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Comparing technological hype cycles: Towards a theory

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ABSTRACT

The notion of 'hype' is widely used and represents a tempting way to characterize developments in technological fields. The term appears in business as well as in academic domains. Consultancy firms offer technological hype cycle models to determine the state of development of technological fields in order to facilitate strategic investment decisions. In Science, Technology and Innovation Studies the concept of hype is considered in studies on the dynamics of expectations in innovation processes, which focuses on the performative force of expectations. What is still lacking is a theory of *hype patterns* that is able to explain the different shapes of hype cycles in different contexts. In this paper we take a first step towards closing this gap by studying and comparing the results of case studies on three hypes in three different empirical domains: voice over internet protocol (VoIP), gene therapy and high-temperature superconductivity. The cases differ in terms of the type of technology and the characteristics of the application environment. We conclude that hype patterns indeed vary a lot, and that the interplay of expectations at different levels affects the ability of a field to cope with hype and disappointment.

1. Introduction

In technological fields one can often observe waves of media attention combined with high rising expectations on technological possibilities. Such expectations play an important role in the emergence of technology by guiding research activities, attracting resources and creating legitimacy [1–3]. Expectations that foresee a bright future for certain technologies might thus benefit the technological development by attracting resources and actors into the technological field. While these dynamics may favor a technology, they are not innocent: when expectations become too positive, they "[…] may present a 'source of 'overshoot' ultimately damaging credibilities and reputations" [4]. In such cases much of the earlier attracted resources may eventually appear effortless and development of new technologies is harmed. Such waves of high rising expectations can be indicated as 'hype' [5–7].

The notion of 'hype' is widely used and represents a tempting way to characterize developments in technological fields. The term appears in business as well as in science domains. The marketing literature has probably been first to recognize that high-rising expectations may amount to a hype that attracts attention, support and complementary assets, and that hypes thus influence diffusion patterns [8–10]. Consultancy firms have used this insight to offer models of technological hype cycles to determine the state of a technological field along its diffusion curve in order to provide advice on strategic investment decisions. A famous example for this is the Gartner hype cycle [11,12]. Science, Technology and Innovation Studies (STI-studies) have considered hypes in studying the dynamics of expectations in innovation processes. They share with the marketing literature the conviction that hypes are *performative*, but have delved more deeply into the complex interactions between 'hype' as a collectively shared rhetoric about an emerging technology and the underlying innovative activities [13].

While the existence of hypes is widely recognized in STI-studies, case studies on hypes have thus far remained localized, explaining specific dynamics in specific contexts. What is still missing is a theory of *hype patterns* that is able to explain the different shapes of hype cycles in different contexts. In this paper we take a first step by studying and comparing the results of three case studies on hypes in three different

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empirical domains — voice over internet protocol (VoIP), gene therapy and high-temperature superconductivity (HTS). The cases differ in terms of the type of technology and the characteristics of the application environment. The following Sections (2 and 3) review the most important concepts used for our analysis and the methodology. Section 4 discusses the cases and investigates the hype patterns. In Section 5 a comparison of the different cases is presented and Section 6 provides some general conclusions of our research.

2. Concepts of hype

In STI-studies, the role of expectations in shaping emerging technologies is widely recognized [1–3,14–16]. Expectations can be defined as "real time representations of future technological situations and capabilities" [1], and as such they provide a guiding structure in emerging technological fields. More specifically, they guide the activities of innovative actors by setting agendas; they provide legitimacy and thus help to attract financing and enroll actors; and they, while often spread through spoken and written words, may materialize in experiments and prototypes. For instance, expectations that position gene therapy as a potential cure for hereditable diseases are likely to attract both investors from pharmaceutical industry and researchers from hereditable diseases and cell biology. Such positioning is unlikely, though, to yield research activities in applying gene therapy for viral or bacterial diseases. When more and more actors share similar expectations, the promises inherent to these expectations are gradually translated into requirements, guidelines and specifications regarding the new technology [2]. In other words, they turn from more or less specified rhetorical figures into more obdurate forces that shape the evolution of an emerging technological field [2]. Innovating actors are not only compelled to join the "bandwagon" [17], but also their activities will be structured according to the specific ideas inherent to it. Expectations are thus *performative* in nature and shape the dynamics of an innovation trajectory.

The performative character of expectations has important implications for the study of hypes. In public discourses, hypes are often seen as something deceptive, incorrectly exaggerating the impact and outcome of an otherwise independent technological development [13]. In contrast to such realist readings of hypes, our perspective on hypes is futureless [18]–not interested in hypes as more or less accurate forecasts, but as collectively pursued explorations of the future that affect activities in the present. While the early and high-rising expectations that characterize hype hardly ever materialize precisely as foreseen, they structure and shape the materializations that eventually occur. A perceived gap between early expectations and eventual technological development is thus not an accurate indicator of a hype, let alone an accurate measure to distinguish a hype from a "truthful" representation of the future. In this connection, Brown and Michael [14] have proposed a different strategy and take a discourse of revolution and technological breakthrough as an indication of hype.

Hypes are usually followed by disappointment, when high expectations are not met by the actual outcome of innovative activity. Disappointment is often marked by an abrupt collapse of positive expectations [16] followed by a slow recovery in a hype-disappointment cycle [4,7]. Fig. 1 displays a stylized representation of such a cycle that is used by the Gartner group

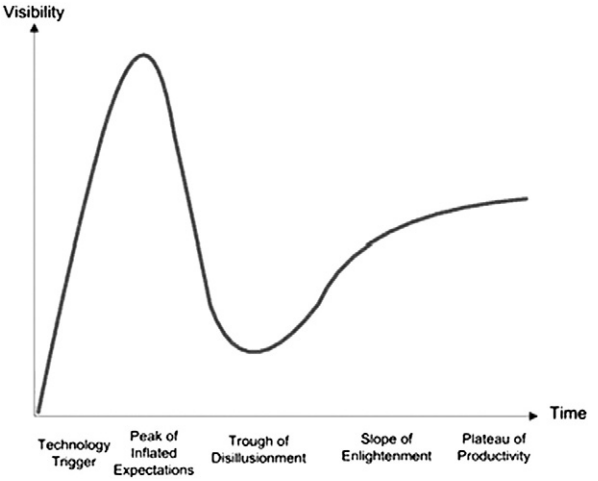

Fig. 1. The Gartner hype cycle.

[19].[1] Research on hypes has suggested that this general pattern can take many different forms, where three characterizing variables distinguish more pronounced from more diffuse hype patterns[13]:

- Hypes have a peak of very optimistic and exaggerated expectations; such a peak is anteceded and followed by more modest and mixed expectations. We consider the *shape of the peak* a first crucial variable of a hype pattern — that is, the degree of enthusiasm and unambiguity during the peak, and the swelling and slope of the peak.
- A trough of disappointment, in which the original expectations do not materialize, follows peaks. We consider the *depth of the trough* to be a second crucial variable – that is, the degree to which enthusiasm breaks down in the trough, and in how far a slow recovery takes place after the trough.
- Finally, we consider the overall *length of a hype* to be a central background variable.

These variables together describe the shape of a hype pattern. In our case analysis below (Section 5), we shall therefore focus on these variables separately to analyze how differences in the shapes of hype can be explained.

More specifically, our empirical analysis zooms in on these variables in terms of two analytical specifications that earlier literature has suggested to be influential for the shape of hype patterns. First, hypes are constituted by expectations at different levels. Van Lente [16] has distinguished between expectations at the micro level or research groups or individual firms, expectations at the meso level of the technological field and, finally, expectations at the macro level of technology in society. In other words, innovation of emerging technologies is embedded in a complex interplay of specific, functional and generic expectations [2]. Ruef and Markard [13], in their analysis of stationary fuel cells in Germany, were the first to adopt this distinction to the analysis of hypes, where they differentiated between expectations on a project level, i.e. statements regarding the outcome of a *specific project*, *generalized expectations* about a technological field, i.e. more general statements on the expected

[1] Adapted from http://www.gartner.com/technology/research/methodologies/hype-cycle.jsp (seen on 1 December 2010).

development of the field as a whole, and *frames* that contain encompassing expectations about social trends such as economic forces and ethical debates. Their research has demonstrated that the consequences of disappointment for underlying innovation activities strongly depend on expectations on all three levels. So, for instance, in the case of stationary fuel cells, disappointing results on the project level did not cause innovation activities to cease because they have been embedded in a continuous positive framing at the societal level [13]. What this exploratory work suggests is that the complex interplay of expectations on different levels has a strong influence on the effects of disappointment in a technological field. In our empirical analysis, therefore, we have taken the distinction between specific expectations, generic expectations and frames as a starting point to come to assess the impact of their interplay on hype patterns (see below).

Secondly, the literature suggests that hype patterns are influenced by the characteristics of the emerging technology itself, and the nature of the environment in which the associated expectations are expressed, shared and refined. For instance, Borup et al. [1] as well as Brown and Michael [14] indicate that the specificity of a technology's envisioned application plays a significant role in determining how pronounced hype cycles will occur. Moreover, environmental factors, such as the funding and actors structure of a field [4,7], the existence or absence of product champions [20], or the complexity of the regulatory, business and wider societal setting in general [21], have been claimed to influence hype patterns.

These studies have not taken hypes as their central concern,[2] and they offer little systematic insight into how such factors influence hype patterns. However, two suggestions transpire from them: First, when a specific applications of a technology is known and pursued, this can be expected to have a negative effect on a hype's likelihood to recover after disappointment. The more specific an envisioned application is, the more difficult it becomes to reorient expectations after disappointment. Emerging technologies that are the generic basis for applications across a variety of fields, therefore, are likely to display more diffuse hype patterns with less profound consequences of disappointment [1]. A suggested reason for this is that emerging technologies with generic applications can be linked to a more diverse set of expectations associated with different paths of social embedding.

Secondly, the influence of the specificity of an application is moderated by the nature of the environment into which a technology becomes embedded. Particularly on the field level, it is likely that a setting that combines research domains with the business opportunities of one or more industrial sectors will positively influence the options to reorient expectations after disappointment. Indeed, according to Geels et al., diverse and rich environments enable actors in the innovation process to redefine expectations and thus cope with disappointment constructively [21]. A related aspect has been explored by Brown and Michael that distinguish between emerging technologies that affect established actor networks, and those that give raise to completely new networks [14]. From a different perspective, they support Geels et al.'s claim: in newly emerging networks, more possibilities exist to reorient expectations. While they have not linked this claim to the analysis of hypes, their work strongly suggests that the nature of the environment in which expectations are created, shared and refined affects the ability to cope with disappointment.

Against this background, we can now specify that the original hype cycle as depicted in Fig. 1 is likely to characterize a certain type of emerging technologies[3] — those with a specific application affecting already established industrial environments [19].[4] The literature, however, suggests that this basic pattern would vary when generic applications are involved, or applications "whose" expectations are not necessarily created and shared within existing industrial structures. This served as a starting point for selecting relevant cases for our analysis and thus also for our move towards a theory of hype cycles. Using a theoretical sampling approach [22], we chose three cases that varied in terms of the characteristics of the emerging technology (generic vs. specific) and the nature of its surrounding environment (see below).

3. Methodology

Following the principles of theoretical sampling [22], we have selected our cases based on their theoretical relevance. That is, the cases were chosen because the underlying technologies seemed to reveal interesting differences in terms of the specificity of their applications and the nature of their environments, and allow for linking these dimensions conceptually to the interplay of specific, generic and frame expectations.[5] Our base case is VoIP, where the application is well specified and the application environment cuts across existing industrial settings [see 23]. VoIP mainly affected the telecommunications sector — a mature sector where the VoIP hype took place in parallel with already considerable changes due to the uptake of the Internet and associated deregulation attempts. From our literature, we would suspect to find a hype pattern in this case that closely resembles the pattern shown in Fig. 1. We have compared this assumed standard case with two generic applications — high temperature superconductivity and gene therapy, both of which have a broad variety of applications in different settings. These cases differ in terms of the environment in which expectations about possible applications were created, shared and refined. Gene therapy, while hitherto clearly not embedded in a well-defined industrial environment, has generated first applications that were heavily debated in a range of emerging and research-intensive industries, such as biotechnology. Hence, the hype of gene therapy that we have analyzed was relatively remote from mass-distributed industrial innovation; however, *as a consideration* mass distribution and partly also commercialization has been at the center of the hype. By contrast, high temperature superconductivity has primarily remained a research endeavor, where promises are raised about a range of

[2] In fact, they have been contributions to the sociology of expectations or the social embedding of technology in general.

[3] We are grateful to the anonymous reviewer who pointed this out.

[4] Indeed, the Gartner hype cycle has been introduced in a business context, and analysts have been concerned with understanding the impact of hypes within existing industries [9].

[5] We should also emphasize that none of these aspects (specific vs. generic, nature of the environment, interplay of different level of expectations) alone served as an explanatory variable. Again, in line with the idea of theoretical sampling we were interested in understanding better how the specific relationships between these aspects have influenced the shape of hype in each of our cases [19].

industry applications related to power transmission. Such applications have not yet materialized, though, and could thus not give rise to technological routines and concrete considerations of business opportunities and models. Our case selection, therefore, has not only allowed us to compare technologies with specific and generic applications, but it has also addressed how the presence or absence of perceived business opportunities and models affects the interplay of expectations at different levels and thus the shape of hype patterns. Again, we don't believe that these are the only parameters that are likely to exert an influence on hype patterns; we do agree with the earlier literature, though, that the specificity of applications together with the degree to which such applications have been spelled out in terms of business opportunities and industrial patterns are key features in defining hype cycles (see Table 1).

All cases were studied from the onset of hype until 2006 to allow for the inclusion of eventual secondary peaks or other variations in the analysis. Following a proposition by Ruef and Markard [13], we conceptualized hypes in terms of both media attention and expectation statements. Indeed, as these authors have highlighted, media attention alone neither indicates a hype, nor does the drop of media attention alone necessarily marks disappointment: "A phase of high media attention without highly optimistic expectations […] is not considered a hype and a drop of media attention has to be accompanied by clear changes at the level of expectations in order to mark a disappointment" [13]. Hence, in our analysis we have considered a hype to reveal itself in both media attention and the actual content of expressions about the underlying technology. To measure the hypes in our three cases we thus combined a quantitative analysis of media attention with a qualitative analysis of media statements. This reflects the insight from earlier literature that hypes are more complex a phenomenon than a pure peak of attention in public discourses. Hypes combine certain patterns of attention with strong ideas – positive and negative and often even contradicting [5] – about the future of a technology.

Methodologically, we followed Ruef and Markard [13] and took the public discourse as expressed in the mass media *as a starting point* to explore expectations. Three reasons justify this choice: First, expectations uttered in the public discourse reflect well the collectively shared expectations in a technological field [7], because they are widely shared beliefs. Secondly, our aim was to compare different hype patterns. For this purpose, it was important to focus on the same type of media in all three cases, and the discourse in mass media was the only source that satisfied this criterion. Thirdly, hype patters were partially conceptualized as media attention; mass media reflects this attention in the broadest possible way.

To study the public discourse, a qualitative and quantitative analysis of relevant articles in the *New York Times* was carried out for each case. Quantitatively, a keyword search and article count led to the identification of attention patterns; this pattern provided us with a first idea about the duration and shape of each hype. Qualitatively, we made a discourse analysis that focused on expectation statements about the future of the technology. These statements were placed in a database and constituted the basis to construct expectation patterns. To further deepen the discourse analysis, we also selected a representative technical journal for each case, i.e. the journal with the highest impact factor in the field, and selected the relevant scientific papers to be included in our analysis. These papers, in particular, gave us a deeper insight into expectations on the project level because they included details about concrete technological developments. Finally, secondary literature complemented the discourse analysis to allow for a contextual story for each case and for triangulation of data to enhance the reliability of the results [24]. Appendix A contains an overview of the data sources we used.

We were interested in the timing (length and year) of peaks, the depth and timing of troughs, and the overall duration of hypes including a possible recovery after the trough. Our data collection yielded empirical data on attention in terms of the numbers of articles published and qualitative information about expectation statements. Following Brown and Michael's [14] suggestion, discourses of 'superlatives' and 'revolution' or 'breakthrough' were taken to be indicative for hype and were labeled as very positive expectations. According to the methods of a grounded theory approach [25], we labeled the value of expectations for each year (see Table 2). Patterns in attention were traced by simply counting the number of articles for each year. The *combination* of expectations value and attention then allowed us to construct a hype pattern for each case. To delve deeper into the structure of these patterns, it was also important to identify the dynamics of expectations on the different levels discussed above. In our database, we labeled each statement according to the levels of project, technological field or frame. Table 3 depicts the analytical framework we have used for this.

4. Three cases of hype

In this section, we discuss three cases in which "hype" is generally seen to have occurred. We provide a brief storyline for each of the technologies that also specify the range of possible applications and environmental settings; we then present the hype patterns we identified in our data. Each hype pattern is illustrated with an attention pattern presenting the results of our quantitative analyses, and a table summarizing the outcome of our discourse analyses.

Table 1
Case selection.

Voice over Internet Protocol (VoIP)	Gene therapy	High temperature superconductivity (HTS)
• Specific application: substituting for traditional telephony • Mature industry setting, but multiple industries involved	• Generic application: cure for wide array of diseases • Emerging industry setting, but under-specified applications	• Generic application: application in wide array of products (magnetic trains to power lines) • Basic-science setting with not-yet materialized *promises* for mature industries

Table 2
Analytical framework to determine value of expectations.

Label	Description	Example of discourse fragment
Very positive expectations	Deterministic expectations. Occurrence of superlatives or emphasize a breakthrough character without mentioning forthcoming problems. Time to commercialization is often short.	Today, Internet telephony,[…] is considered the fastest-growing type of service on the Internet, and $30 million, by one estimate, is expected to be spent next year. […] the question is no longer whether, but when, […] (17-11-97, NYT) "The revolution in human gene therapy, so long ballyhooed and debated, began today[…]" (1-8-90, NYT)
Positive expectations	Expectations on a future for a technology (e.g. in terms of application or number of users) without mentioning forthcoming problems. Superlatives or breakthrough character is absent.	"In the future, scientists hope to enhance the effectiveness of the cancer-fighting cells by transplanting into them genes that can actually enhance their therapeutic effectiveness." (23-5-89, NYT) "Yet the technology is showing signs of gradually expanding to a broader audience, a step that could eventually mean wide-reaching changes in the telecommunications industry, if early experiments by individuals and businesses are any indication." (6-1-03, NYT)
Expectations with both a positive and a negative element	Expectations seeing a positive future but mention problems that have to be solved in order for the technology to succeed.	"Cardiologists were enthusiastic about the results, but said that more work must be done before the method can be tried in human patients." (9-8-94, NYT)
Negative expectations	Expectations seeing problems around a technology which decrease the success of this technology.	One physicist predicted futuristic playlands where skiers would slalom down electromagnetic slopes buoyed by superconducting skis. But in recent months it has been discovered that the very magnetic fields that the new superconductors are supposed to generate could prevent them from superconducting (18-06-89, NYT).
Very negative expectations	Deterministic expectations. Technology is not expected to develop into applications nor commercialization. Negative superlatives or words as disappointment.	"Even the proprietors of Internet telephony see their window closing. "My basic thought is, eventually it's going to die," said Mr. Jonas, chairman of IDT." (26-4-98, NYT).

4.1. Voice over IP (VoIP)

4.1.1. Case description

Internet telephony or Voice over IP (VoIP) emerged during the mid 1990s as a very promising technology that offered free long distance telephone calls. The first applications comprised a computer linked to the Internet and enabled the user to call another user with a computer and a VoIP software. According to Karapantazis and Pavlidou [26]: "VoIP has set off a feeding frenzy in both the industrial and scientific communities. Since its inception, huge strides have been made and now VoIP enjoys widespread popularity as an alternative to traditional telephony in homes and enterprises." The development of VoIP towards the alternative for traditional telephony today did not reveal a gradual slope but was characterized by periods of hype and by periods of overcoming technological and regulatory hurdles.

The term VoIP refers to all technologies that enable the transfer of voice over the internet [27] using the Internet Protocol (IP) to transmit voices as data packages to a receiver. Exactly this is also the application that is discussed during the hype we elaborate in more detail below. VoIP, therefore, is a technology with a specific application that, in comparison with traditional circuit switched networks, has a major potential to reduce costs. However, in the early days of the Internet, VoIP was also associated with a significant loss of voice quality. Progress in Quality of Service (QoS) mechanisms has reduced this drawback substantially over the years. In addition, VoIP allows for a number of additional services, such as video conferencing or parallel chatting, that are unavailable in conventional telephony. Hence, VoIP is offering a potentially better service at lower costs and as such has become an attractive option for consumers as well as for business users. From the outset, the scope of potential applications has been limited to substitute for conventional telephony.

VoIP is a technology with potentially disruptive effects on a number of established industrial sectors. Most importantly, for the telecommunication sector, implementing VoIP implies a radical change affecting the sector's infrastructure, technological basis and cost models [27,28]. Moreover, the deregulation of the telecommunication sector in 1996 introduced fierce competition for incumbent firms, when VoIP became an interesting business field for new firms. Existing firms thus faced the

Table 3
Analytical framework to determine the level of expectations.

Label	Description	Example of discourse fragment
Project-specific expectations	Future characteristics of a technology specific to a product project or firm. Micro level.	That service, called AT&T World Net Voice, will start in three cities, still to be announced, and expand to 16 by the end of the year. AT&T will charge 7.5 to 9 cents (27-1-98, NYT)
Generalized expectations	Expectations referring to generalized features of a technology, expressed in impersonal statements. Expectations address the level of the technological field.	One of the more spectacular applications of superconducting magnets might be their use in high-speed trains floating in air. (4-1-87, NYT)
Frames	Rather overarching expectations which place the technology in the context of generic societal problems or promises (societal debates).	It [gene therapy] is also a source of concern and even fear among some intelligent people who know what evil can lurk in the human mind. (1-9-93, NYT)

decision to either embrace the new technology or take on a more defensive position. Also companies from other sectors, like TV suppliers, recognized the possibility to use VoIP to provide telephony services through their infrastructure. For these sectors, VoIP considerably broadened the range of services that can be provided.

Hence, and somewhat opposing our initial conjecture, the case study has revealed that the application environment of VoIP, while indeed concerning existing industries, was far from simple. To the contrary, the well-specified application in telephony made the pursuit of VoIP interesting also for actors that had traditionally not been in the telephony business. It is noteworthy that this peculiar situation – a relatively straightforward application that nonetheless blurs long-standing boundaries between industrial sectors – aggravated the regulatory challenges of VoIP: traditional regulation distinguished between telecom and Internet services (Internet services were free from regulation) but suddenly regulation was needed for a service that combined both aspects. Despite of the hurdles, the technology has been slowly improving towards a reliable product today.

4.1.2. Expectations and attention

Based on combined quantitative and qualitative analysis of articles, we could roughly distinguish between three phases in the VoIP case — a period of uncritical enthusiasm (1995-1998), a period of relative rest, in which expectations were more balanced (1998-2003), and a period of renewed enthusiasm (2003-now). In what follows, we present a storyline to discuss the attention and expectation dynamics that we observed during each period:

Expectations related to VoIP were very positive in the first years (1995–1998). VoIP was seen as a disruptive technology and promised a market that was expected to grow very fast:

> "Technical drawbacks still keep Internet telephony from being a true substitute for the good old, reliable telephone network. And yet, the number of regular Internet telephone users is expected to rise from fewer than 400,000 last year to 16 million by 1999 […]. By that year, IDC predicts, Internet telephony could constitute a $500 million market."(NYT, 16-8-1996)

Notice that expectations on Internet telephony are mingled with expectations on Internet use. Not only telecom firms adopted the new technology, but also Internet firms that quickly integrated the new technology in their product portfolios by adding multimedia extensions and voice applications. This interest of many companies was reflected in the occurrence of business announcements and very positive project-specific expectations in the public discourse. As a consequence of presenting VoIP as a free telephone service, frames concerned regulation of the traditional telecom sector and VoIP technology.

In the subsequent period attention culminated into a peak in 2000 (see Fig. 2), when attention started to drop again. The traditional telecommunication industry started to react on the emergence of VoIP, which implies that VoIP was regarded as a threat for traditional services: "AT&T maps its battle plan for escalating phone wars" (NYT, 27-1-1998). But as a result of announcements on regulation, negative expectations started to

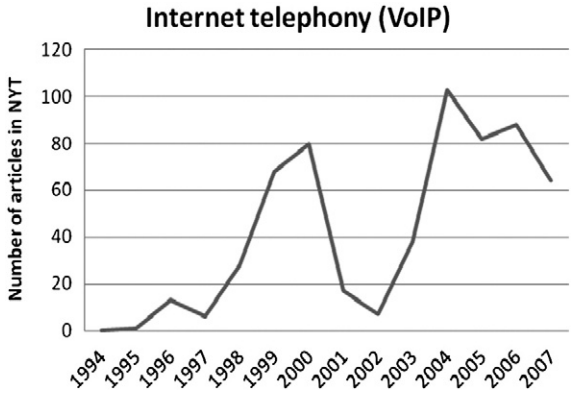

Fig. 2. Media attention (NYT) for VoIP.

appear as well: "My basic thought is, eventually it's *[Internet telephony—CS]* going to die" (16-4-1998, NYT), and by the end of 1998 also the first problems were mentioned relating to the capacity of the network. This situation roughly continued until 2000, when the increasing attention focused on Internet firms yielding mainly positive expectations. Hereafter a sharp decrease in the number of expectations was observed, but expectations remained positive.

In 2003, the convergence of improvements in cable technology as well as in VoIP technology finally brought to the market a viable technology. This was reflected by increasing attention and a new wave of expectations on possible market opportunities and the revolutionary potential of VoIP for business applications:

> "And even skeptics who do not think that Skype is much of a threat agree that the basic technology that drives it – VoIP – will lead to fundamental changes in the industry. VoIP is going to change everything.' says Jeff Kagan, a telecommunications consultant based in Atlanta." (NYT,12-10-2003)

The traditional telecom sector adopted the technology and the emergence of Skype made VoIP easily available for a large public. However, not the enthusiastic, slightly overdone expectations from the earlier years prevailed, but more modestly positive claims dominated in this period, also including moderately critical remarks:

> "Competition in the phone business, intensifying this year as Internet-based calling has taken root, has reached the point where many industry experts are anticipating an era of remarkably cheap and even free calls." (NYT, 3-7-06)

> "To be sure, few people in the telecommunications industry expect an overnight transition. Instead, analysts and industry executives foresee a gradual transition over several years, similar to the way people switched from black-and-white to color television." (NYT, 6-1-03).

As a result of the growing market share of VoIP, debates on reliability of the network became relevant, thus producing frames that placed VoIP in the larger societal context. Although the debates expressed concerns regarding the technology, they triggered positive changes in the development and as such

contributed to improve the technology. Table 4 summarizes the expectations that were observed during each period, and identifies the associated hype pattern that could be discerned from our analysis. The table shows the development of project-specific expectations, which remained positive throughout the years. The generalized expectations remained positive as well, but after the peak were more modest. Technology was positively framed in terms of economic potential, but concerns were expressed that new regulation could harm development of VoIP. Finally the last column shows the recovery phase that set in after the disappointment of the early hyped expectations. More modest but still positively inclined generalized expectations have dominated this period. All in all, therefore, the hype lasted from around 1995 to 2003 when the technological as well as market development slowly started to stabilize. In this sense, our study of the VoIP case confirmed our initial conjecture that emerging technologies with a clearly defined application in established industry settings would, by and large, resemble the standard hype cycle depicted in Fig. 1. However, this has revealed itself only through the joint quantitative and qualitative analysis — the attention pattern alone, as depicted in Fig. 2, would have suggested a different picture.

4.2. Gene therapy

4.2.1. Case description

Gene therapy was regarded as a very promising technology in the early 1990s. The discovery of genetic diseases and viral vehicles triggered a 'rosy confidence' by investigators, research institutions, patient advocacy groups and the lay and technical press. Eventually, approved clinical studies in the gene therapy field began in 1990 [29]. The rosy confidence sustained over the years and seems to have dropped down to a more moderate state of promises and technological development only recently.

Its underlying principles made gene therapy a potential cure for a very large array of incurable diseases, at least in principle. The term gene therapy was first introduced in the 1970s, where it referred to a principle that aimed at introducing an alien gene into human tissue (in or ex vivo) to tackle a disease [30]. Obviously, this definition is very broad, indicating that the concrete applications of gene therapy were initially under-specified, primarily *promising* a cure for a broad range of viral and genetically related diseases. How such cures would take shape, and how they would be provided to patients, however, remained open. The field of gene therapy includes two sub-fields: somatic gene therapy, where only the patient is cured, and germ-line gene therapy, where changes in DNA is not limited to one patient but passed on to later generations as well. Possible applications, therefore, included the immediate treatment of existing diseases, but also preventive diagnostics and possibly treatment of inherited predispositions to certain diseases. In particular, the latter has spurred a host of societal concerns about the makeable human being, which have become associated with the field of gene therapy in general.

As a technology, therefore, gene therapy has, from the outset, been a generic set of opportunities allowing for applications across a wide range of medical domains. Consequently, the principle of gene therapy attracted interest from various fields, ranging from biotechnolgoy investors to desperate patients. Clinical practitioners saw gene therapy as a solution for moribund patients and biologists as well as researchers fiercely competed for discovering the first effective therapy. In terms of its industry setting, gene therapy, therefore, can best be described as being embedded in emerging and research intensive fields, such as biotechnology [31]. Such fields have not yet accomplished the momentum of more established industries, with entrenched ways of producing and distributing product and services; however, they are also not confined to the realm of basic science. In this sense, the gene therapy case is markedly different from VoIP: Biotechnology companies saw the development of gene therapy as a potential source of huge revenues, but the ways in which these revenues should be realized have been far from clear. Consequently, and despite the enthusiasm for the new technology, developments in the field have been slow and only very few patients have thus far benefitted from gene therapy.

4.2.2. Expectations and attention

In the gene therapy case, our analysis roughly revealed five phases, a relatively calm take-off (1980–1989), a period of high-rising enthusiasm (1990–1994), a critical review (1995–1998), and a period of renewed enthusiasm, first quite turbulent (1999–2003) and recently more balanced (2003–2006).

Table 4
Summary of expectations observed in the VoIP case.

		Peak	Trough/Disappointment	Recovery
Duration		95–98	98–03	03–now
Project-specific expectations	Content	Commercial introduction VoIP by int.al. Vocaltec and Net2Phone	Internet firms start to offer VoIP	Traditional telecom sector starts to offer VoIP, Skype
	Value	Very positive	Positive, positive/negative	Positive
Generalized expectations	Content	Free telecom service	Capacity of network too low, cheap telecom service, quality of technology low, offering more services with VoIP	Capacity of Internet and broadband access on sufficient level, quality of technology high, business applications
	Value	Very positive	Positive, Positive/negative	Positive
Frames	Content	Regulations telecom sector, economic potential high	Regulations VoIP, economic potential high	Regulation, reliability of the network
	Value	Very positive	Positive/negative	Positive/negative
Attention		Increasing	Culminating into peak in 2000, sharp decrease from 2000–2002. Increase from 2002	Culminating into a peak in 2004

In contrast to the VoIP case, the gene therapy discourse comprised a more balanced mix between positive and negative expectations during the whole period of analysis. An early seminal event was a clinical trial carried out by Martin Cline in 1980 that yielded mixed statements about gene therapy, which, allegedly, was not yet developed to a point where clinical studies were warranted. Instead, more laboratory studies were said be needed to improve the technology. Time to commercialization was estimated long, because "[…] much remains to be learned in even the best understood genetic disorders — too much to allow gene therapy in human patients […]." (NYT, 31-5-1981) But gene therapy continued to be framed as a technology that would eventually be able to cure yet incurable diseases. By the end of 1984 voices for application of gene therapy in clinical trials began to emerge again, and now the tone became markedly positive:

> "The policy question concerning human gene therapy is no longer whether to attempt such treatments, but when trials in patients should begin, according to a report released yesterday by the Congressional Office of Technology Assessment." (NYT, 18-12-1984)

In the backdrop of these expectations, however, more skeptical frames continued to address broader ethical issues that needed to be solved. During this period attention for gene therapy was generally very low.

With headlines like "The gene therapy era officially began on Sept. 14, 1990" (NYT, 31-03-1991), the early 1990s can be characterizes as a phase were positive expectations and media intention sharply increased (see Fig. 3). The quote refers to the date of the first successful clinical trial with gene therapy that was hailed as a major breakthrough. As a consequence, the virtue of gene therapy, instead of being confined to rare heredity diseases, was turned into a promise that positioned gene therapy as a potential cure for a broad range of illnesses:

> "'What gene therapy really is, in a business sense, is simply a very sophisticated drug delivery system,' said Dr. Anderson. It allows a doctor to put a genetically engineered drug, 'exactly in the cells where it is needed. It is very probable that 15 years from now, genes will be the way that many biologics are delivered.' We feel that gene therapy is potentially a major new medical option. And the most important thing, with any new therapy, is to get started. Now we're getting started." (NYT,5-8-1990)

The quoted Dr. Anderson, who was the leader of the clinical trial in 1990, also became a very prominent figure in public discourses about gene therapy. Hence, not only project-specific expectations were positive in these days, but field-level expectations, too. More critical appraisals, however, continued to be voiced that were concerned with the deep interference of gene therapy with human nature:

> "It is not surprising that gene therapy is getting mixed reviews. Although hailed by many as the most exciting medical development since the discovery of antibiotics, it is also a source of concern and even fear among some intelligent people who know what evil can lurk in the human mind." (NYT, 1-9-1993)

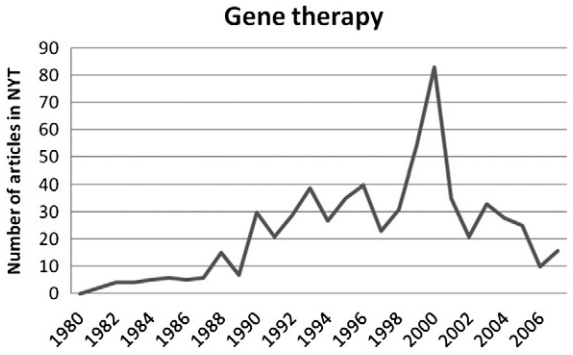

Fig. 3. Media attention (NYT) for gene therapy.

Since 1994, expectations about breakthrough disappeared in our sample, with a negative dynamic setting in in 1995 after a critical report of the National Institute of Health (NIH). Expectations immediately became less positive:

> But for all the frenzy, there has not been a single published report of a patient who was helped by gene therapy. And technical questions have multiplied. For example, scientists have discovered that the immune system may attack and destroy cells that were treated with gene therapy, seeing them as foreign or, when the genes were transferred by a virus, as infected. (NYT, 25-7-1995)

Interestingly, however, this sudden drop did not feed into a widespread disappointment, but into a renewed, if less enthusiastic, optimism in the field — mainly because the generic promises about curing serious illnesses remained intact.

In 1999 and 2000 yet another trough of disappointment appeared after the death of a patient during a clinical trial. For the first time, concrete risks of gene therapy were widely discussed and the belief in gene therapy as a panacea to diseases such as cancer and AIDS ultimately disappeared. Negative expectations, in this period, thus trickled down from the level of frames to both the field as a whole and the specific projects, where successes remained absent:

> "Biotech companies are getting disappointed. Biotech ventures also plunged into experimental areas, like gene therapy and stem cell research, that have not yet paid off and perhaps never will." (NYT, 24-11-2004)

Remarkably, the storyline for gene therapy does not reveal a clear hype pattern, where a pronounced peak is followed by disappointment. Our data rather revealed a gradual slope towards an explicit peak in 2000, where the media discourse was both vast and highly positive thus resembling hype. The disappointment phase after the peak, however, remained diffuse. A reason for this could be that frames about societal risks existed alongside positive expectations on project and field level during the whole period we investigated. Table 5 summarizes the hype pattern that we observed in the gene therapy case. Note again that the project specific and generalized expectations show a pattern that can be indicated as hype (very positive expectations followed by two periods of disappointment; double trough) and that frames developed

Table 5
Summary of expectations observed in the gene therapy case.

		Take-off	Peak	1st Trough	2nd Trough
Duration		80–89	90–93	94–99	99–06
Project-specific expectations	Content	Specific results of laboratory studies	Clinical trial of Anderson, other research successes, biotechnology firms interested	Research results	Death of patients and development of leukaemia in clinical trials. Biotechnologies terminate projects. Success in X-SCID
	Value	Positive	Very positive	Very positive	Negative
Generalized expectations	Content	Time to commercialization long	Gene therapy as cure for many diseases. Time to commercialization short	Field not ready for clinical trials. Time to commercialization long	Gene therapy as cure for very small amount of diseases, loss of believe in gene therapy as a source of revenue
	Value	Positive	Very positive	Positive/negative.	negative
Frames	Content	Solving ethical and scientific issues, gene therapy will revolutionize medical domain	Ethical debates, gene therapy will revolutionize medical domain	Ethical debates, gene therapy will revolutionize medical domain	Tension commercial interest vs clinical interest. Safety & regulation, gene doping
	Value	Very positive Negative	Very positive Negative	Very positive Negative	negative
Attention		Very low	Increasing	Increasing	Culminating into peak in 2000 hereafter decreasing

rather independently. Moreover, it is important that the massive media attention in 2000 is associated with the abovementioned death of a patient. This singular event considerably distorts the media attention curve depicted in Fig. 3, and thus underpins the importance of combining a quantitative analysis of media attention with a qualitative inquire into the content of media statements.

4.3. High-temperature superconductivity

4.3.1. Case description

During the late 1980s high-temperature superconductivity made headlines after the discovery of a new class of materials by Müller and Bednorz at IBM in Zürich. In these materials, superconductivity, i.e. "the loss of resistance to electrical current" [32], occurred at much higher temperatures than reported for other materials before. The new phenomenon was named "high temperature superconductivity" (HTS). While this term is somewhat misleading – HTS still occurs at very low temperatures by common standards – its emergence has marked renewed interest in superconductivity. Indeed, before the Müller and Bednorz discovery in 1987 interest in superconductivity was virtually dormant due to disappointing earlier results.

The discovery of high temperature superconductivity profoundly renewed interest in the field, but mostly for its relevance in basic science. The initial discovery attracted large numbers of scientists searching for new superconducting materials, and for theoretical models that would explain the phenomenon. At the same time, the discovery opened promises of commercial applications in a range of technological domains and this prompted interest from industry. Soon, research programs were initiated to stimulate new developments. However, and in contrast to the emerging gene therapy field, applications failed to materialize due to continued struggle with the technology itself. As Nowotny and Felt have put it: "one specific hope of the early phase has not materialized: no unforeseen application has emerged to 'leapfrog' the difficulties and create a market large enough to fuel research […]." [32] Notwithstanding these difficulties, high temperature superconductivity has received continued support [33], and is, for instance, still part of a funding scheme at the US Department of Energy. It has, however, remained within the realm of science rather than industrial innovation.

4.3.2. Expectations and attention

In the high temperature superconductivity case, our data allowed for roughly identifying two phases — very enthusiastic expectations around the discovery in 1987, and the emergence of more critical expectations in 1988/89. Hereafter, attention decreased and expectations could no longer be observed. However, the technology continued to develop, although in a fragmented and specialized manner, mostly below the threshold of mass media attention.

Our analysis revealed a dominant share of very positive expectations during 1987 and a dominant share of positive expectations in 1988. The discovery of high temperature superconductivity at temperature of liquid nitrogen in 1987 opened up a host of expectations that focused on commercial applications:

> "Scientists have long sought to create compounds that would be superconductive when cooled with liquid nitrogen instead of liquid helium, the cooling agent now widely used to achieve superconductivity. Liquid nitrogen costs a tenth as much, is 20 times more efficient and is much less volatile. Existing superconductors have limited commercial value because of the cost and handling problems associated with the helium cooling agent. Nitrogen liquefies at 321 degrees below zero Fahrenheit, or 77 degrees above absolute zero on the Kelvin scale. […] One of the more spectacular applications of superconducting magnets might be their use in high-speed trains floating in air." (NYT, 16-2-1987).

Most expectations displayed metaphors of a race and emphasized the breakthrough character of the technology. Project-specific expectations about the discovery soon triggered positive generalized expectations on the field level. In addition, frames emerged that were very positively inclined about the societal relevance of HTS, in particular with regard

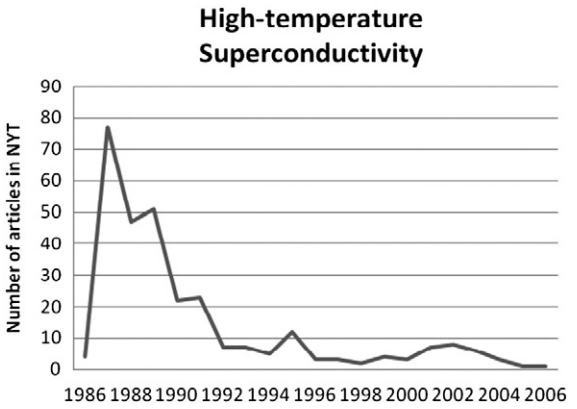

Fig. 4. Media Attention for Superconductivity.

to international competition. These high-rising expectations were accompanied with a sharp increase in media attention (see Fig. 4).

By the end of 1987 awareness slowly grew that it would take a long time before high temperature superconductivity would be commercialized:

> "The commercial rewards of the promising new field of high-temperature superconductors are years away and will require a decade long national research effort if United States companies are to win out over international rivals, a panel of experts says." (NYT, 23-9-1987)

Research efforts did not live up to expectations at the level of the technological field and disappointment quickly spread. After 1988, problems continued to be mentioned but the technology was not debated negatively at the macro level — most likely, because it was simply not regarded important enough to attract significant media attention. After 1989, expectations voiced about HTS almost completely disappeared from the mass media, but, somewhat behind the scenes, the energy saving potential kept HTS on government agendas. Later developments focused on the production of wires and materials that were suitable for this purpose. Table 6 shows the hype pattern that we observed in the HTS field. In contrast to the gene therapy and the VoIP case, the hype pattern is quite pronounced, with a clearly identifiable peak and a sharp disappointment shortly after. This is also visible in the attention pattern depicted in Fig. 4. Finally, it is interesting that HTS seems to be the only case were disappointment was not followed by a gradual recovery, except for the few fragmented research activities. We shall return to this latter point below.

5. Understanding regularities and variations in hype patterns: a comparison

The previous section provided a detailed analysis of three hype patterns by tracing attention patterns and the content of expectations. The specific structure of the hypes differed considerably in terms of the length, intensity and alignment between the levels of expectations. In this section, we explore in more detail these differences and try to link them to the characteristics of the underlying technologies and their environments.

5.1. Shape of the peak

Both VoIP and high-temperature superconductivity showed very positive expectations during the peak at all levels. In the gene therapy case, this was more ambiguous as negative frames addressing ethical and safety issues were present during the whole period we investigated. This did not impede the occurrence of hype, though. Nevertheless, we have found a more diffuse hype pattern in the gene therapy case, with a peak embedded in lengthy periods of mixed expectations. The particular environment in which the hype took place goes a long way in explaining this: disappointments on the project level were balanced by continuing promises on the generic level. And in particular the latter were linked to wider expectations of the commercial success of biotechnologies. The simultaneous struggle to materialize concrete applications, on the one hand, and to give them a role in the emerging biotechnology industry, therefore, has allowed for a mix of partially contradicting expectations on different levels. This, in turn, has led to a more diffuse peak of the hype than Fig. 1 would suggest.

The attention patterns also differed between our cases, not all of which showed a coincidence between attention pattern and the content of expectations. Indeed, only in the superconductivity case, the attention pattern also represents the hype pattern we identified. In the other two cases, the hype revealed

Table 6
Summary of expectations observed in the high temperature superconductivity case.

		Peak	Trough	Fragmented activity
C: durations		87	87–89	89–now
Project-specific expectations	Content	Discovery of higher temperatures and other materials	Disappeared from the sample	Singular, very specific applications
	Value	Very positive	n/a	positive
Generalized expectations	Content	Commercialization prospects for various applications	Technological problems, theoretical explanation lacking, time to commercialization long	Technological problems, theoretical explanation lacking, time to commercialization long
	Value	Very positive	Positive/negative	Positive/negative
Frames	Content	Improving international competition and national economy	Disappeared from the sample	Disappeared from the sample
	Value	Very positive	n/a	n/a
Attention		Culminating into a peak	Slowly decreasing	Low with a minor peak around 2002

itself primarily in the discourse analysis. This confirms Ruef and Markard's [13] claim that hypes should be measured by both the amount of public statements and the content of these statements. Our comparative case analysis adds to this insight that the nature of the hyped technology influences how well media hypes, i.e. marked peaks in media attention, coincide with hypes in the technology field. Hence, our research has shown that also in cases were media attention does not reveal a clear-cut pattern, hypes may still exert a considerable influence at the field level, where expectations show the characteristic pattern of high-rising promises followed by disappointment. Again, we suspect that the characteristics of the technology as well as its environment are crucial in explaining why attention patterns and hypes in technological fields correspond or not. Indeed, only in the superconductivity case, the attention pattern has neatly matched the high rising expectations in the technology field. Our case analysis suggests that, while potential applications of high temperature superconductivity are generic, it's embedding in a basic research setting failed to generate enough momentum for a varied set of generic expectations and frames. Interestingly, this was also the only case where disappointment was followed by an almost complete disappearance of expectations on all levels. We might conclude that very pronounced peaks, where media attention and high rising expectations coincide, indicate an inherently problematic situation because they do not offer many options to redefine the future of the associated technology after disappointment.

5.2. Shape of the trough

In all our cases, hype was followed by disappointment. The nature and consequences of disappointment, however, were quite diverse. In contrast to what the Gartner hype cycle would predict, in the superconductivity case we did not observe that the hype triggered a stabilized development after disappointment. Again, this corroborates Ruef and Markard's [13] finding that what happens after hype is probably more interesting than the occurrence of the hype itself. In both the VoIP and the gene therapy case we found that positive expectations continued to drive the field after disappointment. One possible reason for this is that in both cases the underlying technology has been embedded in a relatively varied field: VoIP raised expectations about a specific application, but this application affected a range of existing industries. Gene therapy has been associated with numerous potential applications, and the expectations surrounding them have been created and shared at the boundaries between science and a number of emerging industries. In both cases, the environment provided sufficient opportunities to rephrase and modify expectations after disappointment, so that disappointment has not hampered subsequent development. In fact, gene therapy started to thrive once the range of possible application became widened during hype, which, among others, has linked the gene therapy hype to the broader commercial promises of biotechnology. Likewise, in the VoIP case the hype fed into a rephrasing of expectations in terms of more concrete business opportunities, and in both cases, therefore, the industrial setting provided a resource for redefining expectations at the project and field level. High-temperature superconductivity, in contrast, revealed a more profound disappointment, which led to the disappearance of expectations at the societal and field level. Again, the absence of a wider commercial field or even societal setting in which its promises could be embedded did contribute to frustrate the successful redefinition of expectations beyond the project level.

Our cases, therefore, suggest that at least a certain degree of concrete commercial, industrial or societal promises is fruitful for emerging technologies. Such promises, while not directly solving the struggle to materialize specific applications, contribute to keep such struggles alive. This is particularly clear in the gene therapy case, where viable applications were virtually absent but where the emerging commercial interest in biotechnology did provide a background to maintain an interest in the technology. Also in the VoIP case, the particular embedding of technological development in a mature, yet flourishing environment of business models, regulations and infrastructure has been sufficiently open-ended to spur a host of commercial expectations by a broad range of actors. This, in turn, is reflected in the fierce competition triggered by these expectations, which eventually led to the successful uptake of the technology. It is interesting that in the gene therapy case, the presence of a generic application and an emerging industrial environment has constituted an open and disputed nature of the field. While this has been conducive for a continuous stream of expectations at all levels, it has also prevented, at least hitherto, the development of applications at the same pace. Our initial suggestions could thus be confirmed that it is the specific interplay of the specificity of an application with the variety offered at the field and the societal level that offers a ground to cope with disappointment. The VoIP case has demonstrated that specific applications, when embedded in a dynamic environment can present sufficient opportunities to redefine and thus maintain positive expectations. The specificity of an application is then a strength as it enables actors in the field to embody these expectations into industrial innovation. As a mirror image, the high temperature superconductivity case has revealed that generic applications do not per se lead to sustained activities after a hype; to the contrary, when detached too far from an interested commercial or societal environment, technologies with under-specified applications are at risk to display a very sharp disappointment.

5.3. Duration of the hype

In terms of duration of the hype we observed some notable differences between the cases. Sharply pronounced hypes, where the attention pattern and the content of expectations coincide thus feeding into a sharp peak, are likely to occur when expectations are well aligned on all levels. This was the case with high temperature superconductivity, where the peak period took about two years. In this case expectations were well-aligned at all levels, so that the hype-disappointment cycle could swell quickly with an equally swift breakdown. For gene therapy and VoIP the boundaries of the hype itself were less articulated and had a longer phase of pre-peak rush, and a less profound disappointment. In particular for the gene therapy case, expectations were not aligned between project, field and frame level. As a consequence, the hype took longer to develop, was more difficult to identify, but also led to a more productive phase after disappointment. The frame level of expectations seems to be particularly interesting in this respect. In both the VoIP and the gene therapy cases, the field

and project-specific expectations were embedded in larger societal trends or interests. Gene therapy emerged as one of many technologies that together constituted the "biotech bubble" [34], while VoIP has been part of the wider trends of the informatization of society. Wider societal trends, thus, are important for the continuous articulation of frames around an emerging technology. These trends, in turn, are a rich source for the redefinition of more concrete project specific and field expectations.

6. Conclusion and discussion

In this paper, we have looked at hypes around technological innovations. Rather than adopting the critical popular view of hypes as exaggerated, misleading and thus faulty predictions of the future, we have taken a different point of departure: the promises of the future that make up a hype, have a performative capacity in the present as they attract resources, coordinate activities, and spur competition. For policy makers and other actors in the innovation process, hypes can thus be considered as a *resource* as well as a *pitfall*, and understanding better how hype patterns take shape may considerably increase these actors' capacity to cope with hypes fruitfully.

Against this background, we compared three hype patterns and combined a quantitative analysis of attention patterns with a qualitative analysis of the content of expectations. We have distinguished between three levels on which expectations operate, i.e. the micro-level of projects, the meso-level of technological fields, and the macro-level of societal trends and frames. Our case selection was guided by two characteristics of the emerging technologies at stake: the specificity of the envisioned application, and the nature of the environment in which the expectations surrounding the envisioned applications where created, shared and refined. Our base case (VoIP) combined a very specific application with a mature, albeit dynamic industrial environment. Our analysis confirmed that in such cases hypes, by and large, resemble the pattern suggested by the Gartner hype cycle depicted in Fig. 1. One reason that transpires from our analysis is that the industry setting in which the VoIP hype was embedded provided enough variety for specific, generic and frame-level expectations to flourish. Indeed, we found the hype pattern most profoundly articulated on the field level, while it was less visible in the attention pattern and the broader societal discussions.

Hypes of generic applications are more precarious, as we found in both the gene therapy and the high superconductivity cases. Indeed, both cases have been characterized by more fundamental struggles with the underlying technology to define viable applications. However, this alone could not explain differences in hype patters. To the contrary, also in these two cases of generic applications the environment in which the expectations have been embedded has played a crucial role. Hence, the gene therapy case supports that a rich environment, combining perceived business opportunities and industrial patterns with the search for applications are conducive for productive activities after disappointment. Again, the hype has most clearly revealed itself on the field level, while it was less pronounced in the expectation pattern or the societal discussions about gene therapy. This, however, has appeared to be a fertile ground for a productive recovery after disappointment. As far as the role of expectations in innovation is concerned, we might thus conclude that application environments that offer cues for possible technological applications *and* varied business opportunities are essential in order to produce a sufficiently diverse and thus productive repertoire of expectations.

The high temperature superconductivity case has demonstrated that recovery after disappointment is not a matter of course. In this case, the three levels of the hype as well as the attention pattern were widely in-synch, and this, probably somewhat counterintuitive, indicates a problem — as high temperature superconductivity was embedded primarily in a research environment, it was lacking significant opportunities to redefine or reorient expectations on different levels. Disappointment, therefore, has led to an almost complete disappearance of expectations on all levels. Again, this indicates that hypes thrive in rich environments, where research, business, and wider societal activities contribute to the creation, sharing and refinement of expectations. If such an environment is absent, the disappointment after hype is likely to be profound because disappointment concerns the project, field and frame level at the same time. Under such circumstances, reorientation of expectations is unlikely to occur.

This leads us to our central conclusions that might guide further inquire into the theory of hype cycles. When expectations at project, field and societal levels are neatly aligned, the risk of a profound disappointment after hype is greater. Some degree of misalignment between these levels may thus help a field to flourish, when visions about the future are sufficiently open-ended to turn disappointment into a productive reconfiguration of expectations. The VoIP case most clearly demonstrates this, where the disappointment after an early hype has been followed by a reconfiguration of expectations around a commercial uptake rather than an undisputed diffusion of a thrilling new technology. Gene therapy, with its scarcity of successful applications, has almost since its inception thriven on a constant redefinition of the field. A rich set of sometimes contradictory expectations have been conducive for this. Our three cases, therefore, jointly suggest that a good mix of different expectations at different levels is a potential predictor for a productive recovery after disappointment. This reminds us that hype cycles are shaped in actions and interactions, as actors create expectations, relate these to the expectations of others, and strategically use them to generate momentum for the emerging field [35]. Our research has supported this view by demonstrating how mature or emerging industry settings provide an environment that allows for coping with disappointment.

As a final remark, for policy makers and other actors in the innovation process, it seems to be essential to acknowledge that hypes differ between fields, and that the conditions of the underlying technology are inherently entangled with the structure of hypes that may occur. We need more knowledge about this to fully specify how different actors can use hypes effectively as a resource. In this regard, this paper has developed a number of promising avenues for further research into the structure of hypes. In particular, the two dimensions of specificity of potential application and the nature of the environment, as well as their relation with the alignment of expectations on different levels seem to be fruitful in linking insights from different case studies into a more systematic understanding of hype patterns.

Appendix A

		VoIP	Gene therapy	HTS
Mass media	Source	New York Times	New York Times	New York times
	Description	Daily newspaper that presents comprehensive coverage of national, foreign, business and local news	Daily newspaper that presents comprehensive coverage of national, foreign, business and local news	Daily newspaper that presents comprehensive coverage of national, foreign, business and local news
	Keyword	"Internet Telephony" and "VoIP", comparing results and eliminate doubles. Eliminate articles that do not have VoIP as subject	"Gene therapy"	"Superconductivity"
Scientific media	Source	Computer networks	Human gene therapy	Physical review B
	Description	International archival journal covering all aspects in computer communications area.	Peer-reviewed journal for rapid communication covering all aspects of human gene therapy.	APS journal devoted to condensed matter and materials physics.
	Impact factor	Impact factor 00: 0.390. 07: 0.829. Journal highest impact factor of journals freely accessible.	Impact factor 00: 6.796. 07: 4.330. Journal mentioned as important in secondary literature. First devoted journal in the field (Friedmann 2005)	Impact factor 00: 3.065. 07: 3.172 Journal mentioned as important in secondary literature. (Nowotny and Felt 1997)
	Key words	"Internet Telephony" and "VoIP", comparing results and eliminate doubles	n/a	"High-temperature superconductivity"
Secon-dary literature	Papers	▪ Swale, 2001 ▪ Karapantazis and Pavlidou, 2009	▪ Friedmann, 2005 ▪ Judson, 2006	▪ Nowotny and Felt, 1997 ▪ Ott, 1994

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