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The Sociology of Expectations in Science and Technology

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Introduction

In recent years a growing number of social science studies have pointed out the significance of expectations in science and technology innovation. This special issue of *Technology Analysis and Strategic Management* brings together authors whose interest has been concerned with exploring a range of questions about the role of expectations in shaping scientific and technological change. Its contributors reflect ongoing scholarship from within a range of perspectives including sociology of technology and science, history, economics and innovation studies. Given that such expectations have been a source of acute interest of late in areas as broad as the biosciences, nanotechnology and energy, this special issue is both timely and important in drawing these strands together, articulating some of the lessons learnt thus far, and defining future areas of investigation.

By definition, innovation in contemporary science and technology is an intensely future-oriented business with an emphasis on the creation of new opportunities and capabilities. Novel technologies and fundamental changes in scientific principle do not substantively pre-exist themselves, except and only in terms of the imaginings, expectations and visions that have shaped their potential. As such, future-oriented abstractions are among the most important objects of enquiry for scholars and analysts of innovation. Such expectations can be seen to be fundamentally 'generative', they guide activities,

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provide structure and legitimation, attract interest and foster investment. They give definition to roles, clarify duties, offer some shared shape of what to expect and how to prepare for opportunities and risks. Visions drive technical and scientific activity, warranting the production of measurements, calculations, material tests, pilot projects and models. As such, very little in innovation can work in isolation from a highly dynamic and variegated body of future-oriented understandings about the future.

Expectations and visions are, however, also important for actor groups beyond scientists and engineers. They play a central role in mobilizing resources both at the macro level, for example in national policy through regulation and research patronage, and at the meso level of sectors and innovation networks, and at the micro-level within engineering and research groups and in the work of the single scientist or engineer.[1]

For these and other reasons, analysing the dynamics of expectations is a key element in understanding scientific and technological change. One of the main reasons for this is, we would argue, because expectations frequently serve to bridge or mediate across different boundaries and otherwise distinct (though overlapping) dimensions and levels. Expectations are foundational in the coordination of different actor communities and groups (horizontal co-ordination) and also mediate between different scales or levels of organization (micro, meso, and macro—vertical co-ordination). They also change over time in response and adaptation to new conditions or emergent problems (temporal coordination). Likewise, expectations link technical and social issues, because expectations and visions refer to images of the future, where technical and social aspects are tightly intertwined. Finally, expectations constitute 'the missing link' between the inner and outer worlds of techno-scientific knowledge communities and fields. At the same time, expectations and visions are often developed and reconstructed in material scientific activities and disseminated in obdurate and durable forms. In a sense, expectations are both the cause and consequence of material scientific and technological activity.

While expectations in their general form can be defined as the state of looking forward (from Latin, *exspectatio*, looking, waiting for), technological expectations can more specifically be described as real-time representations of future technological situations and capabilities. Similar terms, which are commonly used, like technological 'promises' and 'visions' are largely overlapping with 'expectations' but emphasize to a higher degree their enacting and subjectively normative character. They stress that expectations are wishful enactments of a desired future. By performing such futures, they are made real and in this sense expectations can be understood as performative.[2] Along with positive promises and hopes of future capabilities, fears and concerns about future risks are parallel features of these kinds of dynamics.[3] Both positive expectations and fears of risk—though different in character and having different dynamics—can be seen to have considerable influence on the discussion technological change.

While expectations and visions have always been important aspects of science and technology development, they are not historically constant and it may even be argued that hyperbolic expectations of future promise and potential have become more significant or intense in late and advanced industrial modernity. This shift in intensity is probably connected with a number of tendencies in the contemporary character of science and technology. For example, technological and scientific investment has increasingly been tied into strategic rather than say serendipitous innovation. The last half century has seen a 'strategic turn' in science and technology visible in the development of explicit research and innovation policies in many countries and in changes in research and

education systems and their funding structures. Technology development and scientific knowledge are considered of central importance for societal development, not least through economic growth and international competitiveness. Moreover, with the rise of the so-called knowledge society, knowledge has become a central driving element of socio-economic and advanced industrial change and thus a key site of strategic focus. As a result, processes of science and technology innovation have become more complex, with a significant increase in the amount of communication and interaction across institutional and epistemic borders. For example scientists and researchers are increasingly expected to reach beyond the borders of their own specific fields of expertise and establish relationships with wide and heterogeneous networks of potential collaborators. Firms and policy makers are confronted, even bombarded, with technological promises (and their attendant risks) creating new decision-making demands based on the interpretation and analysis of the expectations environment. Just as often, such actors are confronted with disappointing outcomes and with promises that do not seem to hold. Therefore, it has become increasingly important to develop a vocabulary and analytical perspectives with which to make sense of the promissory and future-oriented properties of innovation networks, especially given the highly contested character of expectations and futures.[4] With this special issue we hope to show that social science accounts of expectation are among the most interesting and fruitful areas within science and technology studies.

Approaches within Expectation Studies

As an analytical object, science and technology related anticipatory expectation has recurrently emerged in different social science disciplinary fields over the past several decades. It is fair to say that the growing number of expectation studies in the recent years has its locus primarily in social studies of science, technology and society (STS) often adapting mainstream STS perspectives and findings as, e.g. the heterogeneous and hybrid socio-technical character of technology and knowledge production; the mutual shaping of social and technology order; the actor-oriented approach combined with critical constructivist perspectives.[5] Nevertheless, the disciplinary composition of contributions to the expectations literature is however much more varied drawing on fields as distinct as economics, sociology, the history and philosophy of science, as well as STS. In what follows, we will briefly sketch some of these research and analytical efforts before moving onto a characterization of their main findings and insights.

In STS a number of studies have shown the decisive role of expectations in establishing new scientific and technological fields as diverse as membrane technology,[6] neural computing,[7] gene therapy and pharmacogenomics,[8] nanotechnology.[9] In a similar vein, hype and disappointment dynamics have surfaced as an important element in studies on the development of specific scientific or technological fields[10] and across a range of case studies.[11]

Brown and Michael[12] have analysed the distribution of expectations in relation to the contrasting positioning of different actors (scientists, regulators, publics, etc.) in the innovation process. Expectations as an important element in the shaping of specific artefacts have been analysed in relation to the role and function of 'leitbilder' or 'guiding visions'.[13] A similar approach to the shaping of artefacts by expectations has been taken in a body of literature looking at design and utility.[14] Of particular importance in all these studies are the explicit or implicit actor roles embedded in expectations. Ideal expectations of future users and their attributes are literally and materially scripted into

technologies and socio-technical systems, though these will inevitably be reinterpreted and even subverted in usage. Some of the insights gained in these analytical studies have been translated into important comment and critique on future-oriented practices including scenarios and foresight.[15]

From within the history of technology there are important accounts of how expectations change over time, and particularly longer time spans, in relation to various 'real time' factors.[16] This shows, for example, that expectations tend to reflect current conceptions of technological utility or, as Marvin puts it, 'the tendency of every age to read the future as a fancier version of the present'.[17] This characteristic is also clearly visible in the genre of science-fiction and the tendency to reflect present day concerns and hopes. Historical studies have also shown how the general conception of the future, and accordingly the structure of expectations, has changed over historical timeframes, with the discourse of technical *progress* as a typical modern phenomenon.[18]

More generally, expectations and future orientation as an integral part of human agency have been analysed in both classical and contemporary social theory, especially in the work of Weber, Mead, Schutz and others.[19] Other contributions have been just as illuminating, especially from within sociologies of time in the work of Merton, Adam and Virilio;[20] and memory and commemoration in work by Bartlett, Jedlowski and Halbwachs[21] and the emotions in work by scholars like Barbalet.[22] Here, a common theme is the constant interplay between present, past and future. One notable account here is Merton's writing[23] on the concept of self-fulfilling prophecies, using the example of a bank that runs into trouble when the (initially false) rumour spreads that the bank is in trouble, prompting clients to withdraw their money.

Economics has of course been fertile ground for studies into the dynamics of expectations especially in the context of market behaviour, but also in technology diffusion.[24] These studies show that expectations of rapid technological progress, for instance, may reduce consumers' willingness to adopt new technologies in the expectation of successor technologies yet to come. Behavioural finance literature has researched expectation dynamics and their implications through the notion of 'herd behaviour'.[25] It is now acknowledged that investor behaviour is not only based on rational risk–return considerations, but also influenced by expectations and perceptions of other investors' behaviour. Research in innovation management has shown the importance of expectations as a factor influencing the processes of strategy building, in addition to resources, capabilities or firm culture.[26] Furthermore, research on foresight activities in companies has analysed the perception and evaluation of specific technological expectations within firms.[27]

Yet it is important to note some differences here between traditional approaches to expectations in economics—especially 'rational expectations' literature from the 1960s—and the more constructivist position taken in Science and Technology Studies. Rational expectations assume a realist distinction between people's expectations on the one hand and the 'real' underlying fundamentals or worth of something on the other. The 'constructivist' approach adopted by most contributors to this issue differs radically from this more realist form of analysis. When hype occurs—according to 'rational expectations'—it does so because people start investing in the expectations and not the fundamentals. A crash occurs, so the argument goes, when the difference between real and artificially inflated values becomes inescapably obvious.[28] This realist position assumes that there is a calculable difference in the present between expectations and the real worth of something such that expectations can be adjusted 'rationally' according

to fluctuations in value. While this emphasis on checking is valuable it is also conceptually problematic. It supposes that checking the veracity of claims about a future technology can be done before the technology has been tried out. In many cases however, checking such claims will involve the same activities as trying to build the technology. If we accept that anticipation is actually constitutive of value, then we logically cannot differentiate between our expectations of things (biotechnologies, stem cells, nanotechnologies, etc.) and what those things in fact are. Those 'underlying fundamentals' are themselves future abstractions, expectant projections that alter the now, the future working back on the present. Many of the contributions to this issue would find it highly problematic to calculate 'the real worth' of something independently from our expectations in order to determine whether or not hype is taking place.

Central Themes and Findings

Expectation as Constitutive Force

First and foremost expectations are 'constitutive' or 'performative' (see above) in attracting the interest of necessary allies (various actors in innovation networks, investors, regulatory actors, users, etc.) and in defining roles and in building mutually binding obligations and agendas. At the most general level we can understand expectations to be central in brokering relationships between different actors and groups. Indeed, it would be hard to picture the formation of technology developments and innovation without some kind of shared, though flexibly interpreted, cluster of guiding visions.

The mutuality of expectations may result in what Harro van Lente[29] has described as the dynamics of 'promise and requirement', i.e. of promissory commitments that become part of a shared agenda and thus require action. Note that the phrase 'I promise X' is not just a description, it makes the person who enunciates the phrase accountable for doing X (or a version of X). Pronouncing an expectation does not necessarily create accountability, but does prompt responses and the expectation that the enunciator should justify their future-oriented claim. In the case of widely shared expectations, however, legitimation is hardly required. In contrast, shared expectations can be used to justify other statements and actions, even to such an extent that one should justify an action that deviates from what is commonly expected.[30] Also in more concrete situations, formulating an expectation, say about the usefulness of a tool or a procedure, can be read as an implied warrant to others that they *should* use that tool or the procedure. Expectations are, in this sense, obligatory and open up the potential for present-day promises to be held to future account.

These kinds of dynamics have a particularly salient role to play in the most early stages of technoscientific constructions and innovations. Here it is likely that roles will be ambiguous, lacking form or agreement; regulatory aspects like those of standards and quality control are unlikely to have been developed; market players will experience acute levels of uncertainty in judging appropriate levels of investment; it will probably be the case that numerous competing innovation futures are also being promoted; contestation and conflict may be very high, etc. It is in these early moments of uncertainty that shared expectations increase the possibilities of success by enrolling a wider range of stakeholders. The problem of course is that, because expectations are at their most intense during the early stages of a technology, the vision is ultimately very likely to differ from future reality.

Expectations and Temporal Variability

Expectations usually have a temporal patterning over time. This is often manifested in alternating cycles of hype and disappointment. This phenomenon of early promise/later disappointment suggests that while expectations are essential to mobilizing effective interest, an early surge in hype is necessary in order to get a hearing.

> Initial promises are set high in order to attract attention from (financial) sponsors, to stimulate agenda-setting processes (both technical and political) and to build 'protected spaces'.[31]

Thus disappointment seems to be almost built into the way expectations operate in science and technology. While necessary to raising the profile and attract allies, disappointments are also likely because of the specific structure of the expectations. Early technological expectations are in many cases technologically deterministic, downplaying the many organizational and cultural factors on which a technology's future may depend.[32] In this way, expectations of technology are also seen to foster a kind of historical amnesia—hype is about the future and the new—rarely about the past—so the disjunctive aspects of technological change are often emphasized and continuities with the past are erased from promissory memory. As Luhmann puts it, 'modern society produces its own newness by way of stigmatising the old'.[33] In a similar vein, though from historical sociology, Reinhart Koselleck[34] in his seminal work *Futures Past* argues that while political imperatives may often give rise to a disjunctive sense of change, in reality historical futures tend to intermingle, disrupting hard temporal distinctions. More importantly, in the context of a globalized modernity, different temporal understandings of past and future tend to be superimposed upon one another in a cumulative and layered process of historical disorientation. Memory and present are inextricably bound to futurity. For Kosellek, every present is a former future. Lene Koch in her paper in this issue draws on Kosellek's work in trying to fathom both the continuities and discontinuities that connect the utopian dreams of early 20th-century eugenics with the aspirational social technology of modern genetics.

Nevertheless early hopes – what Mokyr[35] refers to as 'hopeful monstrosities' – are rarely proportionate to actual future results. Indeed, as Brown[36] points out, the number of successive disappointments in fields as diverse as biotechnology, e-commerce, stem cells and nanotechnology have resulted in lasting damage to the credibility of industry, professional groups and investment markets. That is, until the next promise arrives! So, expectations and the frequent disappointments to which they lead are accompanied by serious costs in terms of reputations, misallocated resources and investment. These insights are in fact widely shared already, though more usually tacitly. In practice it remains difficult to see whether—*this time*—'our high expectations' might be justifiably warranted.

So, not only is the future rarely proportionate to future outcomes, but it is also often the case that memories of past expectations tend to rationalize these retrospections according to the way things eventually turned out. More usually, these revisionist histories tend to forget or silence complexity and contingency, transforming a resultant technology into a hero of its own making.[37] Similarly, past disappointments tend to be rationalized such that they present a reduced threat to new and successive expectations. That is, past failures are often isolated as special or peculiar cases with little technically or organizationally in common with the newly proposed promissory solution.[38]

When a promise is accepted and becomes part of an agenda of further work, other more detailed expectations have to be articulated and taken up. A broader, encompassing promise, may help to protect more specific promises providing a protected space, or 'niche'. Van Lente[39] points to the importance of the encompassing promise of technology, the culturally anchored notion—or ideograph—that technology will continue to offer possibilities for progress. This notion goes back to the Enlightenment and has been important in the exploration of new fields such as electricity, ICTs, biotechnology and nanotechnology. Here, the promise of technology as such results in a 'mandate' to technologists: the freedom to explore and develop combined with a societal obligation to deliver in the end.

Now, many of these temporal variabilities in expectations have become part of a widely shared cultural and social stock repertoire for interpreting socio-technical change. One example of this is the Gartner consultancy's 'hype cycle', a highly simplified graphical representation of the ups and downs, peaks and troughs of technological expectations. Here technologies are seen to move along a path from trigger, to a peak in expectations, then plummeting into a trough of disillusionment before eventually giving rise to a range of somewhat more modest applications.

However seductive, there are a number of serious problems with this form of representation. First and foremost, the model is too general in not providing enough room for the kinds of variation and unpredictability that characterize the place of expectations in technological, let alone, social change. Many cases, for example, do not show a neat slope of enlightenment, and simply stop at disillusionment or continue with a new inflation of

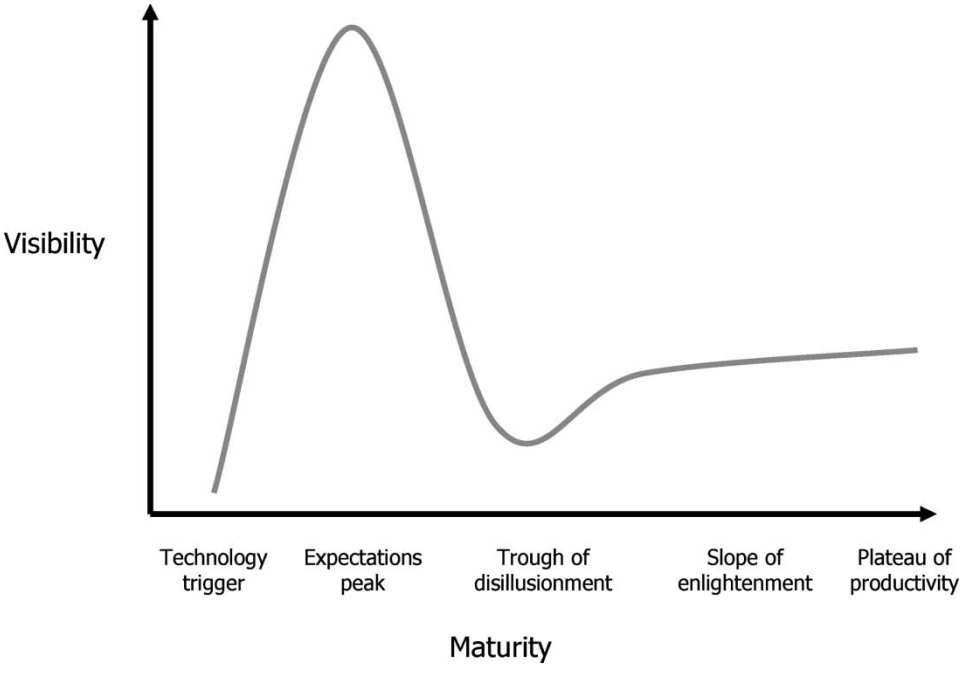

Figure 1. The Gartner Consultancy 'hype cycle'

expectations. Critically, this way of thinking about change re-introduces a highly linear understanding of a technology's path dependency and fails to account for the way artefacts or technologies actually change over time in a continual and practical process of reconfiguring and being reconfigured in use.

Expectations and Socio-spatial Variability

Just as importantly, expectations and future uncertainty are seen to vary between different groups involved in technological development. So, in addition to the temporal variabilities just discussed, fields also exhibit social variabilities where people will attach different levels of trust to expectations. The obduracy of the emerging technology is different for different groups.[40] Expectations have the appearance of greater authority for those who see themselves as having little influence over the outcome of a promise (publics for example). This easily translates into a normative framing of expectations: 'it's going to happen so you might as well get used to it'!

A heightened sense of confidence often reflects a detachment or distance from the acute uncertainties more usually experienced by researchers at the 'coal face' of conducting the research on which a future field will depend.[41] Also, people closely involved in scientific work more usually offer quite contradictory expectations about their field. When wearing a public entrepreneurial hat they might make strident claims about the promise of their research, but when among research peers, they will be much more cautious and equivocal, though publicly still committed to the promises associated with their field. As Brown and Michael point out, this interpretative flexibility and the social patterning of expectations across communities often arises from asymmetries in access to the information on which expectations are based. For example, many of the technical uncertainties of bench and laboratory science are often invisible to the wider public worlds of policy and entrepreneurship.[42] Elevated levels of expectation and confidence also have the effect of inflaming concerns about risk in different communities based on differing values, knowledges or institutional and organizational forms.[43]

Imagination, Materiality and Embodiment

Expectations circulate in various forms and shapes. This raises searching problems for us in thinking about expectations as essentially rhetorical or material in character. That is, to what extent are expectations the enunciated views and ideas of people (utterances), and in what way do they become 'inscribed' in texts, actions, bodies, materials, objects and machines (embedded)? What is the relationship between imagination and materiality? That is, what are the routes of transmission between expectations, embodiment and materiality, and specifically the way and by what means promisory abstractions about the future take on substance, becoming materially embedded in structures, routines, systems, matters, etc? Materiality in the form of artifacts or actions related to science and technology development serve as a materialized indicators of expectations and thereby contribute to expectation dynamics.[44] As Mike Michael has put it:

> The performativity of these representations does not take place in some abstracted, a-material domain. It is conducted in material settings, where bodies and texts, for example, come into contact or close proximity at least.[45]

After a time, or even rather quickly, expectations may be seen to exhibit certain material and social path dependencies (lock-in or irreversibility) becoming the basis for future envisioning, a predisciplining of the imagination through the legacy of former expectations. There are any number of illustrations through which we might explore the dynamics between the imagination and materiality at different levels ranging from large-scale, long-term systems to the more micro moment-by-moment practicalities of scientific and technological imagining.

As Brown and Kraft in this issue explain, the materiality of expectations prompts us to think about the way hopes and imaginings become varyingly embedded in bodies and subjectivities. In what Charis Thompson[46] describes as the 'biotech mode of reproduction' expectations have been seen to condense around particular matters—stem cells, blood, ova, semen, embryos, animal tissues—forming the basis of a new value chain linking the present and future value of biologies. If Industrial capitalism was seen to alienate oneself from one's labour, today it is one's biology and its tissues that are the object of alienation in the contemporary 'capitalization of biology'. For Brown and Kraft, banking the cord blood of the newborn for use in future imagined treatments (stem cell transplantation, gene therapy, tissue engineering, etc.) connects the anxieties and hopes of new parents with an emerging industrially organized and highly privatized biological service. These services are at once highly abstract in terms of the remote deposition of cord blood for a cash payment, and yet also highly subjective and inter-personal in the actions of parents anxious to 'do the right thing' by the future. Hope and expectation invested or embodied in tissues—though also 'disembodied' in the process of banking or storage—parallels widening interest in anticipatory discourse in health and medical innovation.

New Perspectives

The contributions in this Special Issue demonstrate some of the breadth and range of analytical enquiry into expectations identified above. While they all emphasize the dynamics of expectations as a basic and important feature of modern science and technology, they approach the topic from different angles and focus on quite diverging areas of science and technology. This itself accounts for some of the quite different dynamics to which each of the papers attends. Here we want to present a brief overview of the specific perspectives the contributions take on the dynamics of expectations and, at the same time, highlight a number of promising routes for further research.

As pointed out in the introduction, expectations play a central role in science and technology not least because they mediate across boundaries between different scales, levels, times and communities. This mediating role is illuminated by most of the papers in the issue, but several particularly. Berkhout in his article highlights the significance of expectations as 'bids' or future-oriented propositions offered as interjections into the flow of the present. Such bidding is incredibly interactional, with each proposition competitively jostling alongside others in a process of mutual testing and interrogation through which some propositions will come to dominate over others. These encounters between expectations can be seen both between similar or parallel expectations directly competing with each other and also between expectations and visions that occur on different kinds of levels. The article by Konrad illustrates the latter 'vertical' form of coordination and identifies dynamics between *social or collective* expectations and, more locally, specific

expectations within innovation communities in the field of information and communication technologies (ICTs). In a similar vein, Eames and McDowell show the interrelation between generic and local expectations of the hydrogen economy and investigate the complex relations of competing narratives about its future. Similarly, Lösch shows how expectations in the form of imaginary visions mediate between different types of discourses about the future of nanotechnology. Geels and Raven address the interplay between local projects and global niches in the case of biogas and touch upon the interrelation of expectations of competing technologies.

A further topic addressed by several articles is the relation between expectations and the emergence of path dependency. In discussing the 'building up' or accumulation of expectations, Merkerk and Robinson investigate the stabilization and de-stabilization of expectations as part of path development. In doing so, they draw together insights from both innovation studies and evolutionary economics. As a kind of counterpoint, Geels and Raven analyse how expectations contribute to non-linearity and changes in the trajectories of technological niche-development. They show that niche expectations are influenced both by internal learning in the niche and external developments. In addition, we can also find path dependency, lock-ins or irreversibility within 'expectation trajectories'. Expectations shared within certain communities may become the basis for future envisioning, a 'predisciplining of the imagination' (see Brown and Kraft in this issue) through the legacy of former expectations. The contribution of Andreas Lösch in this issue investigates some persistent imaginations about nanotechnology futures, such as the nano-submarine in blood vessels, which frame the form and quality of subsequent expectations. Similar trajectories of expectations about use concepts surface in the analysis of expectations about interactive television in the article of Konrad.

These dynamics, generally speaking, have to do with the traditions, norms, interactions and practices through which expectations are formed and mobilized, and therefore are likely to depend on the specific actor groups involved. In addition, they may depend on the type of technology or scientific fields addressed. For example, we may distinguish between technologies that are specific to particular application fields, and, by contrast, more generic technological or scientific areas that serve as the generic basis for a wide variety of applications. The papers in this special issue touch on both of these. For example, nanotechnology and stem cells represent the latter type, while biogas or interactive television are a much more specific in their application. Others, like Lab-on-a-chip technology or energy technologies based on hydrogen may be considered as an intermediary type. Expectations related to rather specific technologies may be said to be less robust or more fragile than more generic application areas. We might even say that hype–disappointment dynamics are probably more pronounced in the former of these cases.

In addition to differentiating between different kinds of scientific and technological fields it is just as important to differentiate between the attributes of groups and communities. For example, professionalized scientific circles may show more inertia to radical expectation dynamics—but also less sensitivity to disappointment phases than say business circles. One illustration or indicator of this might be the 'attention cycles' that we see in scientific journals compared to those in media or professional journals.[47] Similarly, we may also expect an increasing sensitivity to hype- and disappointment-cycles depending on the funding structure of an innovation field, i.e. if it is dominated by corporate resources, public (research) funding or rather by capital markets. Furthermore, the cases in this issue also point to the importance of public and private distinctions. For

example, in the context of large governmental programs and initiatives, while both public and private sectors have an obligation to justify decisions and investments, this is far more pressing for public sector legitimacy (see for example Van Merkerk and Robinson, and Lösch, in this issue).

This latter point highlights issues and important questions about the politics of expectations. The divergence and spatiality of expectations, scattered across different communities, prompts us also to think about parallel areas in the theorization of knowledge and understanding, especially where these link into inequities of power and authority in defining futures. Ways of thinking about, for example, patient advocacy organizations, public understanding, scientific citizenship, scientific engagement or problem-based knowledge, all provide inroads into the politics of expectations. As Nowotny and others have argued, much of the 're-envisioning' of the future of science and technology must now proceed on the basis of a radically democratized knowledge: 'Visions, images and beliefs cannot sharply be demarcated from knowledge ... . It is important to recognize how visions and images interact and also how wide the gap separating images from practice can become before an uncontrollable backlash is provoked.'[48]

To conclude, a systematic comparison of the differences in dynamics in various fields is an important next step in the study of expectations. To what extent might we be able to identify recurrent patterns in the dynamics of expectations? What lessons might be learnt from a comparison of sector specific insights? What contribution will retrospective case studies make to such an analysis and to what extent are their insights comparable? How do these studies fit within comment and discussion on the wider context of the political economy of expectations? While the papers brought together in this issue go some way towards responding to these kinds of questions, much remains to be done in furthering our understanding of these dynamics and their place in the temporal and spatial organization of innovation.

A related challenge is to reflect on the possibilities of this kind of analysis for a process of learning and the creation of a body of knowledge that itself will feedback on the dynamics of expectations. Is it possible, for instance, to use our insights to influence these processes in such a way as to avoid or minimize the social and legitimatory costs of exaggerated expectations or hype? Would such a minimization itself be risky in terms of reducing or undermining many of the things that hype is supposed to achieve (attracting interest and investment, etc)? Nevertheless, what scope is there for re-connecting the analysis of expectations with the practices of producing and constituting expectations? For practitioners, expectations are, of course, more than an interesting phenomenon. For them, expectations are critical objects of judgement and assessment in discerning their veracity, robustness and reliability. This is all the more complex in conditions of heightened uncertainty where science and technology routinely throws up the unexpected—where the unexpected itself is to be expected. These second order expectations include the widely shared understanding that futuristic representations of science and technology rarely live up to their promise and potential. The irony is that the underperformance of the future is itself to be expected. These are features of the way expectations are culturally managed, the way hype and disappointment become absorbed into the dynamics of expectations. Nevertheless, the ability to discern the veracity of these futures remains a source of critical tension. Sung and Hopkins in their article describe an approach for evaluating technology expectations in such a way as to assess varying degrees of uncertainty, robustness and accountability. Their points about conceptual

distance are intriguing inroads into the question of some kind of 'quality control' for expectations.

Over the last couple of decades any number of techniques, instruments and practices have evolved to articulate and assess expectations in science and technology (technology forecasting and assessment, backcasting, roadmapping, scenarios methods, foresight, etc.). Each in their different way have sought to provide some form of anticipatory competence through which it might become possible to make more strategically prudent decisions about the future. The papers brought together in this issue offer a slightly different perspective by offering observations about the less strategic and formalized way in which futures and expectations are enacted and performed. This distinction was once referred to as the difference between *looking into* the future and *looking at* the future.[49] Probably the most important next step for analysts of expectations is to bring these two dimensions together in a more reflexive attempt to understand the contribution of their findings for the future underway in the present. That is to integrate analysis and practice by merging the perspectives of looking into and looking at the future. It is just possible that the papers in this issue may harbour some nascent suggestions on how that might be achieved.

Notes and References

1. H. van Lente, Promising technology. The dynamics of expectations in technological developments, PhD Thesis, University of Twente, Enschede, 1993.
2. M. Michael, Futures of the present: from performativity to prehension, in: N. Brown, B. Rappert & A. Webster (Eds) *Contested Futures: A Sociology of Prospective Techno-Science* (Aldershot, UK, Ashgate, 2000).
3. M. Sturken, D. Thomas & S. J. Ball-Rokeach (Eds), *Technological Visions. The Hopes and Fears that Shape New Technologies* (Philadelphia, PA, Temple University Press, 2004).
4. N. Brown, B. Rappert & A. Webster (Eds), *Contested Futures: A Sociology of Prospective Techno-Science* (Aldershot, UK, Ashgate, 2000).
5. W. Bijker & J. Law (Eds), *Shaping Technology/Building Society* (Cambridge, MA, MIT Press, 1992); A. Pickering (Ed.), *Science as Practice and Culture* (Chicago, IL, University of Chicago Press, 1992); B. Latour, *Science in Action: How to Follow Scientists and Engineers through Society* (Milton Keynes, UK, Open University Press, 1987); J. Law (Ed.), *A Sociology of Monsters—Essays on Power, Technology and Domination* (London, Routledge, 1991).
6. H. van Lente & A. Rip, Expectations in technological developments: an example of prospective structures to be filled by agency, in: C. Disco & B. van der Meulen (Eds), *Getting New Technologies Together. Studies in Making Sociotechnical Order* (Berlin, De Gruyter, 1998).
7. J. Guice, Designing the future: the culture of new trends in science and technology, *Research Policy*, 28, 1999, pp. 81–98.
8. P. Martin, Great expectations: the construction of markets, products and user needs during the early development of gene therapy in the USA, in: R. Coombs, K. Green, A. Richards & V. Walsh (Eds), *Technology and the Market: Demand, Users and Innovation* (Cheltenham, UK, Edward Elgar, 2001); A. Hedgecoe & P. Martin, The drugs don't work: expectations and the shaping of pharmacogenetics, *Social Studies of Science*, 33, 2003, pp. 327–364.
9. C. Selin, Time matters: temporal harmony and dissonance in nanotechnology networks, *Time & Society*, 15, 2006, pp. 121–139.
10. H. Nowotny & U. Felt, *After the Breakthrough—the Emergence of High-Temperature Superconductivity as a Research Field* (Cambridge, UK, Cambridge University Press, 1997); M. Callon, Variety and irreversibility in networks of technique conception and adoption, in: D. Foray & C. Freeman (Eds), *Technology and the Wealth of Nations—The Dynamics of Constructed Advantage* (London, Pinter, 1993).
11. Van Lente, *op. cit.*, Ref. 1; Van Lente & Rip, *op. cit.*, Ref. 6; J. Deuten & A. Rip, Narrative infrastructure in product creation processes, *Organization*, 7, 2000, pp. 69–63; K. Konrad, *Prägende Erwartungen—Szenarien als Schrittmacher der Technikentwicklung* (Berlin, Edition Sigma, 2004).

12. N. Brown & M. Michael, A sociology of expectations: retrospecting prospects and prospecting retrospects, *Technology Analysis and Strategic Management*, 15, 2003, pp. 3–18.
13. M. Dierkes, U. Hoffman & L. Maez, *Leitbild und Technik: Zur Entstehung und Steuerung technischer Innovationen* (Berlin, Edition Sigma, 1992); W. Rammert, Die kulturelle Orientierung der technischen Entwicklung. Eine technikgenetische Perspektive, in: D. Siefkes, P. Eulenhöfer, H. Stach & K. Städtler, (Eds), *Sozialgeschichte der Informatik. Soziale Praktiken und Orientierungen* (Wiesbaden, Deutscher Universitäts Verlag, 1998); H. D. Hellige, *Technikleitbilder auf dem Prüfstand: Leitbild-Assessment aus Sicht der Informatik- und Computergeschichte* (Berlin, Edition Sigma, 1996).
14. For example, M. Akrich, The de-scription of technical objects, in: Bijker & Law, *op. cit.*, Ref 5, pp. 205–224; W. B. Carlson, Artifacts and frames of meaning: Thomas A. Edison, his managers, and the cultural construction of motion pictures, in shaping technology/building society, in: Bijker & Law, *op. cit.*, Ref 5; J. Jelsma, Innovating for sustainability: involving users, politics and technology, *Innovation*, 16, 2003, pp. 103–116; N. Oudshoorn & T. Pinch, *How Users Matter: The Co-construction of Users and Technology* (Cambridge, MA, MIT Press, 2003).
15. B. De Laat, Scripts for the future: using innovation studies to design foresight tools, in: Brown *et al., op. cit*., Ref. 4; FORMAKIN, Final Report of the Formakin Project (Foresight as a Tool for the Management of Knowledge Flows and Innovation), York etc.: Science and Technology Studies Unit, University of York, 2001. An EU-TSERP project led by A.Webster, L. Sanz-Menéndez and B. van der Meulen.
16. C. Marvin, *When Old Technologies were New* (Oxford, Oxford University Press, 1990); M. Levin, *When the Eiffel Tower was New: French Visions of Progress at the Centennial of the Revolution* (Cambridge, MA, University of Massachusetts Press, 1989).
17. *Ibid*.
18. R. Kosellek, *Futures Past—On the Semantics of Historical Time* (Columbia, NY, Columbia University Press, 2004).
19. M. Weber, Politics as a vocation, in: H. Gerth & C. W. Mills (Eds), *From Max Weber: Essays in Sociology* (London, Routledge and Kegan Paul, 1958), pp. 77–128; G. H. Mead, *The Philosophy of the Present* (Chicago, IL, Chicago University Press, 1932); A. Schutz, On multiple realities, in: *Collected Papers I, The Problem of Social Reality* (The Hague, Alfred Schutz, 1962); A. Schutz, Tiresias, or our knowledge of future events, in: *Collected Papers II, Studies in Social Theory* (The Hague, Alfred Schutz, 1964); M. Emirbayer & A. Mische, What is agency?, *American Journal of Sociology*, 103(4), 1998, pp. 962–1023.
20. R. K. Merton, Socially expected durations: a case study of concept formation in sociology, in: W. Powell & R. Robbins (Eds), *Conflict and Consensus: A Festschrift for L. Coser* (New York, Free Press, 1984); B. Adam, *Timescapes of Modernity: The Environment and Invisible Hazards* (London, Routledge, 1998); B. Adam, *Time and Social Theory* (Cambridge, Polity, 1990); P. Virilio, *The Information Bomb* (London, Verso, 2000); P. Virilio, *Speed and Politics* (Columbia, NY, Columbia University Press, 1986).
21. F. Bartlett, *Remembering. A study in Experiential and Social Psychology* (Cambridge, UK, Cambridge University Press, 1995); P. Jedlowski, Memory and sociology: themes and issues, *Time and Society*, 10, 2001, pp. 29–44; M. Halbwacks, *La Memoire Collective* (Paris, Albin Michel, 1997).
22. J. M. Barbalet, Social emotions: confidence, trust and loyalty, *International Journal of Sociology and Social Policy*, 16(9/10), 1996, pp. 75–96.
23. R. K. Merton, The self-fulfilling prophecy, *The Antioch Review*, 8, 1948, pp. 193–210.
24. N. Rosenberg, On technological expectations, *The Economic Journal*, 86, 1976, pp. 523–535; N. Rosenberg, On technological expectations, in: N. Rosenberg (Ed.), *Inside the Black Box: Technology and Economics* (Cambridge, UK, Cambridge University Press, 1982), pp. 104–119; C. Antonelli, The role of technological expectations in a mixed model of international diffusion of process innovations: the case of open-end spinning rotors, *Research Policy*, 18, 1989, pp. 273–288; F. Lissoni, Technological expectations and the diffusion of 'intermediate' technologies, CRIC (Manchester), Working Paper No. 8, August 1999; D. S. Boone, K. N. Lemon & R. Staelin, The impact of firm introductory strategies on consumers' perceptions of future product introductions and purchase decisions, *Journal of Product Innovation Management*, 18(2), 2001, pp. 96–109.
25. K. Froot, D. Scharfstein & J. Stein, Herd on the street: informational efficiencies in a market with short-term speculation, *Journal of Finance*, 47, 1992, pp. 1461–1484; S. Bikhchandani & S. Sharma, Herd behavior in financial markets, *IMF Staff Papers*, 47(3), 2001.
26. R. M. Grant, *Contemporary Strategy Analysis*, 2nd edn (Oxford, Blackwell, 1995).

27. G. Reger, Technology foresight in companies: from an indicator to a network and process perspective, *Technology Analysis & Strategic Management*, 13(4), 2001, pp. 533–553.
28. R. Koppl, *Big Players and the Economic Theory of Expectations* (London, Palgrave, 2002); J. Pixley, Finance organisations, decisions and emotions, *British Journal of Sociology*, 53(1), 2002, pp. 41–65.
29. De Laat, *op. cit.*, Ref. 15; H.van Lente, From promises to requirement, in: Brown *et al*., *op. cit.*, Ref. 4.
30. Konrad, *op. cit.*, Ref. 11; Van Lente, *op. cit.*, Ref. 29.
31. F. Geels & W. Smit, Lessons form failed technology futures: potholes in the road to the future', in Ref 4, pp. 881–882.
32. *Ibid*.
33. N. Luhmann, The modernity of science, *New German Critique*, 61, Winter 1994, pp. 9–16.
34. Kosellek, *op. cit.*, Ref. 18.
35. J. Mokyr, Evolutionary biology, technological change and economic history, *Bulletin of Economic Research*, 43(2), 1991, pp. 127–149.
36. N. Brown, Hope against hype: accountability in biopasts, presents and futures, *Science Studies*, 16(2), 2003, pp. 3–21.
37. Deuten & Rip, *op. cit.*, Ref. 11.
38. Konrad, *op. cit.*, Ref. 11; Brown & Michael, *op. cit.*, Ref. 12.
39. Van Lente, *op. cit.*, Ref. 29.
40. W. Bijker, *Of Bicycles, Bakelites, and Bulps—Toward a Theory of Sociotechnical Change* (Cambridge, MA, MIT Press, 1995), ch. 5.
41. Brown & Michael, *op. cit.*, Ref. 12.
42. D. MacKenzie, Inventing Accuracy: A Historical Sociology of Nuclear Missile Guidance (Cambridge, MA, MIT Press, 1990).
43. J. Ravetz, What is post-normal science?, *Futures*, 31, 1999, pp. 647–653.
44. Van Lente, *op. cit.*, Ref. 1; Konrad, this issue.
45. Michael, *op. cit.*, Ref. 2.
46. C. Thompson, The biotech mode of reproduction, Paper prepared for the School of American Research Advanced Seminar 'Animation and Cessation: Anthropological Perspectives on Changing Definitions of Life and Death in the Context of Biomedicine', Santa Fe, New Mexico, 2000.
47. P. Weingart, A. Engels & P. Pansegrau, Risks of communication: discourses on climate change in science, politics, and mass medi, *Public Understanding of Science*, 9(3), 2000, pp. 261–283.
48. H. Nowotny, P. Scott & M. Gibbons, *Re-thinking Science—Knowledge and the Public in an Age of Uncertainty* (Cambridge, UK, Polity Press, 2001), p. 232.
49. Brown *et al., op. cit.*, Ref. 4.