations and the plateau of productivity has been termed the ‘time-to-value gap’ (Fenn and Raskino, 2008). This gap may differ depending on each technology's performance constraints, integration complexity, and penetration potential. As a result, the hype cycle pertaining to different products may vary between two years and two decades, although so-called ‘normal technologies’ are anticipated to take five to eight years, in contrast to ‘fast track technologies’ which are deemed to need only two to four years to reach maturity. On the contrary, ‘long fuse technologies’ may go through several hypes and troughs.

2.1. The hype cycle model in the literature

To understand the utilization of the model by the scholarly community, we explored the TIM (technology and innovation management) literature. Our review was designed to reveal the number of publications as well as the predominant outlets (i.e. journals and conference proceedings) citing the concept, and at the same time provide an overview of the theoretical contributions and empirical findings provided by scholars.

We undertook a systematic approach to study the TIM literature. First, we accessed the ISI Web of Science database and conducted a search for the exact phrase “hype cycle” in the title, abstract, and keywords of published journal and conference papers.[2] The results of the bibliometric study show that a total of 30 works have been published since the year 2000. And while there is notable growth in the number of publications from the year 2007 onwards,[3] our results indicate the nascence of this theoretical framework in the academic context. We then read through the abstracts of the 30 publications and established a list of six publications that had explicitly discussed or employed the hype cycle model in the TIM research context.

[1] It must be stressed that the discussion on generalizing technology S-curves is far from concluded with opposing literature. Equally disputed is the ability of S-curves to serve as forecasting tools (Christensen, 1992).

[2] This search was conducted on 10 July, 2013.

[3] According to the ‘citation report’ of the ISI Web of Science, these publications have collectively obtained a total of 70 citations, with an average of 14 citations per year.

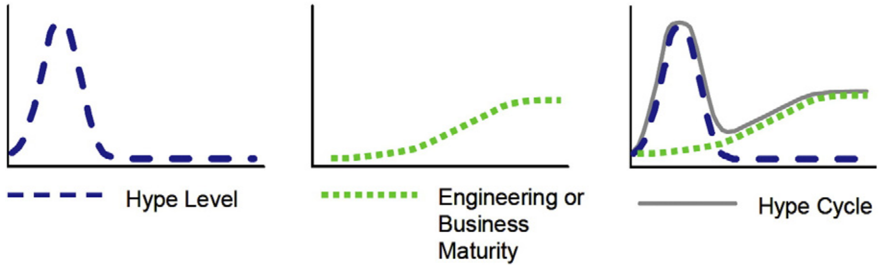

Fig. 1. The two curves that form the hype cycle (adapted from Fenn, 2007).

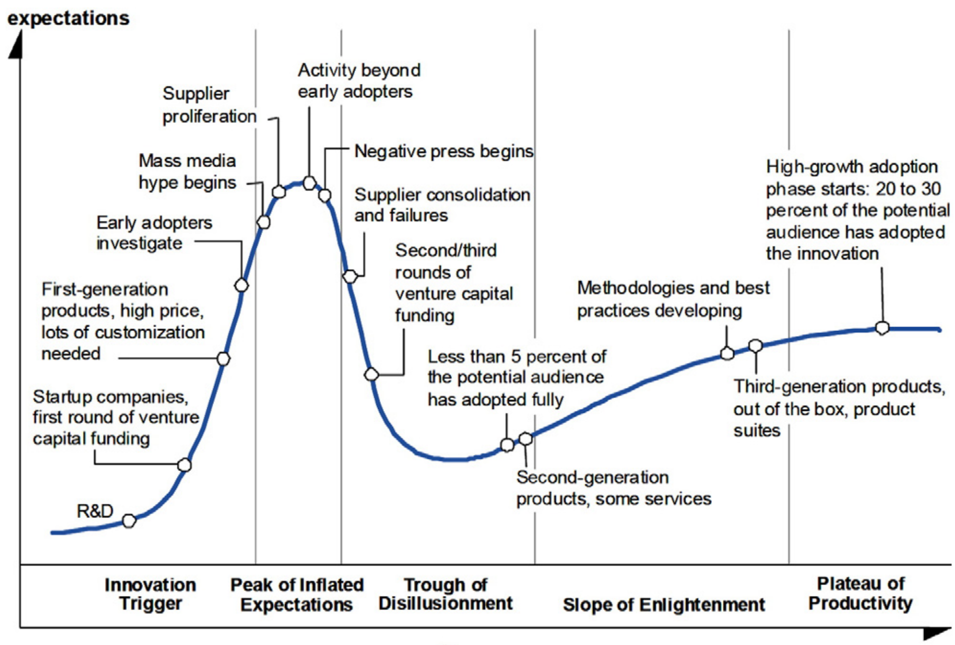

Fig. 2. The hype cycle and its stage indicators (adapted from Fenn and Raskino, 2009).

Second, we conducted a search for the exact phrase "hype cycle" in the full text of papers published in the top 12 TIM journals, as listed by the Technovation journal in 2012 (Linton, 2012).[4] To our surprise, only four of the 12 journals actually published papers that referred to the hype cycle, indicating once again the relative infancy of the model within the TIM field. All in all, 27 papers citing the framework were collected from the top TIM journals, with Technological Forecasting & Social Change emerging as the clear leader with 19 citing papers.

After accounting for any overlaps, we were left with a total number of 32 papers from the two systematic approaches. We continued our review of the gathered literature by analyzing the content of these papers. Our examination showed that 21 papers had not employed the hype cycle framework with sufficient level of depth (either briefly mentioning the concept within the text or in the reference listings) and were therefore omitted from further analysis. Brief synopses of the remaining 11 papers, thematically grouped, are provided below. synopsis摘要

[4] The top 12 TIM journals (as determined by impact factor) are: Technovation, Research Policy, R&D Management, Journal of Product Innovation Management, Technological Forecasting and Social Change, Industrial and Corporate Change, Journal of Technology Transfer, Journal of Engineering and Technology Management, IEEE Transactions on Engineering Management, Research Technology Management, Industry and Innovation, and Technology Analysis and Strategic Management.

2.1.1. Early validation attempts of the hype cycle model with quantitative data

Two conference papers by Järvenpää and Mäkinen, published in 2008, stand out as early and seminal works in the application of the hype cycle model to real empirical data. The authors not only use the hype cycle or its technology forecasts as an argumentative tool, but also attempt to build the theoretical foundation of the model itself (Järvenpää and Mäkinen, 2008a, 2008b). An important contribution of these works is the consideration of "technology life cycle indicators" (Watts and Porter, 1997) when plotting the visibility of a technology (e.g. DVD, MP3, Bluetooth, and Blu-ray) over time. An implicit hypothesis the authors make is that peaks in the visibility of technologies will occur earlier in applied research articles (e.g. Compendex documents) than in the mainstream news articles (e.g. general English language news on the LexisNexis database). However, the results for the MP3, Bluetooth, and Blu-ray technologies refute this proposition, contrary to Watts and Porter's (1997) theory, while the DVD technology provides solitary empirical evidence. Concerning the validation of the hype cycle model, the authors claim there to be hype dynamics in both the mainstream and technical news for the MP3 and Bluetooth technologies, but not so for the Blu-ray technology, while the DVD technology appears to display partial hype dynamics.

Although we mostly agree with these conclusions, we believe that the visibility of the MP3 and Bluetooth technologies in the technical news (as presented in these papers) does not produce clear hype dynamics. For the continued development of the framework, the evident inconsistencies have motivated Järvenpää and Mäkinen (2008a) to emphasize the benefit of analyzing the content of publications to assess whether the counts accurately represent the technology's visibility.

2.1.2. Extending the hype cycle with content analysis

We identified three articles in our literature review that have employed content analysis to unravel the causes of hyped behavior. Alkemade and Suurs (2012), firstly, analyze expectations connected with three sustainable mobility technologies in the Netherlands, namely, biofuels, hydrogen, and natural gas (fuels used in automotive transport). In their empirical study, the authors employ an event history analysis methodology, scouring the Lexis/Nexis database for events pertaining to the three emerging technologies in sustainable mobility between the years 2000 and 2008. Concurrently, the authors establish some key characteristics of each event, including whether the content of the expectation is positive or negative, whether the expectation is general (e.g. ability of the technology to solve societal problems) or specific (e.g. when statements concern technological performance), whether the expectation is a short or long term one, and also the actor that is stating the expectation. Their results show a general increase in the number of events (positive or negative) over time. While the authors claim there to be hype cycle dynamics for all three cases, we interpret the graphs differently. Rather, we observe multiple peaks and troughs of varying magnitudes across time for natural gas and hydrogen technologies, in contrast to two predominant pairs of peak and trough for the biofuels technology.

In the second paper, Konrad et al. (2012) investigate the strategic reactions of actors involved in the development of the stationary fuel cell innovation in German speaking countries to hype dynamics. In particular, the authors consider the sensitivity of organizations to react to changing expectations. The results of the empirical research firstly show typical hype cycle dynamics, as measured through the number of articles with “fuel cell” in the title published in the German daily newspaper Frankfurter Allgemeine Zeitung, with a rise from 1997 until 2001, followed by a period of disappointment lasting until 2007, and a rise in the number of articles thereafter. Notwithstanding, the authors note that fuel cells have progressed through multiple hype-disappointment cycles, and further, that their present study analyzes the most recent of these cycles. The authors also conduct content analysis of the articles reporting on fuel cells along two dimensions. Focusing on actors and application realms, they firstly observe that announcements by car manufacturers were largely responsible for triggering the hype in 1997, with a shift to stationary applications (e.g. for single and multiple family houses) and then to heating manufacturers by 1999. Secondly, the authors assess the level of optimism (ranging from very optimistic to skeptical), with their results indicating a large portion of very optimistic articles during the period of increasing hype, and diminishing optimism during the period of disappointment.

And thirdly, Rachul and Zarzeczny (2012) show hype cycle dynamics in the field of functional neuroimaging through the numbers of commentary and review articles published in mainstream scientific journals about this topic over time. Preliminary content analysis indicates burgeoning skepticism concerning the technology in the literature. To uncover the reasons for this trend the authors review the contents of the articles further and establish categorical themes regarding the content of skepticism. Some of the emergent explanatory themes include methodological challenges and limitations, limitations with the technology, and ethical concerns regarding privacy issues.

2.1.3. Qualitative assessment of hyped expectations

We identified three papers from our review that employed qualitative means to establish hyped expectations. In the first paper, Konrad (2006) begins by distinguishing ‘specific expectations’ that are attributable to individual actors, and ‘collective expectations’ that are pervasive and attributable to groups of actors. In turn, the author conducts two case studies of the e-commerce and interactive TV technologies. Quantitative analysis, as determined from the number of articles published in German daily newspapers citing the two technologies, show a hype-disappointment pattern for e-commerce, but fluctuating dynamics for interactive TV. Qualitative assessment of this hype, using data acquired from interviews and publically available documents, reveal that tightly knit expectations at the specific (or project) level and collective level can help explain the dynamics leading to a hype-disappointment sequence. As witnessed in the case of interactive TV, positively spiraling enthusiasm takes place as project level expectations feed collective expectations, which in turn, further increases project level expectations. And conversely, negatively spiraling enthusiasm reduces interest at both the project and collective levels.

Ruef and Markard (2010), in the second paper, claim that diminishing media attention does not necessarily coincide with disappointment and reducing expectations. In other words, the authors differentiate between ‘expectations’, a qualitative construct, and ‘attention’, a quantitative construct that aligns with Gartner's visibility. In their empirical analysis, the authors analyze the stationary fuel cell technology in the context of German speaking countries. Through discourse analysis of articles published in newspapers they assess expectations, as “real-time representations of future technological situations and capabilities”. Qualitative results are interpreted to reveal three successive periods of rediscovery, hype, and disillusionment, which align with quantitative results displaying a rise followed by a fall in media interest. The results also show that framed optimism continues throughout the period of analysis, while generalized expectations reduce together with diminishing attention in the media. However, innovation activities are unaffected, possibly due to the persistence of positive framing.

And in the third article, van Lente et al. (2013) propose three variables to determine the hype curve: shape of the peak, depth of the trough, and overall length of the hype, and further, that variations in hype patterns with respect to these variables rely upon two dimensions. The authors firstly suggest that increased specificity of the technology's application area reduces the likelihood of rising expectations beyond the trough of disillusionment. And, secondly, they suggest that environmental factors, such as funding opportunities, complexity of regulatory settings, and business potentials, can positively influence the resurgence of expectations following the trough of disillusionment. To test these propositions the authors study the shape of hype curves associated with the VoIP (voice over internet protocol), gene therapy, and high-temperature superconductivity technologies. The VoIP technology is claimed to display hype dynamics (peak, trough, followed by recovery) from the qualitative assessment, despite positive value sentiments over time. The quantitative results on the contrary show oscillating behavior of visibility. The authors observe partial hype dynamics for the gene therapy technology with the peak of inflated expectations followed by two troughs, however, without a subsequent period of recovery. The quantitative results, nevertheless, appear to underline the presence of multiple peaks and troughs in visibility. Partial hype dynamics is also observed for high temperature superconductivity, with a long period of disillusionment following a sharp peak.

2.1.4. Modeling hype with consumer search traffic

Jun and co-authors have published three papers that promote the use of the ‘search traffic’ technique for studying and forecasting technological adoption.[5] In the first article, Jun (2012a) explores the relationship between search traffic and the WTI (West Texas Intermediate) oil price, and then the relationship between search traffic and US GDP growth. While the findings are claimed to confirm hype cycle dynamics in search activities of users, in particular through the manifestation of a

[5] The search traffic method refers to the accumulating data associated with the search queries made by individuals using a search engine, such as Google.

Table 1
Review of the hype cycle model and its application in the TIM literature.

Authors	Outlet	Year	Empirical context	Y axis	Data source	Claimed pattern	Our assessment	Alignment
Konrad	Technology Analysis & Strategic Management	2006	e-Commerce	Article count	Mainstream newspaper	Hype-disappointment	Hype-disappointment	Yes
			Interactive TV	Article count	Mainstream newspaper	Fluctuating dynamics	Fluctuating dynamics	Yes
Järvenpää & Mäkinen	International Engineering Management Conference	2008	DVD	Article count	All English language news	Continuous rise	Continuous rise	Yes
			DVD	Article count	Mainstream newspaper	Hype-disappointment	Hype-disappointment	Yes
			DVD	Article count	Professional magazine	Hype cycle	Hype-disappointment	No
Järvenpää & Mäkinen	International Conference on Industrial Engineering and Engineering Management	2008	MP3	Article count	All English language news	Hype cycle	Hype cycle	Yes
			MP3	Article count	Engineering documents	Hype cycle	Hype-disappointment	No
			Bluetooth	Article count	All English language news	Hype cycle	Hype cycle	Yes
			Bluetooth	Article count	Engineering documents	Hype-disappointment	Hype-disappointment	Yes
			Blu-ray	Article count	All English language news	Continuous rise	Continuous rise	Yes
			Blu-ray	Article count	Engineering documents	Hype-disappointment	Hype-disappointment	Yes
Ruef & Markard	Technology Analysis & Strategic Management	2010	Stationary fuel cell	Article count	Mainstream newspaper	–	Hype-disappointment	No
Alkemade & Suurs	Technological Forecasting & Social Change	2012	Biofuels	Article count	Newspaper & profess. journal	Hype cycle	Multiple peaks & troughs	No
			Hydrogen	Article count	Newspaper & profess. journal	Hype cycle	Multiple peaks & troughs	No
			Natural gas	Article count	Newspaper & profess. journal	Hype cycle	Hype cycle	Yes
Konrad et al.	Technological Forecasting & Social Change	2012	Stationary fuel cell	Article count	Mainstream newspaper	Hype cycle	Hype cycle	Yes
Rachul & Zarzeczny	International Journal of Law and Psychiatry	2012	Neuro-imaging	Article count	Scientific journals	Hype cycle	Multiple peaks & troughs	No
Jun	Scientometrics	2012	Hybrid car	Search traffic	Google trends	Hype-disappointment	Multiple peaks & troughs	No
Jun	Technological Forecasting & Social Change	2012	Hybrid car	Search traffic	Google trends	Hype-disappointment	Multiple peaks & troughs	No
Jun et al.	Technological Forecasting & Social Change	2014	Hybrid car	Search traffic	Google trends	Trough of disillusionment	Multiple peaks & troughs	No
van Lente et al.	Technological Forecasting & Social Change	2013	VoIP	Article count	Mainstream newspaper	No hype cycle	Fluctuating dynamics	No
			Gene therapy	Article count	Mainstream newspaper	Hype-disappointment	Hype-disappointment	Yes
			High-temp supercond.	Article count	Mainstream newspaper	Hype-disappointment	Hype-disappointment	Yes

trough of disillusionment, we interpret the data to show multiple peaks and troughs of varying magnitudes rather than a distinct hype pattern theorized by Gartner. In a subsequent paper, Jun (2012b) studies hype cycles pertaining to three core actors that constitute a socio-technical system, namely, the user, the producer (or researcher), and information distributor. Data is gathered from search traffic generated by web searches for the user, patent applications for the producer, and news reports for the information distributor. The results are suggested to display hype cycle dynamics for the search traffic (i.e. technology users) and news reports (i.e. information distributor), although our own assessment is once again not in alignment with the author's interpretation. And thirdly, Jun et al. (2014) employ the research method of webometrics (e.g. Google trends), in using keyword searches pertaining to the technology (i.e. hybrid car), the brand name (i.e. Prius), as well as the price and mpg (miles per gallon) metrics. For comparison reasons, the authors also explore possible linkages between patent counts and hybrid car sales, as well as news counts and sales, in line with technology life cycle indicators. Their empirical work shows that the traffic of searches for brand name has explanatory power of market sales (i.e. adoption) of the hybrid car, but the searches for the technology do not. The authors suggest that the rapid decrease in search activity despite increasing hybrid car sales volume is partly caused by the hype cycle phenomenon. In other words, consumers' interest in the hybrid car diminishes as a result of unfulfilled expectations in mpg performance. Nevertheless, our own inspection of the search traffic results do not provide convincing support for hyped dynamics as claimed by the authors.

2.1.5. Synthesis of the literature review

In Table 1 we present an overview of the works employing the hype cycle model in the TIM literature. Our summary shows that a total of 15 different empirical contexts have been investigated by scholars. Interestingly, a majority of these pertain to relatively recent innovations, dating to the end of the 20th or beginning of the 21st centuries. We observe strong agreement among scholars that the dependent variable of visibility (or expectations) proposed by Gartner can be measured as the number of articles citing a given technology. Only Jun and his colleagues have taken a recent point of departure from this approach by using search traffic as an alternative means of quantifying visibility. There appears to be similar consensus among authors as to the source for acquiring quantitative data on visibility, namely, mainstream news (or newspapers). However, as argued by Järvenpää and Mäkinen (2008a, 2008b), taken on their own, mainstream publications may not tell the complete story of hyped behavior, and therefore need to be supplemented by research into technical publications. This is commensurate with our own perception that hype phenomena may be observed differently by various stakeholders.

The meta-analysis summarized in Table 1 importantly notes the large diversity in emerging patterns of visibility. In fact, from the 23 empirical results listed, only nine cases are explicated by the authors to have manifested a hype cycle pattern.[6] In eight other cases, the authors have perceived a hype-disappointment pattern, which, in the absence of a recovery period following disappointment, does not represent a complete hype cycle in our view. This means that hype cycles, as theorized by Gartner, were found in less than half of the cases.

Furthermore, after our own assessment of the claimed hype cycle patterns in the literature, we believe there to be only four cases – MP3, Bluetooth (in all English language news), natural gas (in newspaper & professional journals), and stationary fuel cell (in mainstream newspapers) – that align with Gartner's hype cycle. For the remaining cases, we observe nine instances of a hype-disappointment pattern, together with six instances of multiple peaks and troughs (i.e. frequent, irregular ups-and-downs in visibility), and two cases of fluctuating dynamics (i.e. a discernible oscillation in peaks and troughs). Altogether, the lack of consistency among TIM scholars in their empirical observations, together with the notable disagreement between claimed visibility (hype) patterns and our own assessment of the same patterns, question the applicability of the hype cycle framework.

3. Reconsideration of the hype cycle model: an empirical examination

Based on the annual monitoring and hype cycle analysis of around 1500 commercially viable technologies, trends and applications in 80 IT, business and consumer markets, Gartner elaborates numerous hype cycle reports for industries, and derives consulting advices for specific client companies. Nevertheless, the theoretical underpinnings of the hype cycle model create some uncertainty as to the applicability of this framework in the analysis and forecasting of technological development, as also evidenced in our overview above. Firstly, the mathematical summation of two discrete evolution models (i.e. the human centric, hype expectations model, and the technology S-curve model) to form a singular model (i.e. the hype cycle model) seems questionable, as the underlying theories measure different phenomena. Even when considering time as the joint independent variable (x-axis), the dependent variables of both theories remain disparate and cannot be placed simultaneously upon the same y-axis. Moreover, operationalized parameters of a singular, physical performance measure (for technological maturity) and enthusiasm (for hype expectation) do not necessarily add up to Gartner's chosen variable of visibility (or expectations).

A second concern, connected with the above, lies in the definition of the y-axis. At its core, the vertical axis of the hype cycle framework is imprecisely defined, and Gartner's publications shift between the concepts of 'expectation' and 'visibility' in labeling this axis. Despite defining expectation as "expected future value of an innovation", and visibility as "technology presence rate on media channels, conferences as well as in interpersonal conversations" (Fenn and Raskino, 2008), no operational definition is provided. Both of these dependent variables lack quantification, notwithstanding Fenn and Raskino's proposition that "a growing availability of tools that will combine quantitative article counts" as "article references to an innovation can be a very useful proxy measure of expectations".

And thirdly, as underlined by Alkemade and Suurs (2012), expectations are expressed by different actor groups, including entrepreneurial firms (who enter the industry with a new technology), incumbent firms (who are threatened by the new technology), governments (who see opportunities to push for new policies through the new technology), as well as NGOs and lobby groups. It is consequently unclear whether the expectation pattern proposed by Gartner is a generic trend anticipated to emerge over time with respect to each stakeholder, or whether it is a composite pattern. Following Alkemade and Suurs' argument, we propose that a framework analyzing hype patterns should be sensitive to particular stakeholders.

These theoretical concerns have motivated us to reconsider the hype cycle model and explore its robustness through an empirical examination, which we undertake in two steps. In the first we conduct a longitudinal study of the technologies analyzed by Gartner in one of their report series — 'technologies for utilities and the energy sector'. The intention of this initial step is to explore the applicability of the hype cycle model for a collection of technologies (46 in all) that have been deemed to be categorically similar. In the second step, we focus specifically on three technologies from the group of technologies investigated in step one to test whether these technologies empirically show hype cycle conforming behavior.

3.1. Longitudinal exploration of technologies for utilities and the energy sector

In this preliminary review, we aim to find evidence, directly from Gartner, that technologies progress through the five stages of the hype cycle model, thus providing confidence of the model's analytical capability. To this end, we have accessed data on technologies for utilities and the energy sector provided by Gartner, which we assume is complete and consistent. Nevertheless, it must be noted that a longitudinal comparison of technologies is not readily available from Gartner's database. Hence, we have conducted our study by noting and listing the temporal development of utilities and the energy sector technologies along the hype cycle curve from the information accessible on Gartner's individually published annual reports. Table 2 provides an overview of these reports and the number of technologies analyzed in each.[7] Altogether, 46 different technologies were assessed with respect to the hype cycle model across the reports published from 2003 until 2009, inclusively.

At face value, there appears to be a rather steady or gradually increasing number of technologies assessed by Gartner across time. However, a year-by-year examination of the data in Table 3 reveals a number of inconsistencies.

From 2003 to 2004, the 21 technologies in the analysis remain the same, although six technologies move one stage along the hype cycle model. By contrast, from 2004 to 2005, there is a substantial shift as 12 new technologies are added to the list, even though the total number of technologies hardly changes from 21 to 20. This change prohibits the reader from following Gartner's analysis rationale over time. Remarkably, no technology is considered to be at the last stage of the hype cycle model (plateau of productivity) in 2005. There is apparent stability in the years 2005, 2006, and 2007, with only one new technology entering the fray in each subsequent year. However, 2008 sees a significant rise in the number of technologies from 22 to 29, with five of the seven new technologies entering in the second stage of the hype cycle model. And the last report in 2009 evaluates 33 technologies. These inconsistencies have motivated us to look deeper into the individual technologies and their progression along the hype cycle.

Since Gartner defines a normal technology to pass through the hype cycle within five to eight years, an average 'stage speed' (i.e. stage changes per year) is expected to be between 0.625 and 1. For the full set of technologies listed in Table 3, however, we observe an average stage speed of only 0.23 stages per year, which translates to an average

[6] We interpret the hype cycle pattern noted by the authors to refer to a hype, disappointment, and recovery sequence in visibility or expectations.

[7] Our first impression when trying to compare hype cycles over time has been one of difficulty when searching Gartner's database. Links to previous and/or following years are not provided and the titles of the hype cycles have changed over time.

Table 2
Overview of Gartner's hype cycle reports on utilities and energy sector technologies.

Hype cycle report	Authors	Year	No. of technologies
Utility technology	Moore et al. (2003)	2003	21
Utility technology	Moore et al. (2004)	2004	21
Utility industry technologies	Sumic et al. (2005)	2005	20
Utility industry operational and energy technologies	Sumic et al. (2006)	2006	21
Utility industry operational and energy technologies	Sumic et al. (2007)	2007	22
Utility industry operational and energy technologies	Sumic et al. (2008)	2008	29
Utility industry operational and energy technologies	Sumic et al. (2009)	2009	33

hype cycle duration of 21.76 years, above even the longest prediction of Gartner's long fuse technology cycles. Other observations also challenge the analytical capability of the hype cycle model. For instance, four technologies enter Gartner's reports only in the final stage of the model, hardly relevant in terms of hypes and troughs. Assuming Gartner's data to be precise, we interpret this finding to suggest that technologies are capable of entering the plateau of productivity without experiencing inflated expectations or troughs of disillusionment. How far technologies progress along the model also seems to be unpredictable. Most technologies appear to be removed from Gartner's analysis without having passed through to the last stages. This observation leads us to question whether all technologies are expected to advance through all five stages identified in the model.

An equally disputable observation concerns the stage duration of some of the technologies. Our intuitive anticipation is for a very brief duration of peaking interest in a given technology, followed by longer periods in successive stages. And yet, quite a few technologies "peak" for two years, while some even manage to hover for three years at the peak of inflated expectations. Other examples that question the model pertain to technologies that do not seem to fully enter the hype cycle, remaining constrained to the early phases of innovation trigger and peak of inflated expectations. For example, 'hydrogen economy' lingers in the first stage for five years, while 'open SCADA' requires seven years to finally reach a peak in hype. There also appears to be subjectivity involved in the evaluation of market penetration of a given technology and the position of the technology along the hype cycle. For instance, both the wind generation and carbon capture technologies are estimated to have a market penetration between 5% and 20% of the target audience (Sumic et al., 2008). However, while the former is placed in the plateau of productivity stage, the latter is placed in the peak of inflated expectations stage of the cycle (even prior to the peak). Such examples hint at the arbitrary nature of technologies' positioning with respect to the hype cycle.

In addition to these incongruences in the framework itself, there are methodological discrepancies that emerge from our preliminary empirical review. The denomination of technologies in Gartner's database, for example, is not always consistent over time and thus makes temporal comparisons difficult. In one illustrative case, a single technology (high-tech advanced metering systems) was split into two separate technologies (advanced metering infrastructure LC&I, and advanced metering infrastructure residential/domestic), which were in turn reinterpreted to be positioned backward in the hype cycle in relation to the position of the original technology. Later, the two technologies were recombined into a single technology (advanced metering systems) and shifted to an earlier stage of the model. Overall, the analysis of Gartner's hype cycle reports from 2003 to 2009 suggests that individual technologies do not necessarily behave according to the model's assumptions. Furthermore, the observable model dynamics do not appear to consistently conform to Gartner's theoretical framework, with additional concerns born from methodological uncertainty.

3.2. Empirically testing technologies for hype cycle conformity

Our preliminary evaluation above raises some questions as to the consistent applicability of the hype cycle model for a range of technologies. To examine the model further, we have selected three particular technologies from the 46 listed by Gartner's technologies for the utilities and energy sector, namely, tidal power, IGCC (Integrated Gasification Combined Cycle), and photovoltaic generation, for more detailed analysis. The objective of this exercise is to compare Gartner's estimation of the progression of these technologies along the hype cycle curve, as plotted in Fig. 3, with real empirical data obtained from Google News. Our proposition is that for the hype cycle model to be robust, Gartner's published expectations should align with the empirical data.

As the above figure shows, Gartner predicts tidal power to have hyped in 2009 and IGCC to have started its descent into the trough of disillusionment at the same time, after ascending to the peak of inflated expectations from 2005 until 2008. By contrast, photovoltaic generation is expected to have already passed through the trough in 2008 and to be on the verge of entering the slope of enlightenment in 2009. All three technologies are forecasted to reach mainstream adoption in 5–10 years. In order to check the model's assumptions with reality, we first analyzed all three technologies in terms of their visibility in Fig. 4. To spot hype and trough formations, we used data from the Google News[8] archive and plotted the longitudinal presence of technologies in the media from 1990 until 2009. The heights of the bars in Fig. 4 represent the numbers (or counts) of articles (i.e. the proxy for visibility used in our analysis) found in relation to the search term used for each technology.[9]

The evolution of visibility connected with tidal power appears to align with Gartner's evaluation, with a peak of expectations occurring in 2008. Nevertheless, the counts of news articles do not completely adhere to the hype cycle pattern, with a series of minor peaks and troughs marking the period from 1990 until 2002. Furthermore, in the absence of more recent data stretching beyond 2009, it remains plausible that the peak of inflated expectations has yet to be surmounted. Although the IGCC technology is subject to similar perturbation for the first 10 years, two visibility peaks appear toward the end of our timeframe of analysis; one in 2006/2007, followed by a trough in 2008, and a second peak in 2009, possibly indicating the beginning of the slope of enlightenment. This pattern of visibility divulged for the IGCC technology is approximately one year ahead of the hype pattern expected by Gartner, which anticipates the peak of expectations in 2008. The pattern for the photovoltaic generation further demonstrates the difficulty in interpreting hype cycle patterns for some technologies. In the third panel of Fig. 4, it is unclear as to whether the trough of disillusionment has indeed occurred already in 1994–1995, or a few years later following a slight peak in 1996. Nonetheless, the larger peak of visibility in 2008 suggests that this technology is yet to descend into the trough of disillusionment, and further, that prior peaks and troughs are minor oscillations after the innovation trigger. Following this interpretation, a substantial misalignment can be noted between the results obtained from Google News and those born from Gartner's evaluation.

[8] Google News gathers data from worldwide sources, including newspapers, magazines, news and legal archives.

[9] While the values are based on absolute numbers, the y-axis and the specific data points are not presented in our plot, as Google does not give access to the absolute counts.

Table 3
The 46 utilities and energy sector technologies analyzed by Gartner (2003–2009).

ID	Technology	Innovation trigger	Peak of inflated expectations	Trough of disillusionment	Slope of enlightenment	Plateau of productivity	Time in cycle (years)	Ave. stage speed
1	Advanced energy storage 2008: split (a) consumer energy storage, and (b) provider energy storage	2005–2006 2008a–2009a	2007 2008b–2009b				5	0.2
2	Advanced-distribution protection 2008: renamed advanced-distribution protection and restauration carbon capture and sequestration devices			2005–2009			5	0
3	Application outsourcing		2003–2004				2	0
4	Business process outsourcing	2003	2004				2	1
5	Call centers					2003–2004	2	0
6	Combined heat and power		2008–2009				2	0
7	Combined heat and power		2008–2009				2	0
8	Commercial off-the-shelf customer information systems (COTS)/billing				2003–2004		2	0
9	Contact centers		2003	2004			2	1
10	Customer gateways/portals 2006: renamed customer gateways	2005	2006–2008	2009			5	0.4
11	Customer relationship management			2003	2004		2	1
12	Demand response		2005	2006–2009			5	0.2
13	Distributed generation	2005–2007	2008–2009				5	0.2
14	Energy management systems					2006–2009	4	0
15	Energy trading and risk management			2003–2004			2	0
16	Enterprise asset management				2003–2004		2	0
17	Enterprise resource planning					2003–2004	2	0
18	Flexible alternating current (AC) transmission systems		2005–2007	2008–2009			5	0.2
19	Geographic information systems/geographic information technology (GIS/GIT)		2003	2004			2	1
20	Geothermal power generation			2009			1	n.a.
21	High-tech advanced metering systems 2005: split (a) advanced metering infrastructure LC&I, and (b) advanced metering infrastructure residential/domestic 2009: rejoined advanced metering systems	2005a	2006a–2008a	2005b–2006b	2003–2004–2007b	2008b	7	0.57
22	High-temperature superconductivity	2005–2009					5	0
23	Home-area network		2008–2009				2	0
24	Human capital management (HCM)			2003–2004			2	0
25	Hydrogen economy	2005–2009					5	0
26	Integrated gasification combined cycle	2005–2006	2007–2008	2009			5	0.4
27	Intelligent electronic devices			2005–2009			5	0
28	IT outsourcing					2003–2004	2	0
29	Liquefied natural gas			2005	2006–2008	2009	5	0.4
30	Micro fuel cells 2005: renamed fuel cells	2003–2004		2005–2009			7	0.29
31	Mobile and wireless 2009: split (a) mobile communications & (b) mobile devices for utilities			2003–2005	2006–2008 2009a, 2009b		7	0.14
32	Open supervisory control and data acquisition (SCADA)	2003–2008	2009				7	0.14
33	Outage management systems (OMS)		2003	2004			2	1
34	Phasor measurement units		2009				1	n.a.
35	Photovoltaic generation			2005–2009			5	0
36	Plug-in hybrid electric vehicles	2008	2009				2	1
37	Power line communications 2004: renamed power line broadband 2005: renamed broadband over power lines	2003–2004	2005	2006–2009			7	0.29
38	Process data historians			2008	2009		2	1
39	RF networks for utility field applications				2009		1	n.a.
40	RFID for utilities 2008: renamed active RFID for Utilities			2007–2009			3	0
41	Security/surveillance		2003	2004–2009			7	0.14
42	Supply chain management		2003–2004				2	0
43	Thermal solar power generation 2009: renamed thermal (or concentrated) solar power generation		2008–2009				2	0
44	Tidal power		2009				1	n.a.
45	Wind generation				2005–2009		5	0
46	Work management systems			2004			1	0

Our results suggest that Gartner's hype cycle predictions do not conform with the data and patterns of visibility we have been able to muster from news coverage relating to two of the three technologies in question. Furthermore, our attempts to compare Gartner's estimations with the empirical data were hindered on each occasion by the multiplicity of peaks and troughs that were encountered in news press visibility, which remain absent from the stylized hype cycle model. Notwithstanding these non-conformities, we recognize that hype in

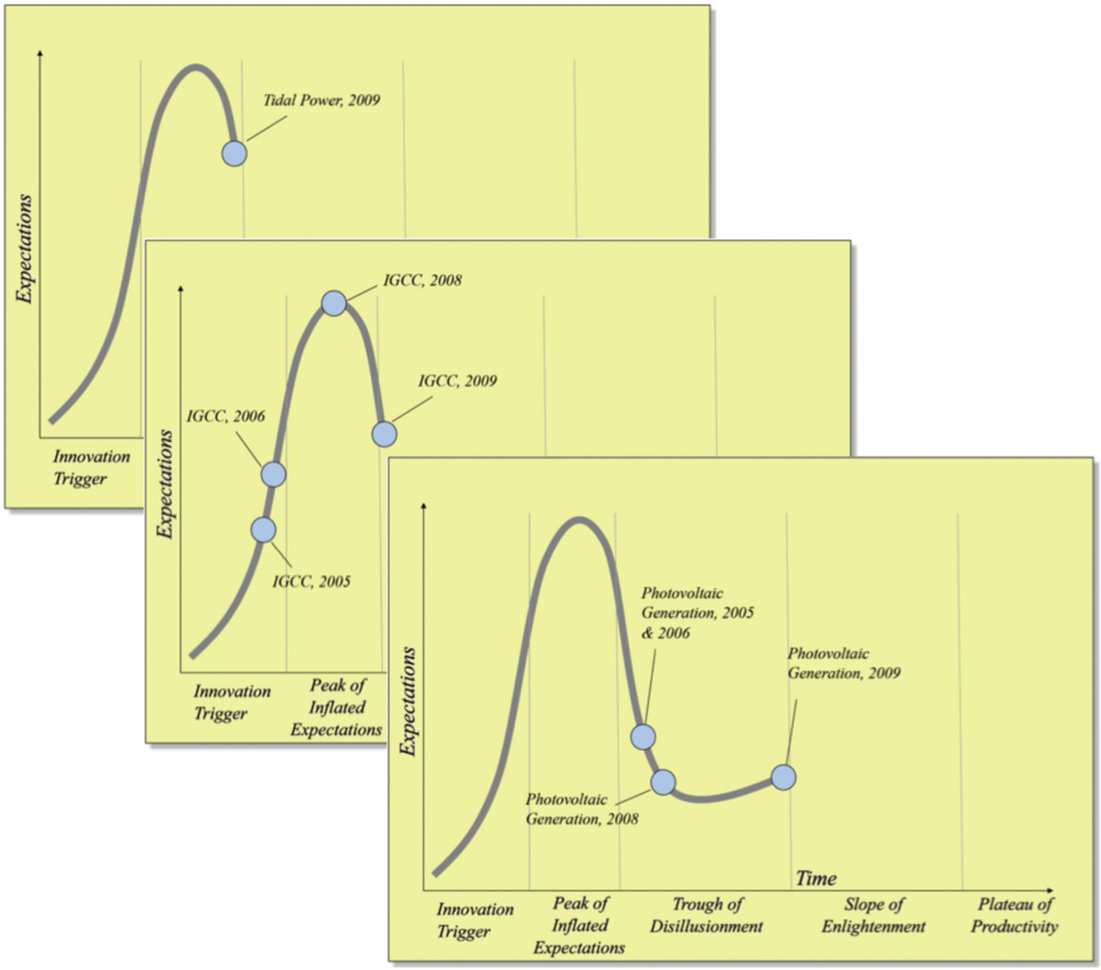

Fig. 3. Gartner's hype cycle for tidal power, IGCC, and photovoltaic generation technologies (adapted from Sumic et al., 2005, 2006, 2007, 2008, 2009).

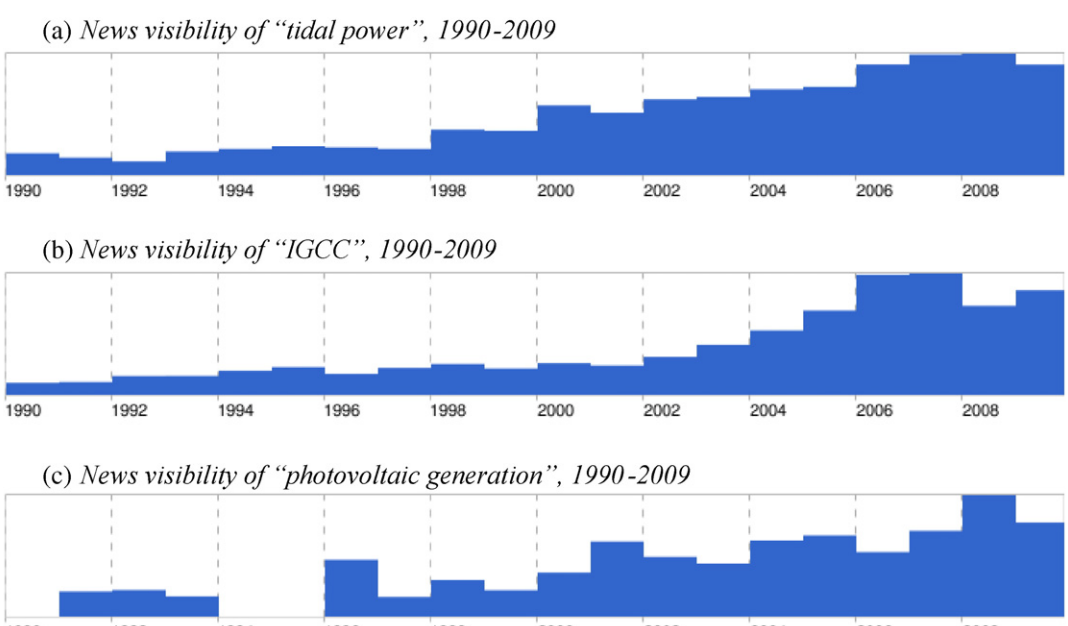

Fig. 4. Google News results on selected technologies, 1990–2009. (a) News visibility of "tidal power", 1990–2009. (b) News visibility of "IGCC", 1990–2009. (c) News visibility of "photovoltaic generation", 1990–2009.

news coverage might not indicate hype on behalf of all potential adopters. Moreover, hype indicates exaggerated growth with respect to a reference point or benchmark. We have therefore conducted a second empirical study that is designed to take these factors into account, and at the same time attempt to improve the alignment between Gartner's hype cycle assessment and real data pertaining to the three technologies. To this end, we have gathered data from Google Insight on the actual query behavior of users over time. In this manner, the act of searching for a certain technology on a search engine indicates the interest of the individual in that technology. The resulting search numbers are consequently taken as proxy of what Gartner circumscribes as expectations in their model.

Fig. 5 presents the results of our analysis by means of moving average and polynomial trend functions, which were normalized and

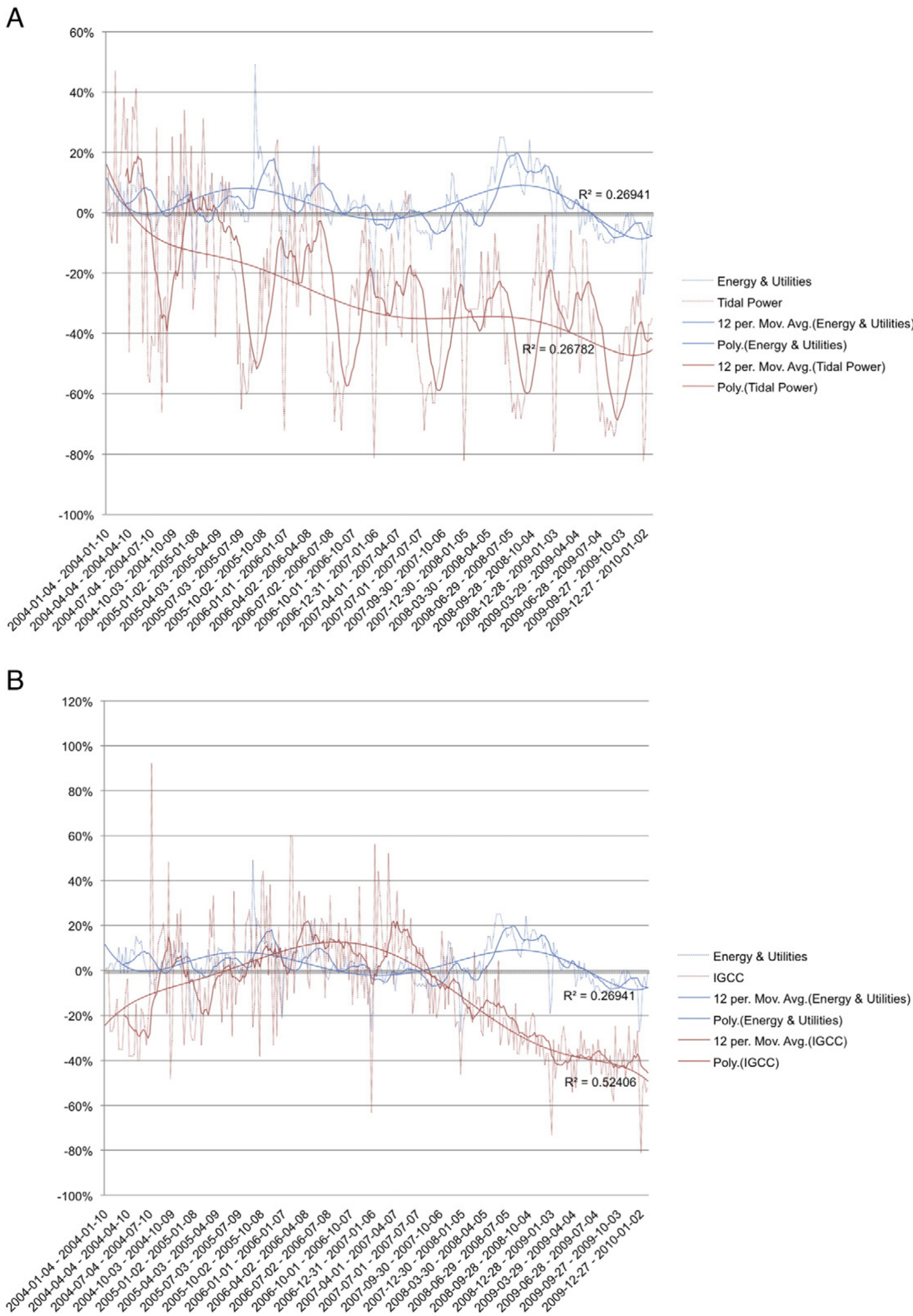

Fig. 5. (a) Searches for 'tidal power' in relation to all searches in the subcategory energy and utility. (b) Searches for 'IGCC' in relation to all searches in the subcategory energy and utility. (c) Searches for 'photovoltaic generation' in relation to all searches in the subcategory energy and utility.

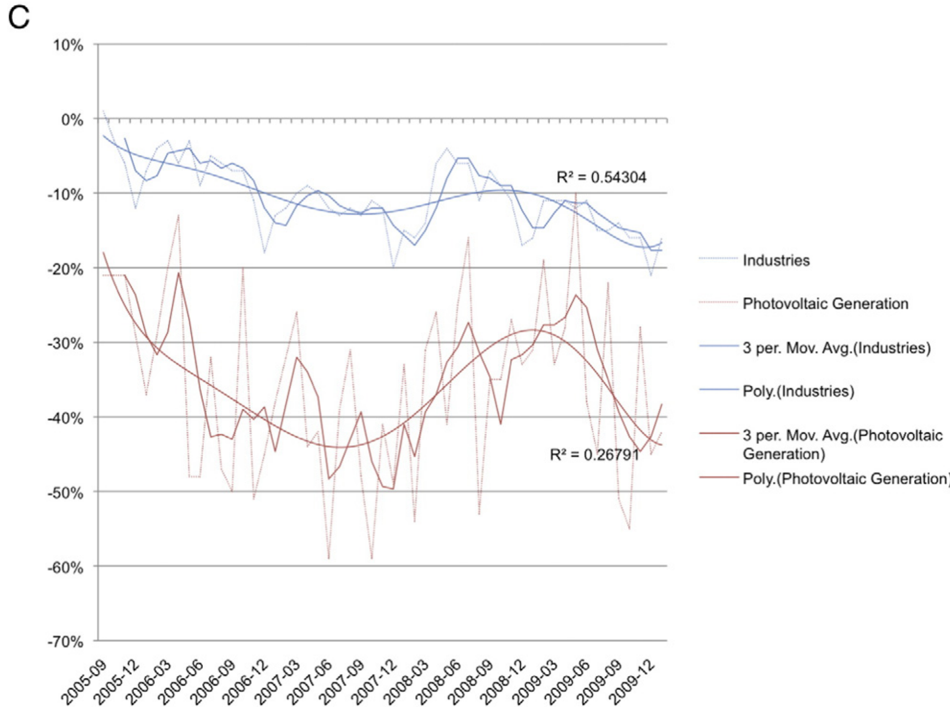

Fig. 5 (*continued*).

compared to the search term evolution for the Energy and Utility Industry as a whole. The figure includes the original data (dotted lines), collected on a weekly basis, for the changes in query behavior associated with the technology as well as the industry, together with a 12 week moving average and a polynomial function with six degrees derived from this data, the latter including R-square values.

The first panel in Fig. 5 shows searches for tidal power in relation to the general searches in the category of Energy and Utility Industry over a period stretching from 2004 until 2010. The figure clearly shows that tidal power has not been hyped in comparison to the general industry category, which is marked by two peaks in 2005 and 2008, respectively. We also note that the general shape of the tidal power search function is saw-tooth shaped in a recursive pattern, displaying six hypes and troughs across the timeframe of analysis, albeit with diminishing interest in the technology. Hence, the peak of inflated expectations in 2008 described by Gartner must be rejected. The search function related to IGCC in the second panel indicates that in comparison to the industry category, the smoothened polynomial function of the searches increases and peaks in the third quarter of 2006. This correlates with a strong peak in visibility based on Google News articles at approximately the same time (see Fig. 4) but is not in line with Gartner's analysis. And for the photovoltaic generation technology, due to the limited absolute number of searches, we collected data on a monthly basis instead of a weekly basis. Altogether, data corresponding to 53 months were collected, with a three month moving average and a polynomial function with six degrees derived from this data plotted. As the third panel of Fig. 5 shows, the search function for photovoltaic generation has a trough in mid-2007, followed by a short but strong peak at the beginning of 2009, before reducing interest once again. This trend correlates to the sharp peak in visibility measured through news coverage at the same time (see Fig. 4), but fails to align with the hype cycle as described by Gartner.

In this second and more detailed empirical investigation, we have narrowed our search to the individuals who are interested in the respective technologies by focusing on the query behavior of users corresponding to each technology, and simultaneously used a benchmark (i.e. the industry) to more accurately estimate hype patterns. Despite taking these elements into account, the alignment between Gartner's hype cycle assessments and the trends acquired from real data continue to show deviation. Nonetheless, the results from this empirical analysis do generally align with the observations attained from our earlier study focusing on news coverage visibility, thus, giving further confidence for the legitimacy of our empirical results and also the inaccuracies of Gartner's estimations.

4. Discussion and recommendations for future research

We believe that the incongruences evidenced from our review of Gartner's hype cycle model are bestowed by the model's theoretical foundations: (i) the juxtaposition of two discrete evolutionary models (the human centric, hype expectations model, and the technology S-curve model) to create a single model; (ii) the equivocal definition of the dependent variable (i.e. y-axis) of visibility; and (iii) the unlikely generalizability of the expectation pattern for all stakeholders. Notwithstanding, we believe that the notion of hype or hyped dynamics, though not necessarily the hype cycle model itself, presents an important addition to existing life cycle models in the TIM research field, which are tools for understanding and forecasting the adoption of technological innovations. To this end, and contrary to Gartner's efforts to combine models, we advocate the identification of hypes in existing individual life cycle models.

Following a more holistic approach, we advocate the identification of overenthusiasm that may (or may not) eventuate in relation to a new technological innovation through the 'diffusion of innovations' framework proposed by Rogers (1962). This seems fitting, given that the core issue addressed by the hype cycle model and our critique of it is the perception and the reaction of a group of adopters to a technological innovation, over time. In this manner, we suggest that the phenomenon of hype should be sought with respect to the three elements that comprise Rogers' framework, namely, the 'innovation', the 'media', and the 'social system', each experiencing change with respect to the fourth element of 'time'. Subsequently, our approach is to seek over-inflations in the growth curves that pertain to each of the three elements that change over time. We elaborate on these in turn below.

Firstly, hypes associated with the innovation itself are expected to result from the innovators' overenthusiastic investment in R&D activities, under competitive pressure or in reaction to the forecast promise of the technology. Quantitatively, these hypes are likely to be manifest in technological growth curves produced from increasing technological performance levels (e.g. Foster, 1986) or patent activities (e.g. Andersen, 1999) across time. Commensurate with our proposition, Grupp and Schmoch (1992) have observed such hypes in patent activities concerning laser beam sources and polyimides, and Grupp (1998) has found a similar pattern for solar cells. The authors have shown that patent application numbers have decreased following an initial period of increase, only later to rise once more (hence, resulting in a similar pattern to Gartner's hype cycle, although with a readily quantifiable vertical axis). Furthermore, from an investigation of 44 technologies published in the EPO (European Patent Office), Schmoch (2007) has identified a 'double-boom cycle' in patenting activities that appeared frequently for many technologies.

Innovation activities related to patents and R&D investments have nonetheless been suggested to provide information at more mature stages of technological development rather than for new or emergent technologies. Moreover, establishing hype dynamics from pure accumulation of patent numbers remains insensitive to the content of these patent applications. Alkemade and Suurs (2012) subsequently promote the use of event history analysis as an alternative methodology for analyzing expectations connected with new technological innovations. Event history analysis can be performed by studying the sequence of events pertaining to actors, institutions, and the technological innovation itself. The data for such event history can be gathered from professional or mainstream sources (e.g. engineering journals or newspapers), using keyword searches and identifying the events that make statements regarding the use of the technology. In turn, the number of events that accumulate over time may indicate hyped activity concerning the innovation.

Following Rogers' definition of the diffusion of innovations as "communication of innovation through channels over time", hyped dynamics are, secondly, anticipated to materialize in the form of overenthusiasm in the media of communication channels with respect to a particular innovation. In fact, our review of the TIM literature illustrates precisely this, as scholars focus their empirical work on the manifestation of hype in the mainstream media (e.g. newspapers) in operationalizing Gartner's visibility construct. Commensurate with these prior works, we advocate bibliometrics, defined as a generic approach for measuring texts and information, as a suitable method of analyzing hype in the media. However, as demonstrated by Järvenpää and Mäkinen (2008a, 2008b), media hype can be more effectively studied by considering sub-divisions (or separation) of sources, following the technology life cycle indicators proposed by Watts and Porter (1997). In this manner, rather than counting all news articles citing a particular technological innovation, analyzing mainstream news sources (e.g. New York Times) separately from technical news sources (e.g. Electronic Engineering Times) can more readily manifest hype dynamics. Specification can concurrently allow distinguishing and contrasting hype activity for early adopters and the mainstream adopters of a given innovation. A limitation noted by scholars in employing a purely bibliometric approach, however, is once again the insensitivity of quantitative evaluation to the content of the counted news articles. As a result, and in agreement with Järvenpää and Mäkinen (2008a), we emphasize the need for integrating content analysis into the research methodology to increase the accuracy of article counts pertaining to the innovation and subsequently attaining a more exact representation of hype.

And thirdly, we propose that hype in the social system will materialize in the form of overenthusiasm of the social system of actors, in other words, the adopters of a particular innovation. One approach to studying the social system hype is to analyze the accumulating number of adoptions or sales of a given innovation over time. While the base pattern pertaining to the cumulative adoption of an innovation is that of a symmetric 'S' shaped curve (often represented by the Bass model (Bass, 1969)), under the influence of external factors such as marketing and promotion as well as government intervention, the diffusion pattern may be positively skewed (Phillips, 2007; Davies and Diaz-Rainey, 2011), thus indicating hype. However, hypes identified through this quantitative approach are often outcomes of an ex post analysis. For organizations interested in forecasting potential hypes in adoption we believe that Jun (2012a, 2012b), and Jun et al. (2014) provide a highly suitable quantitative method in 'search traffic'. As also demonstrated in our own empirical study of tidal power, IGCC, and photovoltaic generation technologies, such webometric techniques evaluate the number of search queries made by individuals using a search engine, such as Google. Hypes become evident as growing interest in a given innovation promotes increasing search numbers only to be followed by diminishing interest and search traffic. Moreover, as search traffic concerns the levels of interest of potential adopters, it serves as an ex ante analytical tool for organizations.

We summarize our recommendations for the extension of existing models to incorporate hype activity, through the quantitative approaches, dependent variables (i.e. the y-axis), the sources of data, as well as the relevant TIM context pertaining to each of the three elements (innovation, media, and social system) in Table 4.

Our proposed framework importantly circumvents the ambiguities associated with Gartner's hype cycle model discussed earlier. It is additionally comparable with the approach of Jun (2012a), who, building on Geels (2004) model of the socio-technical system, identifies three key actor groups that need consideration in the analysis of hype. In alignment with the three elements defined in our own proposed framework, Jun identifies these actors as the user, the producer, and information distributor (i.e. media). Furthermore, and once again congruent with the framework we have devised in Table 4, the data sources utilized in Jun's (2012b) empirical study include web searches conducted by the user, patent applications for the producer, and news reports for the information distributor. Although our framework has been built upon Rogers' diffusion of innovations model, the high degree of agreement with Jun's recent and valuable contribution, despite the difference in point of departure, gives us confidence in the approach we have proposed.

Notwithstanding, the elements of Rogers' diffusion model are naturally interdependent such that hyped dynamics in any of the three elements is likely to influence, and be influenced by, the dynamics of the other two elements. This sentiment is echoed by Yeon et al. (2006), who, in consideration of the Technology Acceptance Model (Davis, 1989) suggest that as external variables can alter attitudes and subjective evaluations of the social system, organizations may be motivated to intentionally create innovation hype. Similarly, we would, for instance, anticipate hyped dynamics in the media channels concerning an innovation to cause hyped reactions from the social system. While Jun (2012b) has examined a number of hypotheses that define causal influence between the consumer, media, and producer, these propositions have been tested only in the singular context of the hybrid car. Moreover, the hypotheses have not been formulated to center on hyped behavior. We therefore advocate further empirical research to increase our confidence of the causality among the three elements, building on Jun's work, at the same time testing new hypotheses that seek causality of hyping behavior among the innovation, media, and social system elements.

A likely limitation of our study results from the inherent ontological question pertaining to life cycle models in general (Martin and Sunley, 2011). As Van de Ven and Poole (1995) suggest, the life cycle depiction is only one of four possible motors driving change. While it is difficult to comprehend innovation change simultaneously through these evolutionary, dialectal, teleological, and life cycle lenses (Van de Ven and Poole, 1995, p. 520), analysis of innovation change can be argued to remain limited with the selection of only one mechanism to observe.

Table 4
Proposed framework for studying hype in existing life cycle models.

	Quantitative approach	Dependent variable	Data source	TIM context
Innovation	Patent activity trends	Patent counts	Patent offices	Mature stages of technological development
	Event history analysis	Event counts	Engineering journals or newspapers	Early stages of technological development
Media	Bibliometric and content analysis	Article count	Technical journals	Early adopters
	Bibliometric and content analysis	Article count	Mainstream newspapers	Mainstream adopters
Social system	Diffusion pattern	Number of adoptions	Market research databases	Ex post adoption behavior
	Search traffic	Number of search queries	Search engines (e.g. Google trends)	Ex ante adoption behavior

Nonetheless, the stylized life cycle perspective can be endorsed when repeating sequential phases (e.g. those of birth, growth, maturity, and decline) are detected in different settings and with a sufficient level of predictability. Indeed, it is the lack of repeatability in the sequential phases of the proposed hype cycle model, which puts to question the ontological fitness of capturing innovation hype through this particular life cycle depiction.

At the same time, hyped dynamics may also be observed with respect to already established life cycle models utilized by both academics and practitioners to understand industry, product, and technology evolution (Routley et al., 2013). We may, for example, observe hypes in the industry life cycle (ILC) that otherwise demonstrates regularities in relation to the number of firms constituting an industry over time (Agarwal et al., 2002). This stylized model proposes that the number of producers in an industry will increase until a peak is reached and then begin to decrease, while the number of entrants into the industry will follow a similar pattern, or alternatively peak at the very outset and then decline thereafter. We believe that the anticipation of hyped dynamics can extend this life cycle model, thus enhancing its analytical power. For example, a peak of inflation may materialize in the early stages of the ILC as a high supply of potential entrants decide to enter the industry over a short period of time, such as in response to perceived demand or opportunity munificence. The high density of entry would subsequently reduce the remaining number of potential entrants (Klepper, 1996, p. 566), causing a notable trough in the number of firms entering the industry in the following period. This hype-disappointment sequence can influence industry characteristics – such as the overall number of firms, the amount of R&D spending, and the rates of product and process innovation – in a different way than that predicted by the stylized ILC model, and therefore have different strategic implications for the firms concerned.

The product life cycle (PLC) can similarly underscore hypes when plotted as a bell shaped curve of the unit sales, or the annual revenues or annual production pertaining to a given product. As illustrated by Routley et al. (2013), the PLC for the Ford Model T resulted in a series of peaks and troughs (i.e. hypes and disappointments) from 1908 until 1927. Phillips (2001) additionally draws a distinction between a hype that occurs relatively early on in the PLC and one that emerges during late maturity. While the hyped behavior in the former is bestowed by technological improvements in the product (accounting for the recovery in product sales), the latter, referred to as 'revitalization', often results from the discovery of new markets and uses of application for the product, which increases sales. For instance, the VCR experienced a very notable revitalization in sales when the innovation penetrated the home market, following the much smaller studio market where it had initially gained a foothold (Phillips, 2001). Overall, these considerations suggest that different types of hyped behavior may arise under particular circumstances.

Our paper offers alternative lenses through which the hype phenomenon can be viewed in TIM settings, concurrently circumventing the theoretical ambiguities that fundamentally lie within Gartner's hype cycle model. We believe that future empirical work can arrive at a typology of hype dynamics, which can further assist organizations forecast changes in the industry, product, and technology. Such a typology should capture not only the generic types of hyped behavior that mark existing life cycle models, but also the conditions that promote the manifestations of various hyped behaviors. Additionally, although the focus of our paper has not been to examine the mathematical underpinnings of hypes in established models, we believe that this serves as a further avenue for future research, especially taking into account the various factors that may trigger hyped behavior.

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