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Constructing entrepreneurial advantage: consensus building, technological uncertainty and emerging industries

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In 1976, Cambridge, MA, and Berkeley, CA, responded to concerns about the environmental effects of recombinant DNA by adopting identical biosafety ordinances. This paper explores the mediating factors that explain how scientists and entrepreneurs came to view these regulatory interventions in diametrically distinct ways. We argue that although the regulations were the same, the process behind their adoption and implementation and, in particular, differences in citizen engagement and technology education account for these divergent outcomes. The paper suggests ways that contemporary regulatory responses can result in a constructive (rather than combative) approach to entrepreneurial accountability and thus contribute to constructed jurisdictional advantage.

Key words: biotechnology, regulation, entrepreneurship, economic development, jurisdictional advantage
JEL classification: L5, L26, O1, O3

Introduction

New technologies and new industries, while offering potential for economic growth, begin rather humbly, often made as discoveries in academic laboratories. At the instant of discovery, the commercial potential is unknown and only a few experts may appreciate its significance. Translating the discovery into commercial activity and realizing its economic potential entail a process that involves building an appreciation of what is possible among potential investors, customers and employees alike. Moreover, realizing the commercial potential of a technology requires taking it out of the laboratory, into a community and building entrepreneurial support. Increasingly there is recognition that what matters for place-specific industrial development is not necessarily scientific resources and know-how but the social dynamics that occur within a place and define a community of common interest around a nascent technology or emerging industry. Community involvement—as opposed to insular scientific dialogue—can be essential to regional industrial development by constructing a shared understanding and appreciation of an emerging technology.

Of course, new technologies often pose environmental, health and safety risks that are felt most immediately in the communities where the research is conducted. This can create public pressure for regulation and local oversight to protect against these risks. Harkening back to an older manufacturing economy, local regulation is often presumed to conflict with local industrial development goals. Emphasis is placed on the creation of a 'favourable' business climate through minimal regulation, limited public oversight and low taxes. An alternative view, however, is that local regulation can produce socially and economically optimal outcomes by widening the public dialogue through participatory democracy and open decision-making processes. This reconceptualization of regulation is especially relevant for technology-based economic development that relies on information sharing among networks of engaged individuals in order to promote greater scientific literacy and understanding. Viewed this way, regulation may also limit firm liability by providing industry standards and making expectations about public safety explicit, thereby, making a regulated location more attractive for nascent entrepreneurs and their financiers. Moreover, the process of public discussion and debate about regulating the industry may inform citizens and local officials about the industry's economic and employment potential and increase understanding of what is required to build the capabilities to anchor it within a locality. Thus, the process of regulating the industry may create the conversations necessary to foster the type of virtuous business climate that leads to entrepreneurs choosing to locate there. It may also result in the development of a shared vision or community identity that enables specific places to begin the virtual, self-reinforcing cycles of cluster development.

This paper considers the role of community formation in the development of an emerging technology cluster. The research has its origins in trying to understand the dense concentration of the biotech industry in Cambridge, Massachusetts.[1] Our investigation uncovered a contentious early debate that centred on fear of genetic engineering, the early name used for the technology. Indeed, the City of Cambridge passed a regulation in 1977 that was more onerous than national biosafety standards at the time and engendered great discussion and notoriety, including initial criticism from local and non-local molecular biologists. Berkeley, California, another jurisdiction where significant academic research offered commercial opportunity enacted nearly identical regulation, yet no biotechnology industry took root there. Start-ups from the University of California instead dispersed to other San Francisco Bay communities in the 1970s and 1980s, namely, Emeryville and South San Francisco. Arguably, what is different is the process of open citizen participation and community building that occurred in Cambridge as a result of the perceived need to regulate the new technology.

The remainder of the paper is structured as follows: the next section provides our theoretical model. We argue that local industrial development is facilitated by shared conversational space that plays a role in transforming local scientific knowledge into a powerful—and widely supported—engine for local economic development. We examine the adoption of biosafety regulations by the City of Cambridge, MA, during the formative years of the US biotechnology industry as an example of a shared conversational space and contrast the Cambridge, MA case with that of Berkeley. We conclude the paper by drawing lessons for other regions that are seeking to use legal mechanisms to regulate today's unproven or controversial technologies.

Participatory democracy, regulation and constructed advantage

Our focus is on understanding social processes that constitute an advantage for economic activity in certain locations. This is motivated by an observation that many places, despite having substantial scientific and technology resources and articulated economic development objectives, have been unable to garner significant economic rewards. Our thesis is that the genesis of an industrial cluster is defined by social relationships that create a shared vision of what is possible and thus allow a region to harness existing technology and scientific assets. Over the course of human history, certain geographic places at certain times have been the locus of creative, innovative activity. Silicon Valley, specifically the San Jose–Palo Alto corridor, is perhaps the most recent representation of this phenomenon (Saxenian, 1996)—earlier examples include Florence, Italy, under the Medicis, Paris, France, in the 1920s and Birmingham, UK, during the Industrial Revolution. Understanding and especially replicating these successes have proven difficult. Our thesis is that public conversation and community openness—especially for controversial or highly complex technologies—create conduits for information sharing and knowledge diffusion, which ultimately contributes to industrial success and sustainability.

Our conceptual model focuses on the earliest stages of the product life cycle model when a nascent technology is shrouded by great uncertainty and is still being defined. At this point early in its life cycle, there is considerable ambiguity about the direction the technology will ultimately take, whether it will create new business opportunities and what form these will take. Of course, entrepreneurs, as social agents, help to create these opportunities and contribute to building geographic capabilities as they develop their firms (Feldman, 2001). With more individuals able to understand the technology and participate in its translation and commercialization, there is even greater potential for meaningful and valued breakthroughs. Through an engaged, participatory process, a common language can be developed for better describing, promoting and, if necessary, defending the technology and its related applications. At the same time, competing technological paradigms can be identified and reconciled. Through public discourse, individuals in the community will learn about investment and employment opportunities.

Borrowing from observations of radical product innovation, consensus and community building around a new technology may be achieved through the creation of what Lester and Piore (2004) describe as shared conversational space. Within the context of the firm or organization, conversational space encourages 'conversations among people from different backgrounds and with different perspectives' and representing distinct technology specializations (Lester and Piore, 2004, 51). Bell Labs, for example, created conversational space that ultimately enabled radio and telephone engineers to move beyond the boundaries of their own unique technology fields to develop a radically new communication device, the cellular telephone. Similarly, Levi Strauss and other established jeans makers created dramatically new fashion designs by linking textile manufacturers with industrial-scale launderers and retail customers.

From a community or jurisdictional perspective, shared conversational space provides the basis for extending the dialogue about a new technology outside the scientific or engineering profession and into the greater society. Non-technologists can enter this space because they wish to contribute to or learn more about the technology. Some may also wish to advance their own political or economic agendas as either technology advocates or opponents. By participating in the conversation, these individuals become part of a community of common interest and in turn can greatly influence the course of technology and industrial development.

As Lester and Piore (2004) note, however, participation in this conversational space will not eliminate all sources of social conflict—and this may be especially true for controversial technologies associated with environmental or public safety risks. In this regard, new technologies pose a double-edged sword, offering opportunity for industrial development and economic growth while creating considerable concerns about public safety and security. Safeguarding public health and mitigating potential adverse outcomes is the basis for government oversight and regulation. While industry regulation is often seen as contributing to an unfavourable business climate, our thesis is that regulatory oversight enhances participation in conversational space and creates the conditions for a participatory process that informs citizens about the technology, including its beneficial properties and economic potentials, while providing greater confidence about risk mitigation. Conflict resolution often requires keeping the conversation alive, so that 'participants overcome their initial lack of comprehension, work through their early misunderstandings and make new discoveries (about) the situations they confront' (Lester and Piore, 2004, 54). Therefore, by adopting a conversational approach to technology regulation, government agencies can more effectively manage social conflict through the promotion of a respectful, deliberative and well-reasoned social dialogue (Fung and Wright, 2001). At the same time, public conversations help to develop a shared technology language so that the diverse actors involved in the conversation can interpret new information and articulate previously tacit or uncodified knowledge (Gertler, 2004; Lester and Piore, 2004; Sabel, 2001).

This view of regulation as conversational space contrasts with the conventional wisdom that regulations do little else but constrain or limit the behaviour of economic actors (Macgregor et al., 2000; North, 1984). Regulations, such as environmental standards, workplace safety rules and medical testing requirements, are perceived by some institutional economists as distortions that 'limit the operation of markets' (Macgregor et al., 2000, 2) and, therefore, detract from economic outcomes. Based on this assumption, some economists and business strategists advise governments to limit regulation so as to avoid unnecessary market distortions or inefficiencies (Porter, 1997). Some institutional economists, however, have challenged this market orthodoxy by pointing instead to differences in regulatory function. Regulations, such as the assignment of private property rights, are market complements that enable market transactions and strengthen economies (Chang and Evans, 2005; de Soto, 2000; Hodgson, 2005).

While perhaps a useful first approximation, this functional classification fails to capture the complex and shifting relationship between regulation and economic activity, especially in emerging technology fields. Regulation can provide an important source of legal clarity about liability highly valued at the early, uncertain stages of technology development. Interventionist regulations around medical testing, research protocol and environmental and safety standards have been known to simultaneously facilitate market expansion and entrepreneurial opportunity by placating consumer fears and concerns. It is not surprising, therefore, to find cases where technological innovators, as well as their financial and industrial allies, actively support regulatory interventions as mechanisms for promoting research progress and market expansion. Early pharmaceutical manufacturers benefited greatly from the passage of the 1906 Pure Food and Drug Laws that advanced the industry by providing guarantees for consumer safety and forced out marginal producers who were most likely to market low-quality, unsafe products (Wood, 1985). Medical device inventors have long expressed support for federal testing regulations, as compliance certificates provide credible evidence of quality product standards that are useful during negotiations with prospective financiers and product development partners.[2] Monsanto advocated for state-level field experimentation regulations in the 1980s in order to establish clear guidelines and legal protections for testing Genetically Modified Organisms (GMO) (Ezzell, 1989). It was feared that the absence of such regulation would result in organized resistance from non-GMO farmers, thus delaying time-sensitive and costly genetics research. A recent example is regenerative medicine, specifically, the decision by a growing number of US states to adopt regulations that provide clear rules for the acquisition and use of stem cells (e.g. prohibiting offers of financial incentives to egg donors). These regulations have enabled this nascent, yet highly controversial, research field to continue through the creation of strict national ethical review standards and research protocols (Rabin, 2007). The US Environmental Protection Agency's decision to consider national standards for nanotechnology is yet another example of regulation that promotes technology development and advancement.[3] Similarly, venture capitalists acknowledge waiting for clear Food and Drug Administration testing guidelines before continuing to invest in companies that produce genetically engineered animals for human consumption (Pollack, 2007). Automobile and energy companies have also pushed for clearer rules on environmental standards to facilitate exploration of new energy-saving technologies.[4]

Still, the realization that interventionist regulations might facilitate innovation and market expansion seems counterintuitive, thus requiring closer examination. Complicating matters is the uneven application of technology-oriented regulations across time and space, which allows sceptical technologists to skirt regulated jurisdictions altogether. At the same time, companies developing new technologies are starting to raise legitimate concerns that local and state regulators lack the scientific and engineering expertise to effectively intervene in and monitor emergent technology markets. Within the scientific community, there is a related concern about the low level of scientific literacy in the population. This has led some to advocate for models of national self-regulation based on peer-review processes (Miller and Conko, 2000; Wright, 2001). Nevertheless, this response ignores deep-seated tensions over governance that exists between scientific experts or technocrats and society at large. More specifically, this view overlooks the mediating steps that might be required to reconcile the needs of pioneering technologists, on the one hand and growing demands for greater scientific accountability by concerned residents of communities where these technologies are first discovered, tested and commercialized on the other (Krimsky, 1982). Furthermore, it closes off channels for citizen involvement that can actually strengthen opportunities for innovation and entrepreneurship by increasing technology awareness within a community, thus elevating levels of social trust and scientific literacy.

Legal scholars have long recognized the tenuous relationship between economic actors and regulation. Those studying this complex relational dynamic are especially interested in 'law-in-action', and more specifically the 'extralegal social processes (that) continuously construct and reconstitute the meaning and impact of legal norms' (Suchman and Edelman, 1996, 907). In contrast to conventional approaches to legal analysis, sociolegal scholarship deals directly with the social and political processes that influence individual and organizational responses to formal legal actions and structures (Suchman and Edelman, 1996). Less emphasis is placed on the strength and enforceability of these rules (i.e. law-on-the-books), but rather the degree to which these extralegal social processes facilitate community consensus around that which is being regulated (Rodríguez-Pose and Storper, 2006). Local responses to regulatory interventions thus vary greatly depending on how these extralegal social processes unfold at a given location or time.

In this respect, sociolegal analysis complements sociological studies of economic institutions and, specifically, the role regulation plays in market development. Beginning with Weber, regulation was initially associated with traditional, pre-capitalist societies, weakening over time as markets grew more 'rational and predictable' (Swedberg 1994, 266). Recent analyses have challenged this deterministic logic, emphasizing the continued and varied use of regulation by government agencies seeking to shape and control industrial markets (Fligstein 1990; White, 1988). Furthermore, regulation is often used to build 'trust' and establish 'moral order' within existing and emerging markets (Swedberg, 1994; Zelizer, 1988).

This emphasis on moral standard setting in turn opens up the possibility that actors other than government agents can also influence the development and promotion of regulatory action (Friedland and Alford, 1991). At the same time, it challenges the assumption that regulation can and should be evaluated along efficiency lines and specifically, for its role in balancing public and private 'interests' as prescribed narrowly by economic models of social welfare (Chang, 1997). Rather, under the right circumstances, regulation can become an important device for expressing and mediating social tension and conflict and for enabling non-market actors to weigh in on important and controversial technological developments and advances. With different actors entering the regulatory debate, emerging markets begin to take on new shapes thus creating the possibility for 'varieties' of entrepreneurial capitalism based on distinct local norms, values and development trajectories (Feldman, 2001; Owen-Smith and Powell, 2006).

This raises important questions about the role that technology-oriented regulation can also play in the intensity and location of entrepreneurship. If implemented in ways that facilitate consensus and community building, regulation can enhance a region's entrepreneurial capacity. In this regard, the regulatory process may help to construct a region's innovative capability through the creation of shared conversational space in which everyday citizens, technologists and economic and institutional actors participate. This, in turn, may create a distinct industrial advantage and form the basis for cluster development and deepening.

Research design

This paper is based on interviews in the two ordinance-adopting regions, Cambridge–Boston–Somerville in Massachusetts and Berkeley–Emeryville in California. A semi-structured interview was used to assess the contribution of local regulation on the location and expansion decisions of individual start-ups and the level of involvement in regulation setting by biotechnology scientists and entrepreneurs.

Our initial sample included biotechnology firms in the two regions that were established prior to 1985. We used industrial directories, notably BioScan and Bioability, to identify these start-ups. We augmented company data with searches of business and industry press publications available from Lexis-Nexis, firm websites and financial documents (e.g. prospectuses, annual reports and 10-K filings) available from the US Securities and Exchange Commission. For the Cambridge area, we interviewed entrepreneurs that established a facility within the boundaries of the City of Cambridge. For the West Coast sample, we conducted interviews with entrepreneurs that had linkages to the University of California, Berkeley, and, therefore, were likely to consider Berkeley as a potential location site for business development. In the interviews, we asked for additional interview contacts that had knowledge of Berkeley's regulatory environment. We also conducted interviews with key public officials and biosafety officers that were involved in the early days of ordinance implementation in Cambridge and Berkeley. In total, 30 interviews were conducted in 2005 and 2006.

To supplement our interview findings, we analysed archived documents pertaining to the genetic engineering debates in the 1970s and specifically materials related to the adoption of biosafety ordinances by US municipalities. Archival materials were examined at Massachusetts Institute of Technology (MIT) as part of the Institute's Recombinant DNA History Collection, 1966–1978, the University of California Bancroft Library Bioscience/Biotechnology Archive and Manuscript Collection and the City of Berkeley archive. These collections included transcripts and minutes of public hearings and city council meetings, as well as transcribed oral histories with elected officials, environmental activists and biotechnology scientists and entrepreneurs.

Debating genetic engineering

The modern biotechnology industry began with the discovery of recombinant DNA (rDNA) by academic scientists Stanley Cohen and Herbert Boyer in the fall of 1972. The technology, which allowed the controlled design or engineering of genetic material, was the focus of intense national debate over perceived environmental and health risks. The fear was that genetic engineering, the term used to describe the industry at the time, would produce harmful and even Frankenstein-esque biological mutations (Turney, 1998). Popular science fiction movies, like the 1975 *Andromeda Strain*, fuelled public concerns about the potentially disastrous consequences of an accidental release of genetically altered organisms. Today, of course, it is difficult to fully relate to these concerns—after all, biotechnology—clearly a more benign term than genetic engineering—is well regarded for its scientific and economic contributions. Yet, in the early days when the technology was still in its nascent stage of development, there was considerable debate about the desirability of continuing to pursue the discovery.

Debate also existed within the scientific community, with scientists raising concerns about the risks of this emerging field of biological science. Smith Hughes (2001) and others have documented this early history. For our purposes, a series of national meetings known as the Asilomar Conferences on Recombinant DNA are particularly relevant (Wright 2001). At these meetings, scientists with research interests in the technology eventually agreed that national regulation was needed to ensure adequate safeguards against sub-standard experimentation and accidental organism release. Most conference attendees, however, advocated for safety monitoring by a panel of scientific peers, rather than by non-scientists or the community-at-large. As one policy analyst put it, 'the (Asilomar II) conference was about persuading the American people and their representatives in Congress to allow the community of molecular biologists to pursue genetic engineering under a system of *self-governance*' (Wright, 2001, 236; see also, Weiner, 2001). This perspective reflected a shared belief among molecular biologists that the technology was far too complicated for non-experts to fully grasp and therefore nearly impossible for them to regulate in a deliberate, informed and effective manner (Fredrickson, 2001). Asilomar II held in February 1975 resulted in the National Institutes of Health (NIH) biosafety guidelines, published 23 June 1976. These regulations covered all NIH-funded research projects.

National debate over biosafety risks and regulation quickly touched down in a number of US cities and, specifically, within localities with universities that had rDNA research capabilities and interests (Krimsky, 1982). Public debate not only focused on health and safety issues but also addressed the balance of power between the local jurisdiction and the university and the degree to which university concerns were subject to local government oversight.

In 1976, city councillors in Cambridge, MA, and Berkeley, CA, were the first to respond to growing citizen concern about the environmental and health effects of this new technology by approving nearly identical rDNA ordinances. Both cities adopted the NIH guidelines for rDNA research as local law. Both also went beyond these national guidelines, subjecting university and private sector laboratories, regardless of their funding sources, to frequent site visits, inspection fees and stiff penalties for non-compliance of approved safety protocol. It is important to note that federal-level standards provided a basic framework for biosafety that was central in the design of local regulation within these two jurisdictions. In this regard, local policies benefited greatly from initial federal action and oversight and also widespread media coverage of the emerging national scientific debate over rDNA. But this relationship was far from unidirectional. As indicated below, local regulatory responses were motivated by a view that national guidelines, as originally proposed by the NIH, were too narrow in scope and promoted an insular review process that provided little room for citizen comment and oversight. Interestingly, the intensity of local debate around this issue would eventually percolate up to the national level, resulting in important changes to NIH review procedures. An illustration of this is the Institute's decision to expand the membership base of the NIH Recombinant DNA Advisory Committee. When the committee was initially formed in the mid-1970s, it only involved technical advisors with rDNA research experience. By 1979, however, and in response to local regulatory actions, the Institute required one-third of committee members to be drawn from the public-at-large and include vocal critics of NIH policies (Krimsky, 1982). Early members included non-scientists involved in the local debate in Cambridge, MA. This suggests a dynamic, recursive relationship between national and local regulatory responses—an observation that holds important lessons for emerging technology debates today.

Cambridge and Berkeley's biosafety ordinances

Cambridge, MA's rDNA ordinance was the result of protracted public debate, initiated by a request from Harvard bioscience professor Mark Ptashne in 1976 to retrofit an existing Cambridge laboratory for biosafety level 3 genetic and viral research experiments (Lipson, 2001). On 14 June 1976, Harvard Dean Henry Rosovsky announced internal approval of plans for the laboratory renovation. That same day, the Cambridge City Council asserted its authority and voted unanimously to hold a public hearing to solicit citizen input on Harvard's plans, determining that the issue was not simply an internal university concern, but rather 'a matter of public interest'.[5] Potential environmental and health effects of this emerging technology prompted several local officials to initially recommend an all-out ban on rDNA research (Krimsky et al., 1982).

An additional hearing was scheduled, the result of which was the creation of a nine-member citizen review board—the Cambridge Experimentation Review Board (CERB)—assigned the responsibility of advising council members on this controversial issue. A 3-month moratorium on rDNA research in the community was initiated in order to allow the CERB time to deliberate. The moratorium would eventually be extended by an additional 3 months, resulting in a 6-month stoppage of rDNA research. During their review, CERB conducted over 100 hours of meetings, including interviews with numerous research faculties—both advocates and critics of this emerging technology—from MIT, Harvard University and Medical School and Columbia University. In addition, they heard hours of testimony from scientists from the National Institute of Health that were activly engaged in developing rDNA safety guidelines. CERB also organized an open public scientific debate in November 1976 that involved two Nobel Laureates in biology. The city also scheduled a public science fair in Harvard Yard, giving molecular biology researchers an opportunity to publicly present their research and discuss their work with everyday citizens.

On 5 January 1977, CERB presented its final recommendations to the city council. In a cover letter addressed to the city manager, CERB member and Tuft's University professor Sheldon Krimsky stated:

> While we should not fear to increase our knowledge of the world, to learn more of the miracle of life, we citizens must insist that in the pursuit of knowledge appropriate safeguards be observed by institutions undertaking the research. Knowledge, whether for its own sake or for its potential benefits to humankind, cannot serve as a justification for introducing risks to the public unless an informed citizenry is willing to accept those risks. Decisions regarding the appropriate course between the risks and benefits of potentially dangerous scientific inquiry must not be adjudicated within the inner circles of the scientific establishment.[6]

Based on CERB's recommendations, Cambridge City Council enacted the nation's first municipal-level biosafety ordinance on 7 February 1977. While the ordinance permitted rDNA research to continue at or below biosafety level 3 (i.e. it banned biosafety level 4 containment laboratories), local law now mandated the NIH biosafety guidelines be followed regardless of research funding sources. In addition, any research conducted within the Cambridge city limits was subject to local regulatory oversight. The ordinance required scientists leading projects involving rDNA to submit an application for external review to a five-member citizen review board known as the Cambridge Biohazards Committee (CBC), participate in a public hearing, agree to regular site inspections by local public health officials and, if necessary, complete a pre-approved biosafety training course. The latter also provided a mechanism for ensuring worker safety, especially for non-scientific staff and personnel, like academic secretaries and cleaning crews and novice science students. Failure to comply could potentially result in the loss of operating permits in Cambridge and in some cases, the closure of a violating laboratory. The ordinance generated considerable negative publicity nationally and was initially viewed as a potential research deterrent.

City Council members in Berkeley, CA, quickly followed Cambridge's lead and enacted identical legislation in late 1977. The action was prompted by a request to create an rDNA laboratory facility by the firm Cetus, which had been located in Berkeley since its founding in 1971. At the time, the company was headed by Donald Glaser, a University of California, Berkeley, scientist and Nobel Laureate. The City of Berkeley opted to simply copy the legal text of the Cambridge BioSafety Ordinance and, thus, eliminated the need for protracted public debate. Unlike Cambridge, however, Berkeley did not form a citizen review board and, instead, hired an environmental inspector to review research application requests.

Entrepreneurial responses

Interestingly, despite the similarities in regulatory structure, scientists and entrepreneurs in and around these two jurisdictions came to view these local policy interventions in dramatically different ways. While the East Bay biotechnology community considered adoption of the ordinance by Berkeley as proof of the city's 'technology ignorance' and 'political arrogance', their counterparts in Cambridge, embraced local regulation as a mechanism for reducing industry risk and uncertainty and, ultimately, as a source of entrepreneurial advantage.[7] To quote an early biotechnology entrepreneur, being in Cambridge 'allowed (our firm) to fit into a set of regulations that the university and the community had already accepted…. A regulatory framework that provided a *social structure* for these new activities, (which) really was an important (locational) aspect' (parentheses and emphasis added).[8]

How similar regulatory actions came to be perceived differently by the scientific community subsequently affected the course of entrepreneurial growth and development in these two cities. Early support for Cambridge's regulation by the city's first biotechnology start-up, Biogen, greatly influenced the location decisions of other entrepreneurial firms. As a result, Cambridge, had already amassed a sizeable number of biotechnology firms by the mid-1980s, establishing the beginnings of what would eventually become one of the USA's most vibrant life science 'clusters'. Today the City of Cambridge is home to the largest concentration of biotechnology establishments of any municipality in the USA and includes industry giants, like Biogen, Genzyme and Vertex. Berkeley's growth trajectory could not have been more different.

In response to Berkeley's regulatory action, Cetus chose to relocate its rDNA facilities to neighbouring Emeryville, thereby avoiding Berkeley's biosafety review process altogether. Interestingly, Cetus' relocation decision resulted in the City of Emeryville adopting an rDNA resolution in April 1977 (Krimsky et al., 1982). This resolution, however, was substantially weaker than that passed in Berkeley and due to its status as a city resolution did not carry the same regulatory weight as an ordinance. In passing the resolution, Emeryville was seeking to 'improve the city's image, which some maintained had been tarnished by loose regulation of business and industry' (Krimsky et al., 1982, 15). Still, in an effort to maintain its pro-business stance and build on its industrial legacy, public officials made assurances to Cetus and other biotechnology suitors that there would be limited citizen involvement and political influence in resolution implementation and oversight. Knowledge of Cetus' relocation decision greatly influenced the perceptions of other West Coast biotechnology entrepreneurs, who opted to locate their research and development facilities in less 'defiant' West Coast municipalities. To our knowledge, no other biotechnology firms have ever located in the City of Berkeley.

One could easily assume that these distinct entrepreneurial responses simply reflected existing differences in industrial support and, in particular, variation in crucial entrepreneurial resources, such as financing, technological know-how and qualified labour. Looked at through this lens, the gains for nascent entrepreneurs locating in close proximity to crucial industrial supports and, in particular, to Cambridge's pre-eminent research universities would outweigh the costs associated with these additional regulatory requirements.

But this explanation ignores a number of important attributes common to both municipalities in the formative years of the industry. By the mid-1970s, universities in Berkeley and Cambridge not only shared similar biotechnology-related research strengths but also provided crucial sources of local talent vital to this industry's entrepreneurial pioneers (Jong, 2006; Vettel, 2006). In fact, University of California Berkeley's early scientific representation is visible in the list of founding scientists of two Northern Californian biotech pioneers, Cetus and Chiron Corporations—Donald Glaser and Ed Penhoet, respectively, both had University of California, Berkeley, faculty appointments. Furthermore, in the early years of the biotech industry, proximity to research universities was essential as it enabled start-up firms to employ faculty, graduate students and post-doctoral fellows who wanted to maintain their daily academic connections and routines (Kenney, 1986). While University of California, San Francisco (UCSF) and Stanford were key labour market contributors in Northern California, University of California, Berkeley, also play a key role in local industry talent formation. Additionally, both municipalities were in close proximity to well-established venture capital markets that were eager to support technology-based research and entrepreneurial endeavours (Owen-Smith and Powell, 2006). In other words, from an industry resource perspective, Berkeley was a similarly attractive location.

In selecting Cambridge, MA, as their preferred New England site, East Coast entrepreneurs were not merely complacent and accommodating of local regulation and simply willing to accept this unwanted, but necessary cost. In fact, in contrast to what one might expect, Cambridge-based entrepreneurs not only embraced this regulation and used it to justify their location decisions, but did so to the point that many would eventually take it with them as they set up satellite operations in neighbouring municipalities that offered greater physical space to grow and expand laboratory and manufacturing facilities. At their request, towns like Framingham, Waltham and Andover Massachusetts established similar biosafety ordinances throughout the 1980s.[9] Nor can we explain these differences as an outgrowth of greater West Coast citizen activism, a logical assumption given Berkeley's long-standing anti-establishment reputation. In fact, the debates leading to Cambridge's ordinance were far more heated and divisive than those taking place on Berkeley's streets or in its city council chamber in the mid-1970s. Cambridge's mayor at the time, Al Velucci, even went on public record threatening an all-out ban on rDNA research in 1976 and again as a city council member in the early 1980s—Berkeley officials did not entertain this option.

These differences in entrepreneurial response and, in particular, the strong support for local regulation by molecular biologists in Cambridge, are especially surprising when we consider national scientific norms around biosafety in the formative years of the industry. As mentioned earlier, Asilomar II had promoted a model of national self-regulation. Bioscientists were not necessarily opposed to regulation, but rather were concerned about the level at which regulation occurred, the knowledge capabilities of those doing the regulating and the predictability of these local actions. Cambridge's ordinance directly challenged the national regulatory model by assigning regulatory responsibility to community representatives who had no prior knowledge of biotechnology: in fact, initial members of the CBC included two practising physicians, a nurse and an environmental technology consultant. Why then did events play out so differently in the Cambridge context? Why did bioscientists-turned-entrepreneurs not fear this additional layer of community oversight as their counterparts did on the West Coast?

Before moving on to these questions, it is important to note that the location decisions of Berkeley entrepreneurs did not necessarily undermine entrepreneurial potential in the field of biotechnology. In this regard, our contrasting cases should not be interpreted as a comparison of a successful versus failed cluster. After all, Berkeley-based scientists would build on their professional relationships with researchers from UCSF and Stanford University to create successful biotechnology start-ups in other locations in the San Francisco Bay Area, concentrating initially in Emeryville and South San Francisco (Jong, 2006; Vettel, 2006). In this regard, they would still contribute to the region's burgeoning biotechnology industry. Over time, northern California's biotechnology industry would also intersect with another local economic strength, that of San Jose–Palo Alto's microelectronics and information technology industries (Saxenian, 1996), eventually generating new innovations and synergies in informatics and related technology fields.

Still, the location decision of Berkeley scientists-turned-entrepreneurs did have the effect of dispersing firms across California's industrial landscape, rather than concentrating them in one central locale or jurisdiction, as we find in Cambridge. It also had the effect of branding Berkeley as an 'uncertain business environment', thus limiting opportunities for new business development in key technology fields well in to the 1990s (Levi Holtz, 1989; San Francisco Chronicle, 1992).[10] While the full impact of this dispersion is hard to quantify and is beyond the scope of this paper, it did have the effect of strengthening perceptions within the San Francisco Bay scientific community that local regulatory actions were inferior to national models of governance based on scientific self-regulation. In turn, this view of local regulation reinforced a disconnect between bioscientists and citizens in the San Francisco Bay Area, shutting off an important communication channel through which the concerned citizens could weigh in on and even influence the development of the region's biotechnology industry. In 1982, Leon Wofsy, an immunologist at the University of California at Berkeley, noted in a public lecture, 'there has been a striking lack of discussion on the Berkeley campus about the new world in which biology finds itself' (Wade, 1984, 20). We believe the experience and observed reaction of Berkeley-based scientists should therefore be viewed as a contributor to local 'varieties' of entrepreneurial capitalism, with Berkeley's regulatory response helping to influence and reinforce a version of entrepreneurship that was far more insular in quality, with limited access to industry networks by actors outside the technology community, especially social activists and concerned citizens.[11] Interestingly biosafety would not reemerge as an important policy issue in the San Francisco Bay Area until the post-9–11 era due to growing concerns over bioterrorism.

This observation, in turn, enables us to draw connections to other historical comparisons of the US biotechnology industry that speak directly to the issue of industry concentration and its implications for localized business strategy. Research on entrepreneurial strategies of biotechnology start-ups in Cambridge, MA, and San Francisco/Emeryville, CA, by Owen-Smith and Powell (2006) has noted important differences in the disease-areas bioscientists initially targeted in each locale. While researchers-turned-entrepreneurs in the San Francisco Bay Area prioritized less risky and high-volume drug discoveries, their counterparts in Cambridge, MA, emphasized low-volume and riskier 'orphan' treatments for rare diseases. Orphan drug treatments, while certainly less profitable given their smaller market share, were nonetheless highly valued within academic circles and also by local medical and public health authorities and professionals. Owen-Smith and Powell attribute this difference in strategy to variations in institutional influence and, specifically, the stronger role of universities in research standard setting in Cambridge. In contrast, research targets by entrepreneurial firms in the San Francisco Bay Area appear more influenced by the profit-making desires of local venture capitalists.

Our findings lend additional support to this variety of entrepreneurship claim, adding a further institutional layer to this comparison, namely, the differing role that social actors outside of the technology community may play in influencing industry standards and moral codes. As indicated below, the Cambridge environment around biosafety helped to strengthen the anchoring role of MIT and Harvard University by ensuring a high density of spin-off biotechnology firms in close proximity to these institutions. At the same time, the implementation of the biosafety ordinance in Cambridge and the responsibilities this put on university administrators for formalizing and defending safety procedures and practices, strengthened their role in establishing and reinforcing industry standards for university-affiliated spin-offs. This undoubtedly added to the legitimacy and authority of Cambridge-based universities in influencing the research priorities of faculty and post-doctoral researchers working at these local entrepreneurial establishments. By this same logic, the dispersed geography in the San Francisco Bay Area allowed other institutional actors—namely venture capitalists—to assert greater influence on business strategy and in the process overshadow other institutional voices and interests.

Timing and town-gown tradition

Two important historic differences provide partial explanation for these distinct jurisdictional responses. First, Cambridge benefited from a 4-year lag time between the passing of its initial rDNA ordinance in 1977 and the 1981 siting of the city's first biotech firm, Biogen. This grace period did not exist for Berkeley, where Cetus, an established Berkeley-based medical diagnostics firm, took steps to diversify into biotechnology before local regulatory response were even considered. In fact, it was Cetus' initial request in 1977 to establish an rDNA laboratory facility in Berkeley that first prompted city officials to consider adopting biosafety regulation (Krimsky et al., 1982).

A second important difference relates to legal lines of authority that have long patterned town–gown relations in these two jurisdictions. The University of California, Berkeley, as a state institution, remains exempt from most locally-enforced zoning and environmental laws. In California, as in most states, public universities and institutions of higher education are accountable to state agencies and a state appointed board of regents. Harvard and MIT, as private institutions, lacked similar institutional immunity at the municipal level and instead had to deal directly with local authorities when it came to questions about research activities, workplace practices and laboratory siting. This governance artefact, in turn, required Cambridge-based university officials and bioscience faculty with rDNA research interests to engage and maintain a dialogue about biosafety with city officials. At the same time, the 4-year lag in entrepreneurship on the East Coast allowed for the institutionalization of a set of procedures for citizen review of university research that would be well understood by the time Biogen's scientific founders from MIT and Harvard began their search for a commercial research site in the USA in 1980—prior to this, Biogen's research and development facilities were based in Europe.

As Biogen noted to the Cambridge city manager in December 1980 inquiring about the possibility of establishing a Cambridge-based biotechnology facility:

> Cambridge (Massachusetts) is our first choice (for a U.S. facility) … for several reasons, including the proximity to Harvard and MIT, the availability of necessary personnel, and good communications with Europe. We are ***also*** attracted by the fact that the City (of Cambridge), as a result of the initial work of the Cambridge Biohazards Committee, has made the political and scientific decision to permit the use of recombinant DNA techniques within the framework of the City's Ordinance and the NIH Guidelines; the City, through the Committee, has had approximately four years of experience in monitoring such activities; and the City appears receptive to Biogen Inc. (emphasis added).

In response to Biogen's letter of inquiry, the City of Cambridge reconvened the CERB to advise them on this matter. At the recommendation of the CERB, the city council approved an extension of its original biosafety ordinance on 7 May 1981 to permit large-scale production processes and commercial uses of rDNA (Lipson, 2001). CERB's experience with academic rDNA created local expertise that could be tapped to safely monitor commercial activity.

Taken together, these events contributed to shared conversational space that would help citizens and scientists-turned-entrepreneurs overcome initial differences of opinion. Still, in isolation these historic differences cannot fully explain how and why regulation became a valued source of local entrepreneurial advantage—after all, a forced dialogue between two potential adversaries does not guarantee conflict resolution and social harmony. Related to this, it is important to recognize that at the start of this dialogue in 1976, Cambridge molecular biologists actually shared similar fears and concerns over local regulation as their West Coast counterparts. As with most US bioscientists at the time, they had advocated for federal systems of governance that would not only limit local government involvement but also promote NIH-style models of peer review and scientific self-reporting. Many Cambridge scientists were present at the Asilomar II conference and were early supporters of self-governance. Furthermore, at least one academic scientist responded to Cambridge's 1976–1977 research moratorium by initially transferring to a West Coast university in an unregulated municipality. Historical accounts of the US biotechnology industry have even gone so far as to blame Cambridge's regulation, and the intense public debate leading up to it, for the early loss by Harvard and MIT-based scientists to West Coast researchers during a 1970s competition to synthesize insulin that was funded by Eli Lilly & Company (Hall, 1987). The assumption is that the intensity of the Cambridge debates and the 6-month rDNA moratorium stalled time-sensitive research and fragmented Cambridge's scientific research teams.

By the early 1980s, fears of Cambridge's regulation had not only subsided within New England's fast growing molecular biology community, but the rDNA ordinance was increasingly viewed as a valuable asset to nascent entrepreneurs. To paraphrase an early Cambridge entrepreneur, the ordinance put law on the side of the scientist and, entrepreneur and in the case of an unforeseen laboratory accident, would enable the company to demonstrate due diligence and procedural accountability. To understand this dramatic shift in 'world-view', it is therefore necessary to consider the nature of the dialogue between Cambridge citizen and scientist and, in particular, the actions of those responsible for moderating it. This coordinated conversation ultimately helped to make the local regulatory process less ambiguous and allowed leading Cambridge bioscientists to conclude that it was 'better to locate (in Cambridge) where the battles (had) already been fought, than to set up firms somewhere that (had) yet to go through the same process' (Spotts, 1992, 114; parentheses added).

Conversational coordination

A third and significantly important difference between Berkeley and Cambridge lies in the enforcement of the regulation and, specifically, conversational coordination by biosafety officers in Cambridge. Acting in the capacity of technology translators, these officers took on the challenging task of educating citizen representatives about the complexities of this emerging technology field and at the same time articulating citizen concerns to scientists in a professional and non-confrontational and emotionally neutral manner. In 1977, MIT and Harvard became the first universities in the nation to hire biosafety officers, assigning them responsibility for educating bench scientists on federal and local biosafety procedures. The duties of these officers included 'scrutinizing (rDNA research) applications in depth, certifying that the investigators are in fact who they say they are, have the training they say they have, and that the techniques are consistent with the laboratory that will be used in this work'.[12] MIT's first salaried biosafety officer, Dan Lieberman, was also responsible for helping bioscience faculty at the Institute write and edit research grants to ensure 'no hidden biohazardous components (remained) in (the) project'.[13] Ultimately, his work with faculty helped to eliminate potential conflict with local regulatory processes and raised scientific awareness of public health and safety concerns.

Their role in biosafety enforcement, however, was not confined to the ivory tower. These officers also represented MIT and Harvard at monthly meetings of the CBC and were responsible for answering committee member questions about university safety and reporting procedures. In addition, they were asked to report to the CBC on the progress of all pending university rDNA research projects. When a new application for rDNA research was filed before the CBC, these officers would often assist university faculty in their formal presentation to the committee. During committee deliberations, they were available to provide a more thorough explanation of an abstract or confusing technical term and if necessary would identify and compile written sources that the CBC members could use to remain in step with this evolving technology.

Ultimately, the biosafety officers helped reduce the knowledge gap between scientist and citizen, using a variety of translation techniques to explain complicated scientific procedures. As a result of their work, CBC members came to appreciate the contribution of the technology to modern science and medicine and, in turn, the importance of maintaining a reasoned and deliberative review process (Feldman and Lowe, 2007). The additional knowledge CBC members gained through their exchange with biosafety officers also contributed to the meaning and significance of this representative role on the committee and helped to reduce feelings of citizen powerlessness and disenfranchisement that could potentially arise from a lack of formal technical training. Overall, the biosafety officers helped to raise the level of scientific literacy within the Cambridge community.

Through their interactions with these officers, university bioscientists, for their part, also became more comfortable with the concept of citizen participation. In 1978, at the urging of MIT's biosafety officer, the CBC chairman was invited to attend MIT's internal biosafety meetings[14]—these monthly meetings were initiated in 1976 in response to NIH recommendations to universities. Biosafety officers also scheduled university laboratory tours that would enable them to introduce committee members to key research faculty and would give faculty an opportunity to openly discuss their research and also demonstrate their commitment to laboratory safety. In this way, the biosafety officers helped to also establish informal social exchanges between scientists and CBC members.

During one particular tour in October 1977, MIT professor and Biogen founder, Philip Sharp was given an opportunity to showcase a new biosafety level 3 laboratory (BL3) that would house his rDNA experiments.[15] Sharp reviewed the laboratory lay out and answered member questions about research processes and safety procedures. Similar tours were conducted at Harvard University in 1978, giving CBC members an opportunity to view various construction phases of a BL3 laboratory facility.[16] These exchanges, among others,[17] had an impact on Sharp's decision in 1980 to request laboratory space for Biogen in the City of Cambridge and also allowed him to influence the opinions of other, initially sceptical, Biogen co-founders. This quote from Sharp puts it best:

> Let's say you are two guys with the responsibility … of finding a building and hiring 20–30 people and starting the company. You had to make investments that had years of time periods on them. … What you don't want to do if you are making those long term commitments, is to have to go to the city and say, well we are doing this new type of science, which the newspapers have said could be potentially dangerous, and therefore we need your approval on how to do it…. At the time we were making these [location] decisions, Cambridge had already had a year or two years of debating the technology and putting in place an ordinance, establishing a city process; a (CBC) member … that would sit on NIH review committees here at MIT; the public health officer had to be informed. And, a whole set of regulations were put in place. Biogen was able to say, 'we are doing the same thing as what is going on at MIT and Harvard. We will adhere to all their same rules.' That was very reassuring, because if the city had not gone through that process, we would have to initiate it. And I would say for certain, that it would be a year or two year process, even if you were absolutely sure the answer was going to be yes.

The dual role of the biosafety officer in both educating citizens and advising university bioscientists could potentially be viewed as a conflict of interest. But it is important to recognize their more neutral role in mediating relationships between these multiple interests. While it is true that as paid university staff their loyalties would likely be strongest to their research-oriented employer, it is also true that as pioneers in this emerging occupational field, they helped to establish and reinforce local and national standards around biosafety. University biosafety officers from Cambridge would go on to become key players in the Recombinant DNA Advisory Committee of the National Institutes of Heath, thus strengthening federal oversight. Through this work, they would eventually help to institutionalize national norms of citizen participation on scientific review panels. These same officers also helped to establish new occupational roles in and norms around biosafety in the private sector. Today, Cambridge-based biosafety experts—both university-based and private sector—continue to play a central role in industry standard setting, helping small start-up firms in Cambridge, including university spin-offs, achieve a high level of professionalism and present clear evidence of due diligence to venture capitalists and industry partners. At the same time, they uphold norms of scientific accountability, ensuring new entrepreneurial start-ups have qualified citizen representation on their internal review boards (IRB)—citizen participation on IRBs is an additional regulatory requirement that was added to Cambridge's Biosafety Ordinance in 1981 with its extended coverage to commercial uses of the technology.

Interestingly, the City of Berkeley and the University of California, Berkeley, had an opportunity to institutionalize a similar process of mediation in the early days of the biotech industry. In 1978, the City of Berkeley hired environmental scientist, Otis Wong, to assist in locating biological research companies in the city and inspecting private rDNA facilities. In less than a year, however, his position with the City was eliminated due to budgetary constraints brought on by the passing of California Proposition 13. Interestingly, Wong was soon hired by the University of California to continue in the area of biosafety and assist with implementation of federal-level biosafety guidelines, thereby potentially lessening the financial and institutional challenges for the City of Berkeley created in the wake of Proposition 13. Still, with no formal requirement to engage with city officials and staff, university biosafety officers, including Wong, were unable to build on this early city–university connection. Instead, university bioscientists-turned-entrepreneurs continued to view Berkeley's regulatory process with great suspicion and would follow Cetus' lead in searching for entrepreneurial space outside of Berkeley's jurisdictional reach.

Cambridge's greener grass

As indicated above, Biogen's decision to set up shop in Cambridge in 1981 was an important and influential factor in the location decisions of other New England entrepreneurial firms. So too were emerging events in neighbouring towns that helped to reinforce industry perceptions that Cambridge had a 'more mature understanding of the field' (Lipson, 2001, 3). In 1981, to the surprise of many East Coast bioscientists, heated debates around biosafety surfaced in the neighbouring towns of Somerville and Boston, MA. As with Cambridge 4 years earlier, local concern in Somerville over the environmental and health impacts of rDNA resulted in a temporary research moratorium. Similarly, this process took approximately 9 months to complete, ending in October 1981 when the town's aldermen passed an rDNA ordinance designed to regulate both institutional and commercial applications of the technology (Krimsky et al., 1982). Across the Charles River in Boston, intense debate ensued in the spring of that same year, initially sparked by the public statements and actions of a well-organized neighbourhood group in Mission Hill. While a research moratorium was not called in the Boston case, the atmosphere was still described as 'combative' and 'highly politicized'. In our interviews, this was noted to greatly influencing the perceptions of and location decisions of New England scientists and entrepreneurs involved with this technology.

In contrast to Cambridge's initial rDNA debate (1976–1977) that focused narrowly on research activities at Harvard and MIT, the primary target of the 1980s actions in Somerville and Boston was private industry and, specifically, the location choice of a small Harvard University spin-off firm called Genetics Institute. The company's founders, Harvard faculty members Dr Mark Ptashne and Dr Thomas Maniatis, had originally planned to lease space in a former silver processing factory along the Cambridge–Somerville line.[18] Initially, the town's aldermen were 'receptive to the idea of high-technology research being done in the city' (Krimsky et al., 1982, 23). Strong opposition at a public meeting, however, resulted in the formation of a citizen review board, similar to that developed in Cambridge. As with their Cambridge counterparts, members of this committee were responsible for conducting research on the rDNA controversy and making policy recommendations to local elected officials.

Genetics Institute responded quickly, withdrawing its building permit request and searching for a new location in a neighbouring jurisdiction. In the spring of 1981, the company leased a small section of Boston's Brigham and Women's Lying-In Hospital. Yet even here community groups organized quickly and in response to strong protests by Mission Hill residents, the hospital amended its standard lease to require that the company comply with all NIH guidelines for rDNA research and commercial activity (Krimsky et al., 1982). Elected officials soon got involved, triggering a series of heated exchanges between city council leaders and company executives. These exchanges ultimately influenced the company's decision to exclude Boston and Somerville from their list of prospective locations for a new research and development facility. After consulting with Biogen executives and Cambridge city officials, including then mayor Al Velucci, the company narrowed its search within Cambridge. Their experiences in Somerville and Boston not only shaped their views on local regulation but also gave them a newfound appreciation for the subtle, but important differences in how local regulation was developed and enacted in Cambridge. As then Corporate Executive Officer of Genetics Institute, Gabe Schmergel, explained it, 'Boston was not really working properly in establishing regulation.... We were interested in having something in place that set the rules of the game and that the local population, would accept and wouldn't be nervous [about]'.[19]

Interestingly, both Boston and Somerville went on to adopt rDNA ordinances similar to that of Cambridge in early 1982. Still, the politicized and polarized nature of the debates in Boston and Somerville—compared to the deliberative and reasoned process already underway in Cambridge—raised concerns within the New England bioscience community that this issue was not fully resolved in the minds of local residents and could, at a moments notice, result in additional requests for more restrictive regulation. As Biogen co-founder Walter Gilbert described it, 'places (like Boston and Somerville) that hadn't been inoculated blew up entirely'.[20]

In conjunction with Biogen's initial location decision, these events helped to highlight Cambridge's entrepreneurial advantage in already working through local concerns over this emerging technology field and establishing a reasonable and predictable set of regulatory practices. It also helped to demonstrate the high level of scientific literacy within the Cambridge community. Quoting an early biotechnology entrepreneur who followed Biogen's lead in setting up facilities in Cambridge in 1981, this difference in atmosphere ultimately 'tipped the balance between Boston and Cambridge, because Boston [regulation], at that time, was still a little vague and it was a concern ... [Whereas] Cambridge was the devil you knew'.

Interestingly, even today, Cambridge's ordinance continues to play an important role in firm location and thus industry expansion. In fact, a recent survey of biotechnology firms in Cambridge, identified the City's rDNA ordinance as a more important locational factor than venture capital availability, business tax incentives and institutional support for clinical trials. While other factors did rank higher—namely a pool of skilled labour force and a concentration of university research laboratories—the influence of the ordinance on firm location demonstrates the ability of city officials, citizens and established entrepreneurs to promote this as a key locational advantage for the city (Breznitz and Anderson, 2004).

Regulation and the construction of jurisdictional advantage

Places around the world—and especially in advanced industrial economies—are searching for strategies to anchor new industries and reach the technological frontier. Primacy is accorded to the concept of a friendly business climate, which is construed as little or no government regulation. Yet when a technology is new and unproven, the need for regulation and monitoring are most tangibly felt at the local level, due to the nature of the physical siting of laboratories and facilities.

Yet, attempts to regulate a new technology may be perceived as detrimental to local entrepreneurial activity, placing economic development goals at odds with public health and safety goals. Alternatively and harkening back to an older view, regulation may be viewed as public stewardship that advances broadly-defined community interests. The first dictate of regulation is to serve the public interest. Of course, the issue is then defining the public interest and balancing competing needs. With new complex technology, there is always great uncertainty and the question becomes who is in a position to adjudicate. This may be done by trusted intermediaries or fiduciaries serving as agents for the public. In our example, this was the responsibility of the biosafety officers. Of course, public choice economists argue that any agent of the public, either civil servant or consultant, will be predisposed towards serving their own self-interests, creating the classic principal–agent problem. The alternative then is for citizens to also become involved to ensure that good decisions are made and decisions are based on broadly construed ethical considerations, rather than strictly focused on efficiency concerns. Good governance fuses efficient processes with transparent substantive outcomes. If this is done well, through an informed and deliberative process, the multidimensional interests of the community will best be served.

Emerging local industry may benefit if regulation turns uncertainty into calculable risk, providing standards and delineating acceptability. In addition, the process of introducing and debating regulation and engaging various constituents creates legitimacy for the emerging technology. Politicians, community activists and average citizens may gain a more sophisticated understanding of the potential of the industry and then consider new opportunities for employment, investment or entrepreneurship. In this way, the activities of the industry, rather than being understood by a small community of experts come to be more generally discussed. Alfred Marshall tells us that the secrets of the industry are ‘in the air’ yet never fully discloses the social process by which these secrets are atomized. The Cambridge example offers such a means for increasing technological understanding and subsequently fostering industrial development.

Motivating our analysis is an observation of different responses to local regulation by early biotechnology entrepreneurs in the USA. In the mid-1970s, the nascent US biotech industry was the focus of intense national debate over the environmental and health risks of rDNA activities. This debate began within the scientific community but quickly touched down in a number of US localities, intensifying in several cities with existing rDNA research capabilities and interests.[21] In 1976, city councillors in Cambridge, MA, and Berkeley, CA, responded to growing citizen concern about the environmental and health effects of this new technology by approving nearly identical rDNA ordinances. In both cases, the ordinances utilized federal biosafety standards, while still adding additional layers of local oversight. Yet differences in the way these similar regulatory actions were enacted and enforced subsequently affected the course of entrepreneurship and industrial development in these two jurisdictions.

By documenting how this process unfolded in each locale, we begin to see lessons for today’s controversial or emerging technology fields, including nanotechnology, stem cell research and GMO foods. As the Cambridge, Massachusetts, case demonstrates, pioneering communities can both support and regulate new technologies to the shared benefit of society and economic development. What is important however is the deepening of social relations through shared conversational space and transparent interaction that enables technology pioneers to view them as valued members of their larger host community, rather than simply targets of social conflict and distrust (Lester and Piore, 2004). While federal-level policy actions may be critical in exposing debate within the scientific community and also for establishing a general regulatory framework, local political and social processes may prove key for engendering broad-based citizen support and thus can provide a useful feedback mechanism for strengthening national technology standards. Interestingly, this possibility is not isolated to biotechnology, but is now visible in local and federal discussions over how to define and regulate nanotechnology. Ultimately, this enhances opportunities for responsive forms of innovation that reflect acceptable norms of scientific accountability, as well as provides a powerful tool for shifting insular scientific practices and technocratic views.

In presenting these contrasting cases, we are not suggesting that communities simply adopt new regulatory systems with the goal of jump-starting their knowledge economy. After all, Cambridge and Berkeley's entrepreneurial potential in biotechnology is itself an outgrowth of well-established university research capabilities, an expansive local scientific talent pool and readily available industry financing. As illustrated through numerous studies of economic geography, these capabilities and resources—especially for highly advanced, science-based industries, like biotechnology and nanotechnology—are concentrated in only a handful of North American municipalities. The reasons for these spatial concentrations are debated as other places try to construct advantage for emerging industries. We argue that the explanation is not due solely to either concentrations of scientific resources or early mover advantage. Our view is that the internal dynamics and social dialogue within the cluster created its own advantage, thus reinforcing virtuous growth potential. Our goal here is to demonstrate the conditions and processes under which new technology regulation harnesses a region's innovative potential. In this way, a dialogue and vision for the emerging industry are constructed and institutionalized and a coherent system may be created that defines jurisdictional advantage (Feldman and Martin, 2005).

The wrong lesson to take from this case comparison is that local regulation, in and of itself, facilitates high-tech entrepreneurship. We are the first to acknowledge that many of today's emerging technologies, precisely because of their complexity, can only be developed in regions that already have a well-established knowledge infrastructure. Outside of these places, regulation will probably do little to enhance entrepreneurial capacity. Still, we view the Cambridge case as proof that technology regulation, under the right circumstances, can become a source of constructed jurisdictional advantage through the creation of shared conversational space.

Endnotes

[1] The Cambridge biotech industry is tightly concentrated in the area around Kendall Square. The San Francisco Bay Area, while having a greater number of firms, is not as tightly agglomerated with distinct local clusters in Palo Alto–San Jose, South San Francisco and Oakland–Emeryville in the East Bay (DeVol et al., 2004, 83).

[2] We thank Andrew DiMeo of the North Carolina Medical Device Organizations for providing us with this example.

[3] See, http://www.nanotechproject.org/.

[4] We thank an anonymous reviewer for this insight.

[5] MIT Oral History Program; Interview with Barbara Ackerman by Rae Goodell, 16 March 1977, p. 6.

[6] CERB, Guideline for the Use of Recombinant DNA Molecule Technology in the City of Cambridge, 5 January 1977.

[7] Phrases in quotes are based on interviews conducted by the authors with founding entrepreneurs in both regions. Also see, Spotts (1992).

[8] Interview conducted by authors, 2005.

[9] BioScan and Bioability data allow us to document firm location by jurisdiction for the formative years of MA's biotech industry. We have chosen 1985 as a cut-off date as this corresponds with the subsiding of public debate around biosafety. A clear locational pattern exists between a town's rDNA regulatory status and firm location. In fact by 1985, 72% of the state's 21 registered biotechnology firms were located in cities or towns that had adopted some form of rDNA ordinance.

[10] One important exception is in the area of environmental technology. Berkeley has experienced a rapid growth of this industry in recent years and as such has positioned itself as a national leader in clean-technology research and entrepreneurship. Interestingly, the City's long-standing commitment to environmentally friendly practices and related citizen concern for public health and safety that first resulted in the 1977 rDNA ordinance has also been an important contributor to the City's recent 'clean-tech' success.

[11] Our research differs from other cross comparisons that do not explicitly consider social actors and social processes outside the technology community (see, for example, Owen-Smith and Powell, 2006; Saxenian, 1996).

[12] Minutes of the CBC 26 September 1977.

[13] Minutes of the CBC 26 September 1977.

[14] Minutes of the CBC January 1978.

[15] Minutes of the CBC October 1977.

[16] Minutes of the CBC October 1977.

[17] Philip Sharp was also in regular contact with CBC members through his role as technical advisor for the MIT Biosafety Committee. In 1981, the Chairman of MIT's Committee, Dr Mel Chalfen, would become Cambridge Health Commissioner for the City of Cambridge overseeing the work of biosafety inspections, further institutionalizing the formal linkages between university biosafety experts and members of the CBC.

[18] Somerville Community News February 1981.

[19] Interview conducted by authors, 2006.

[20] CERB Debate Interviews, Walter Gilbert 1988, p. 13.

[21] For a detailed account of these local debates, see Krimsky (1982).

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