Local Disclosure Ordinance as Regulatory Catalyst:

Early Insights from the Berkeley, California Manufactured Nanoscale Materials Health and Safety Disclosure Ordinance

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Abstract

In December 2006, the Berkeley City Council became the first government entity in the United States (US) to approve a specific law requiring the reporting of nanomaterials used in local facilities. In this research, we analyze the Berkeley Manufactured Nanoscale Materials Health and Safety Disclosure Ordinance (BNO) as an example of targeted transparency, an increasingly prominent regulatory approach in US consumer protection and environmental policy. We test several hypotheses about the context (causes) and consequences (effects and effectiveness) of the ordinance using qualitative data, including content analysis of public records and applicable media accounts as well as stakeholder interviews with actors embedded in relevant policy networks, including city council staff, local businesspersons and entrepreneurs, environmental health services personnel, organizational spokespersons, and scientists. Our aims are to: (1) document and understand the importance of this event in the emerging landscape of nanotechnology governance even as the science, commerce and public perceptions of nanotechnology continue to evolve, and (2) to use the BNO case to shed light on the feasible and appropriate roles that local disclosure laws can play in shaping risk policies more generally.

Introduction and Policy Context

In this research, we analyze the Berkeley Manufactured Nanoscale Material Health and Safety Disclosure Ordinance (BNO) as an example of targeted transparency, an increasingly prominent regulatory approach in United States (US) policy (Fung et al. 2007). Mandatory disclosure laws have been particularly important in California consumer protection and environmental policy; examples include the Alquist-Priolo Special Studies Zones Act[1] of 1972, the California Safe Drinking Water and Toxic Enforcement Act of 1986 (also known as Proposition 65), and the 1997 Los Angeles County restaurant hygiene law. Although occasionally mocked for its maverick ways, Berkeley itself has been a leader in previous environmental policy initiatives, such as banning Styrofoam containers.

By adopting the BNO in December 2006, the Berkeley City Council became the first government entity in the US to approve a specific law requiring the reporting of nanomaterial use, anticipated hazards, and safety plans. The ordinance amends the municipal hazardous materials code to compel "facilities that produce or handle manufactured nanoscale materials" within city limits to report what nanoscale materials they are working with, describe any known toxic effects, and give a plan for how the materials will be handled safely. The ordinance defines manufactured nanoscale materials as "manufactured chemicals that are engineered and have one dimension less than 100 nanometers." The first wave of reporting began in June 2007.

The BNO appears to reflect societal ambivalence and uncertainty about the risk-benefit tradeoffs involved in the development of nanotechnology. Nanomaterials have the potential to improve currently available technologies and new applications in areas such as environmental remediation, sensors, manufacturing, energy production and delivery, drug delivery, and optics

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[1] This law created a duty for realtors and property sellers to inform potential buyers if a property is located within a certain distance on either side of a known seismic or fault zone.

(Roco 2005). On the other hand, research related to the fate and transport, exposure, and toxicity of nanoparticles, both natural and engineered, indicates that nanotechnology may pose important environmental and human health-related risks (Biswas and Wu 2005; Dunphy-Guzman et al. 2006; EPA 2007). Factors *other than mass* such as size, surface area, surface chemistry, solubility and possibly shape may determine the potential risk, although the most important risk-related characteristics are not yet determined (Oberdörster et al. 2005). A consensus exists that these research efforts need to be greatly increased (Roco 2005; Maynard et al. 2006; Renn and Roco 2006; Sherman 2006; EPA 2007).

The underlying motivation for our study is the importance and difficulty of managing the risks of emerging technologies. Numerous historical examples exist of new technologies where opportunities were missed to act upon early warnings of environmental and health risks (Harremoës et al. 2001). The BNO presents a case that we can learn from in ways that might be useful as society continues to struggle with how to responsibly manage nanotechnology and that might contain lessons for other contemporary or future technology risk-trade-off problems (e.g., estrogenic-mimic chemicals, climate change, or as-yet unimagined issues). A number of groups have called for more proactive risk management or even a complete "precautionary" approach regarding the rapidly evolving set of nanomaterial products and applications. Early science evidence, as noted above, suggests that some caution is warranted.

Nanotechnology also provides a case setting for dynamically observing what may be a new era or mode of risk policymaking. At present, professional societies, trade organizations, national government agencies, academic research centers (often funded by federal grants and private foundations), non-governmental organizations (NGOs), and international institutions (e.g., the ASME standard setting process) are engaged in a dialogue concerning the nomenclature, metrology, and relevant technical attributes that would support the creation of nanotechnology standards. The unusual entrance of the BNO is an event that could significantly change the trajectory of expert or public opinions and eventually standards and laws. The BNO is not an outgrowth of the traditional scientific and deliberative bodies mentioned above slowly working towards unified technological standards; it instead imposes a change on standard operating procedures for a small set of organizations involved in nanotechnology science and commerce that may help create important knowledge artifacts for technological standards being developed by industry and governments elsewhere. The BNO may impose new costs on compliers above and beyond whatever voluntary knowledge organizing efforts by industry and scientists cost.

We seek to provide evidence about what a relatively low-cost, un-enforced disclosure policy like the BNO adds to the dialogue that may be different than what is contributed by other entities interested in effective proactive risk management of this emerging technology. The small number of actors in the local industry and government may facilitate practical learning about nanomaterial risk-related data collection that may have utility for entities well-outside Berkeley city limits. In particular, we theorize that the BNO will change the dialogue about nanomaterial risk in the following ways: (1) it will engage new participants; (2) it will change the focus of the discussion to more practical concerns such as cost and implementation; and (3) it will develop key concepts and categorizations as well as identify gaps in our risk understanding at a faster pace than other extant standard-setting processes.

We test these and other hypotheses about the context (causes) and consequences (effects and effectiveness) of the ordinance using qualitative data, including content analysis of public records and applicable media accounts as well as stakeholder interviews with actors embedded in relevant policy networks, including city council staff, entrepreneurs, environmental health services personnel, organizational spokespersons, and scientists. Our aims are to: (1) document and understand the importance of this event in the emerging landscape of nanotechnology governance even as the science, commerce and public perceptions of nanotechnology continue to evolve, and (2) to use the BNO case to shed light on the feasible and appropriate roles that local disclosure laws can play in shaping risk policies more generally.

Background

What is nanotechnology and why are some people worried about it?

By convention, nanomaterials consist of any physical particle that is less than one hundred nanometers in one dimension or more. A nanometer is one billionth of a meter. In general, the term nanotechnology is used to mean any human attempt to achieve something useful through the manipulation of matter at this dimensional scale. In an applied sense, the emphasis lies not on the scale or size, but on the potential to apply size-dependent qualities for an innovative function, that is, on leveraging the effects of nanoscale substances for some new, useful purpose. The US Environmental Protection Agency (EPA), drawing from the definition developed by the US government's 2001 National Nanotechnology Initiative (NNI), defines nanotechnology as:

> "…research and technology development at the atomic, molecular, or macromolecular levels using a length scale of approximately one to one hundred nanometers in any dimension; the creation and use of structures, devices and systems that have novel properties and functions because of their small size; and the ability to control or manipulate matter on an atomic scale".

In its February 2007 Nanotechnology White Paper, the EPA states that nanotechnology research and development spending for 2006 is estimated at $9 billion globally (EPA 2007, citing Lux Research). Furthermore, the National Science Foundation in 2006 invested $5.4 million alone on ethical, legal and social research and education related to nanotechnology (Sherman 2006). The Woodrow Wilson International Center for Scholars has created a Consumer Products Inventory that currently catalogues almost 500 consumer products that use nanotechnology in some way (primarily in the electronic, cosmetic, textile, automotive and medical sectors). These figures attest to nanotechnology's importance on the US federal research agenda and its growing economic importance.

Nanotechnology could bring important improvements to currently available technologies and applications in areas such as environmental remediation, sensors, manufacturing, energy production and delivery, drug delivery, optics, and many others (Roco 2005; Maynard et al. 2006; EPA 2007). Nonetheless, novel nanoscale materials may also pose some hazards to human health and the environment. Over the past two years there has been an exponential increase in the number of published articles on nanotoxicology, owing to the 're-discovery' of past discoveries but also new findings on potential health benefits of nanomaterials (Oberdörster et al., 2007). Existing studies are concerning enough to lead many to conclude that research efforts in nanotoxicology need to be greatly increased (EPA 2007, Maynard 2006, Roco 2005, Renn 2005, Sherman 2006). Some examples of recent research and findings related to the hazards that nanomaterials might pose for human health or the environment include the following:

- Oberdörster et al. (2005) observed a range of potential human health hazards. In particular, he finds that nanoparticles can: (i) when inhaled, reach "potentially sensitive target sites" (for example, bone marrow, lymph nodes, spleen, and heart) and can access the central nervous system and ganglia, and (ii) penetrate the skin and can absorb into lymphatic channels.

- Studies of nanoscale quantum dots and fullerenes have found that these may absorb into the skin and disperse into other tissue and that they have pro-oxidant and toxic effects. On the other hand, many studies on these materials also show potential health benefits as antioxidants (Oberdörster et al. 2007).
- Studies on dendrimers, used for drug delivery, show that the surface charge of a nanoparticle can alter the integrity and permeability of the blood-brain barrier (EPA, 2007).
- Recent studies with poorly soluble particles of low toxicity, like titanium dioxide, provide evidence that surface area is a key feature (Fadeel et al. 2007) Monteiller et al. 2007 cited in Fadeel et al., 2007).
- Regarding airborne nanoparticles, Maynard and Aitken find that some maybe more toxic than larger particles of the same chemical composition, rendering conventional mass per unit volume of air measures inadequate(Fadeel et al. 2007). This is the case with titanium dioxide (TiO_2). Other studies show that airborne carbon nanoparticles impair phagocytosis of microorganisms, potentially increasing susceptibility to infections (Fadeel et al. 2007).
- Transloaction, the ability of nanoparticles to cross from one organ or tissue to another, is a major issue in nanotoxicology. For example, gold nanoparticles have been found to translocate across the blood-air barrier of the lungs, depending on their size and surface coating (Oberdörster et al. 2007). *Technegas translocation*, on the other hand, is an example of the evolving nature of nanotoxicologies. Studies from

some years ago have been refuted as new methods for manufacturing these nanoparticles have developed. The new studies show the risk of translocation is much lower than previously thought (Fadeel et al. 2007).

- Other studies on the inhalation of nanoparticles have found that the accumulation of materials in human lungs varies with the presence of a pre-exisiting condition such as asthma (EPA 2007).
- Carbon nanotubes have been found to be toxic for the lungs, although the effect depends on dosage, tube coating and other factors. For example, studies show that metal coatings, like iron, cause oxidative stress in the lungs, not the carbon nanotubes themselves (Kagan et al. 2006; Pulskamp et al. 2007). Other tests show that the gravity of the effect depends on the condition of the lungs as well as dosage(Fadeel et al. 2007). Yet other research is looking at coatings that are more easily engulfed by phagocytes, which play an important role in the human immunological system. The objective is to develop better targeted drug delivery mechanisms and a better understanding of how nanomaterials are absorbed into the body.
- In the environment, nanomaterials appear to have a tendency to cross cell membrane barriers and accumulate, though some mitigating effects may exist. Studies have been undertaken with fish, but much more research is needed.
- Some research into nanomaterials and soil finds that these are more toxic on a mass-based exposure metric, while some nanomaterials show unique toxicity not explained by size. Furthermore, it is known that uptake in soil, plants and water is different. Toxicity is further complicated by the coatings used on some nanomaterials, which may be reactive even if no uptake is observed.

From the research on toxicity conducted thus far, two key patterns emerge. First, the absence of evidence of toxicity does not necessarily imply that there is no hazard; to date, not enough toxicology research has been conducted to draw general conclusions about the safety of various classes of nanomaterials (Roco 2005; Maynard et al. 2006; Renn and Roco 2006). Concerns for error-making go in both directions. As the *technegas* case shows, the types and methods of toxicity tests are evolving. This means some nanoparticles may appear dangerous but later be shown not to present the suspected hazard. The second take-away point is that chemical composition, weight and mass do not capture all the relevant variables that might affect the potential for toxicity of nanomaterials. Many other factors need to be considered, such as surface-to-mass ratio, surface chemistry (coating), or *in vivo* surface modifications, among others (Oberdörster et al. 2005; Oberdörster et al. 2005; Davies 2006; Dunphy-Guzman et al. 2006; Maynard et al. 2006; EPA 2007).

Why might regulating nanomaterials be challenging?

In the US, the current debate is about whether nanomaterials can or should be regulated using existing legal frameworks at the federal level — e.g., under the Toxic Substances Control Act (TSCA), the Occupational Safety and Health Act (OSHA), the Food and Drug Administration (FDA) and a collection of other laws ranging from the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)— or through a new, nano-specific framework (Davies 2007; EDDP 2007).

The debate centers on at least three distinct legal and implementation obstacles. First, it is up for legal interpretation whether or not nanomaterials are “new” chemicals as defined in TSCA or hazardous materials as defined in the Health and Safety Codes of various states. It would be much easier for agencies such as the EPA to enforce safety, process, or use controls if nanomaterials are considered "new". However, many substances we now use at the nanoscale have been in use for centuries—silver oxides, lead and carbon, for instance. The EPA has taken such steps as convening several working groups to study the issues, introducing a voluntary nanomaterial reporting program in 2005, and guidelines in 2006. Also, in November of 2006, the EPA declared that it would consider nanomaterials used to kill bacteria and other pests as pesticides and therefore subject to its jurisdiction under FIFRA.

Second, groups pushing to regulate nanomaterials are arguing that many nanomaterials constitute new hazardous materials, which would allow maximal application of existing laws. However, this view is legally contestable; in the long run, a clearer legal mandate with which to manage nanomaterials will be necessary. Additionally, even if nanomaterials could be effectively incorporated under existing federal and state rules, there is growing agreement that the current regulatory framework not only inadequately addresses the potential hazards of nanotechnology (EPA 2007, Roco 2005, Davies 2006), but also inadequately addresses the hazards of chemicals. In particular, extensive research by federal agencies and academic institutions points to the failures of TSCA to "assess the hazards of chemicals in commerce or control those of greatest concern" (Wilson 2006). Given these inadequacies, the argument for a new, improved nano-specific framework is gaining force, although society and long term economic development would benefit more from a comprehensive reform of TSCA. Recent efforts in the European Union at strengthening chemical regulation are increasingly seen as an example to follow (ED-DuPont 2006; Wilson 2006).

Finally, as noted above, some nanomaterials differ even from their chemically-identical brethren in that toxicity may be more a function of the materials' physical (e.g., relative dimensions or surface-to-mass ratio) properties than of the quantity being handled. This shifts the focus of regulation from standards and emergency preparedness to lifecycle assessment and exposure control; experts suggest that this should be reflected in the type of data collected under 'right-to-know' frameworks. Traditional media- or volume- based regulatory thresholds might prove either irrelevant or permit dangerous materials to be used or transported without triggering existing regulatory controls.

What nano-related science, policy and regulation efforts are currently underway?

The broader nanotechnology debate currently involves a host of public and private entities and formal initiatives associated with science and voluntary standards as well as a few tentative steps toward regulation. Table 1 depicts many of the larger players in the dialog by jurisdictional level.

	Funded Science & Research	**Voluntary Standards & Safety Practices**	**Regulatory/ Legal**
Local			BNO
Regional/State	"Nano-Centers"		
National	NNI DHHS NIOSH	Am. Chem. Council Env. Defense-Dupont	EPA FDA
International Government	OECD EU	ISO	
International NGO/ Industry	ICON IGRC	ASTM-International	

Table 1. Institutional players in the global nanotechnology governance debate by jurisdictional level.

In 2001, the Bush Administration established a National Nanotechnology Initiative under the offices of the National Science and Technology Council. Increasing interest in nanotechnology from the science and innovation perspectives led to concern over agency redundancy or counterproductive actions. Creating a centralized entity to coordinate planning and funding among the twenty-six federal agencies with program interest in nanotechnology seemed like a "win-win" science and economic development policy.

The NNI covers federal efforts with a budget of over $1.5 billion. The bulk of that money goes to the thirteen member agencies that have research and development budgets for nanotechnology. Some agencies have in turn handed out grants to a collection of over 60 quasi-public and academic "Nano Centers" across the country. Nano Centers engage not only in basic and applied science research on nanomaterials, but also in social science research such as public opinion surveys and active efforts to engage and educate the public through activities such as "Nanocafés."[2]

In the private sector, various trade organizations have initiated nano-focused subgroups. Examples include the Nano Business Alliance (representing small and medium sized businesses), the American Chemical Council (representing larger chemical companies) that facilitated the Chemical Industry Vision 2020 Technology Partnership (published an R&D roadmap for nanotechnology in 2003), and Lux Research (the leading consulting and marketing organization specializing in nano business). Professional societies such as the American Bar Association (ABA), American Institute of Chemical Engineers, and the American National Standards Institute have established nano-focused groups or conferences.

In general, awareness of and concern for nanotechnology remains low in the broader population. Several major environmentally-minded non-profit groups (e.g., Environmental Law Institute, ETC Group, Natural Resources Defense Council, Environmental Defense) and other

[2] Information on the UC Santa Barbara NanoCafé series can be found at: http://www.cns.ucsb.edu/news/new-nanocaf-series-promotes-discussion-and-education-about-emerging-nanotechnologies/ (Accessed: 9/10/07).

organized interests such as the AFL-CIO and Tri-TAC (a technical advisory group for waste water facilities in California), have mounted informational nanotechnology campaigns. A few nano-specific NGOs have been established with ostensibly research and public education rather than lobbying purposes, including the International Council on Nanotechnology, The Nanoethics Group, www.wisenano.org, and the Center for Responsible Nanotechnology.

One of the most innovative efforts is a three-year collaboration between Environmental Defense and DuPont (ED-Dupont) to explore ways that nanomaterials users can identify and manage potential hazards of nanomaterials across the entire lifecycle. The effort culminated in a jointly-released whitepaper in June 2007. The framework lays out the questions organizations working with nanomaterials should ask themselves, the information needed to effectively minimize risks to humans and the environment, and recommends standards for toxicity tests and risk categories. The emphasis is on information gathering and its use to inform risk management strategies at different stages of a product's lifecycle. It is therefore an adaptive and flexible framework, and includes cost estimates, organizational positions and protective measures.

On the international level, the EU, Japan and Australia have played particularly active roles. In June 2007, the EU implemented a hotly debated new approach to chemicals regulation called REACH, short for Registration, Evaluation, Authorization and Restriction of Chemicals. REACH unifies European chemicals regulation, and requires the registration of chemical substances, and explicitly mentions nanomaterials. The objective is to close information gaps on hazards and identify appropriate risk management measures. Industry is responsible for generating the required data required to make risk management decisions and for demonstrating that a chemical is safe. The European Chemicals Agency (ECHA) will evaluate particularly suspect chemical substances, recommend safer substitutes, analyze alternatives and implement total or partial bans when a risk is considered unacceptable. Furthermore, REACH imposes the same procedures on all chemicals, eliminating any distinction between new and existing chemicals.

Additionally, several think tank-type institutions have been established that claim a programmatic interest in nanotechnology, most prominently the International Risk Governance Council (IRGC). American Society for Testing and Materials-International (ASTM) and the International Standards Organization (ISO) are both developing nanomaterials nomenclatures with the collaboration of industry, government agencies, universities and professional associations. ASTM-International released the first standard classification in December 2006. Both organizations have permanent committees with voluntary members. The ISO's Technical Committee 229 on nanotechnologies has a working group on health, safety and the environment led by the United States, under the direction of the American National Standards Institute (ANSI). The ISO/TC 229 aims to have twice-yearly meetings attended by organizations from many countries.

The Berkeley Nanoscale Materials Health and Safety Disclosure Ordinance

In the midst of all the above activities, the City of Berkeley took the initiative of approving a nanotechnology disclosure ordinance within the existing legal framework governing hazardous materials. The aim of this ordinance is to compel laboratories using nanomaterials to inform the local government and community of what materials they are using how much they know of their potential toxicity, and what measures they are implementing to contain potential risks, with the objective of contributing to a wider debate on nano-regulation.

The City of Berkeley formally adopted its nanoscale materials disclosure ordinance on December 12, 2006. The law embeds manufactured nanomaterials within the hazardous materials business plan (HMBP) requirements and makes them subject to the same definitions and conditions as other chemical substances. In California, a hazardous material is defined as "any material that because of its quantity, concentration, or physical or chemical characteristics, poses a significant present or potential hazard to human health and safety or the environment if released into the workplace or the environment."[3] The BNO state that any facility that produces or handles manufactured nanoscale materials – defined as "manufactured nanomaterials that are engineered and which have a dimension less than 100 nanometers" – must submit a yearly report. Using an open format questionnaire, nanomaterial users are required to inform the City government of the potential toxicity of the nanomaterials being used and, if the *user* determines there is a risk, what measures the user is taking to minimize exposure and hazard to workers and the community.

The ordinance establishes a "control band" four-level rating scheme that combines degree of toxicity and potential for human exposure to guide decisions on how to manage certain classes of nanomaterials. Nanomaterial users are asked to qualitatively assign the materials they are using to one of four possible levels, ranging from low risk (low toxicity, no exposure) to high risk (high or unknown toxicity, high exposure). Materials falling into the 3rd or 4th control band are subject to "high levels of controls measures." In this way, the ordinance acknowledges that some materials should be subject to a higher management standard than others.

[3] Ch. 6.95 Div 20 California Health and Safety Code.

Research Questions

As an example of targeted transparency, the BNO is a useful case for developing tools for studying risk policymaking in general and exploring how a disclosure law can affect the risk management trajectory of an emerging technology. Through this research, we seek to document the context and importance of a new element in the emerging nanotechnology governance landscape: the existence of a local disclosure ordinance that requires nanoscale material risk reporting. The ordinance has received considerable attention in the nano business, scientific, public health, legal and regulatory communities as well as in the mass media, but to what consequence?

We have in mind three broad research questions. First, what contextual factors led to the passage of the Berkeley Nano Ordinance? Second, what did stakeholders expect the BNO to do? This second question is key to understanding why some stakeholders did or did not actively participate in the activities leading up to the passage of the law. Third, what effects is the BNO actually having, especially on the overall debate about nanotechnology governance? More specifically, is the BNO altering the behaviors of government agencies, other information users, or disclosers themselves, and if so, how?

Research Approach

Understanding the Context of the BNO's Passage

For the first stage of our project, we are using a mix of qualitative methods to assess the events, circumstances, institutions and actors that contributed to passage of the ordinance. The two primary methodological tools are archival and document analyses and structured stakeholder interviews. Documents publicly available and currently in hand include the hearings, agenda and minutes of Berkeley's Community Environmental Advisory Committee (CEAC) and City Council hearings & meetings. We plan to request from stakeholders various unofficial documents and email correspondence that might shed further light on the activities and opinions of various actors at the time.

Our preliminary inquiries suggest that the BNO was drafted and passed by the Berkeley City Council based on the efforts of a handful of individuals, with very little pressure or input from the public (neighbors, citizens, consumers, or constituents) or local industry (the entities that would be directly affected by the law). Who then was advocating for this ordinance, and why did persons who might be adversely affected by it fail to speak up?

We propose to apply two different theoretical approaches to understanding the context surrounding the passage of the BNO. The first comes from a family of contemporary theories related to interest group behavior, new institutionalism, and political mobilization (March and Olsen 1984). These theories emphasize that political actions are generated by individual perceptions of self-interest but also on institutions and social groups weighing the benefits and costs of participating in a particular political process. Interest group theory suggests that the benefits of participation in shaping the BNO must have been perceived by non-participating stakeholders or interest groups as too small relative to the costs of participation.

Through our research, we will explore three potential explanations for the lack of mobilization both for and against the ordinance. One hypothesis is that the facilities to be regulated lacked avenues for collective input, were not paying attention, and/or lacked information about the city's plans. Another possibility is that regulated groups stood aside because they perceived more benefits than costs from the regulation, possibly because the costs are so low or the ordinance had the potential to produce group-specific benefits such as reduce regulatory uncertainty, produce public relations benefit, or reveal useful information from competitor activities or about what other groups know about the risks of the nanomaterials they are working with.

The cultural theory of risk is a second approach that can be used to understand the behaviors of the political actors associated with the BNO. First proposed by Douglas and Wildavsky in 1982, cultural theory is based on the belief that patterning and habits within social networks and relationships generates distinctive ways of looking at the world and that adherence to a particular world view in turn legitimizes a corresponding type of social relations (Douglas and Wildavsky 1982). This results in only a handful of worldviews, variously described as hierarchical/caste-ist, egalitarian/sect-ist, individualistic/entrepreneurial, fatalistic, and hermit-like. Cultural theory would suggest that certain people or groups might find it in their best interest to mobilize society around a particular risk such as nanotechnology, and that other groups might be culturally inclined not to resist.

Later in the project, we will conduct a series of stakeholder interviews with actors embedded in relevant policy networks, including city council staff, entrepreneurs, environmental health services personnel, organizational spokespersons, and scientists. Our questions will focus on the interests and values they ascribe to, their opinions of the ordinance, and how they perceive it has affected them. We may use short psychometric questionnaires to locate each stakeholder on the cultural theory continuum.

Effects and Consequences

For the second stage of our project, we will focus on what has and is happening since passage of the BNO. Again, we find two useful frameworks in the existing literature for understanding the effects of the BNO. The first thing to note is that the BNO is an example of targeted transparency, an increasingly prominent regulatory approach in US policy (Fung et al. 2007). The leading approach in the literature for studying the effects of targeted transparency policies is to classify documented outcomes of an ordinance according to the degree to which the disclosed information becomes embedded in the decisions and behavior habits of both disclosers and users. Table 2 shows some examples of contemporary transparency policies and the level of effectiveness they are reported to have achieved.

Effectiveness Level	***Description***	***Examples***
C	no one uses the disclosed info; disclosed info does not alter the behavior of either disclosers or users	• Plant Closure/Mass Layoff Disclosure Laws • Patient Safety Disclosure (NY/PA)
B	disclosed info alters the behavior of at least the users and possibly also the disclosers *but in incomplete, unanticipated, or partially undesirable ways*	• Toxic Release Inventory • Mortgage Lending • Nutritional Labeling
A	disclosed info alters the behavior of both users and disclosers towards desired public outcome(s); the policy evolves and is sustainable over time	• Los Angeles County Restaurant Hygiene Law • Federal Corporate Financial Disclosure Laws

Table 2. Recent transparency policies and the level of effectiveness they are reported to have achieved. Adapted from Fung et al. (2007).

An alternative, perhaps more comprehensive, framework for understanding social responses to different hazards and risk events is the Social Amplification of Risk Framework, or SARF (Kasperson et al. 1988; Pidgeon et al. 2003). The basic elements of SARF are risk events (emergence of a new technology, a disaster episode, passage of a law, or sometimes even a particular news story), risk stations (the socially-networked individuals, groups, and institutions among which communications about the risk events are passed), ripple effects (the passage and re-formulation of risk event information across, for instance, geography, time and sectors), and impacts (the perceptions and behaviors of stakeholders and of society at large toward the particular risk).

Kasperson et al. propose that four main factors lead to social amplification of risk perceptions: volume (the relative amount of information being transmitted is taken as a signal of importance or social significance); dispute (disagreements and clashes of opinion appear to be more salient, interesting, or meaningful); dramatization (things which people find particularly shocking, scary, poignant, exciting, or anxiety-producing garner more attention); and symbolic meaning (terms, images, and concepts as communicated can have different impacts on different people or social groups and cause messages to conjure up unintended associations and linkages). These forces can result in amplification of a risk event but also attenuation, depending on the social processes that unfold.

The most obvious immediate effects of the BNO can be found in the replies from local nano-users. In addition to reviewing the first round of replies, we will also: 1) assess media coverage of the BNO, focusing on content and message framing differences that might be evident in local versus national sources, and 2) document self-reported behavioral change using stakeholder interviews. We hypothesize that the BNO is a new node in the social network surrounding and perpetuating the nanotechnology governance debate. Using social network analysis, we will attempt to determine whether it is a central or peripheral node.

Preliminary Results

Actors, Institutions and Interests

Figure 1 summarizes the key players and "non-players" in the passage of the BNO.

Present and Active	**Minimally Involved or Silent**
Advisory and Decision-making Institutions: • CEAC • Berkeley City Council	Local Nanomaterial Users: • UC Berkeley • Bayer, Inc. • other local nano-businesses • nano-businesses located elsewhere
Advocates/Risk Entrepreneurs: • Michael Toffel, Chair of CEAC while completing PhD at UC Berkeley • Nabil Al-Hadithy, Secretary of CEAC and Toxic Wastes Division/HazMat Manager for City of Berkeley • Robert Clear, Member and Previous Chair of CEAC, part-time employee at LBNL	Other Potential Stakeholder/Observers: • federal and state agencies • media • consumers of nano-products
Citizen Watchdog Groups: • Committee to Minimize Toxic Waste (local group advocating against toxic wastes and LBNL)	
Research Entities: • Molecular Foundry/LBNL (federally-funded public creator/user of nano)	

Figure 1. Institutions and actors either active or absent from the debate about the Berkeley Nano Ordinance.

The Timeline for Passage of the BNO

Figure 2 presents a simple timeline of CEAC activities related to nanotechnology between 2002 and 2007 based on information obtained from the formal meeting minutes of CEAC during that time period. It immediate evident upon reading the meeting minutes that three key people guided the process with very minimal involvement from nano-using businesses or from Berkeley citizens. The one exception on the citizen front is a local watchdog group called the Committee to Minimize Toxic Waste (CMTW). CMTW was formed out of concern about activities at Lawrence Berkeley National Laboratories (LBNL), particularly tritium and other radioactive materials which they felt might pollute the groundwater underneath the lab if improperly disposed of or used. LBNL is a federally-funded facility under the Department of Energy, and therefore is not obligated to report its activities with hazardous material under typical state laws.

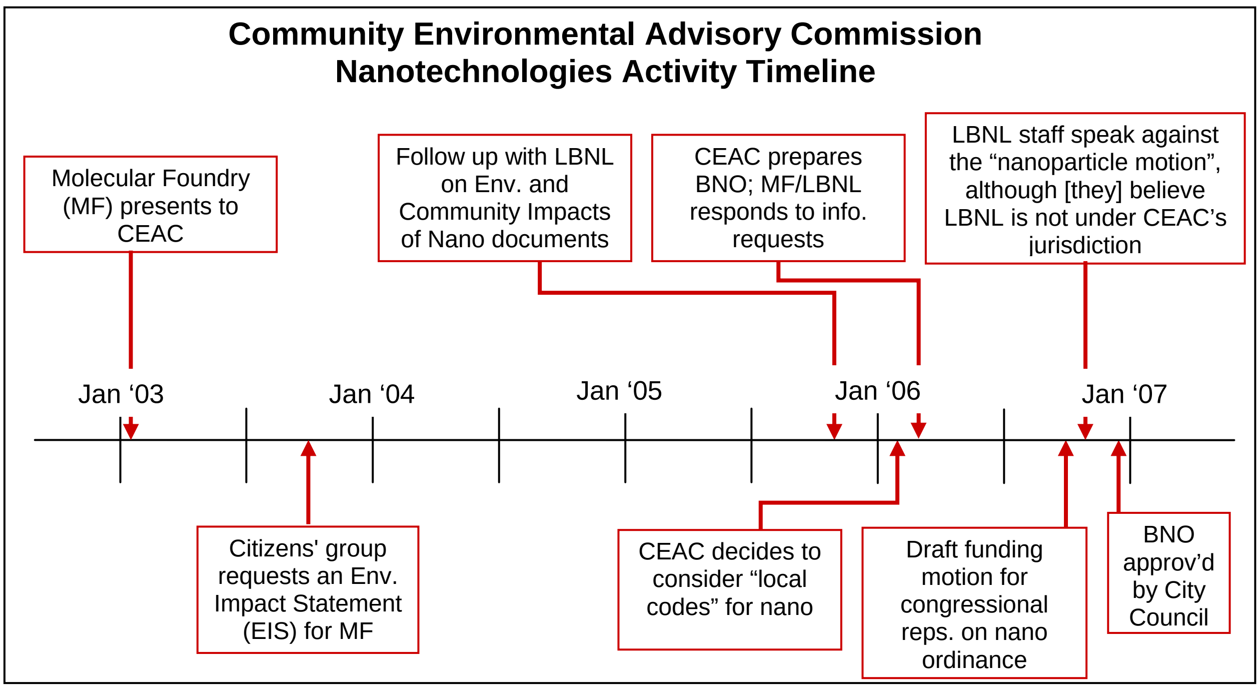

Figure 2. Activities of the Berkeley Community Environmental Advisory Commission (CEAC) related to nanotechnology, 2002 – 2007.

LBNL, long aware of citizen concerns and sent a representative to many CEAC meetings during this time period and gave "courtesy" presentations to the Committee on the safety and waste management processes they use. Scientists and LBNL/MF staff occasionally offered CEAC help with specific actions the committee was considering. Regarding nanomaterials, for instance, LBNL representative expressed the view that the labs and UC Berkeley are small users of nanomaterials compared to industry and helped define nanoparticles, spoke out about some of the drawbacks of regulating nanomaterials use.

The First Round of Reporting and Early Effects

Media Coverage. The BNO is a novel first salvo in the effort to explicitly regulate nanomaterials use. Despite the fact that very few entities are compelled under the law to report, the ordinance attracted immediate media, industry, and governmental attention worldwide. Figure 3 shows that the BNO did register one of six major news events in 2006, based on data on mainstream coverage of nanotechnology in the United States (Weaver and Bimber (in press)).

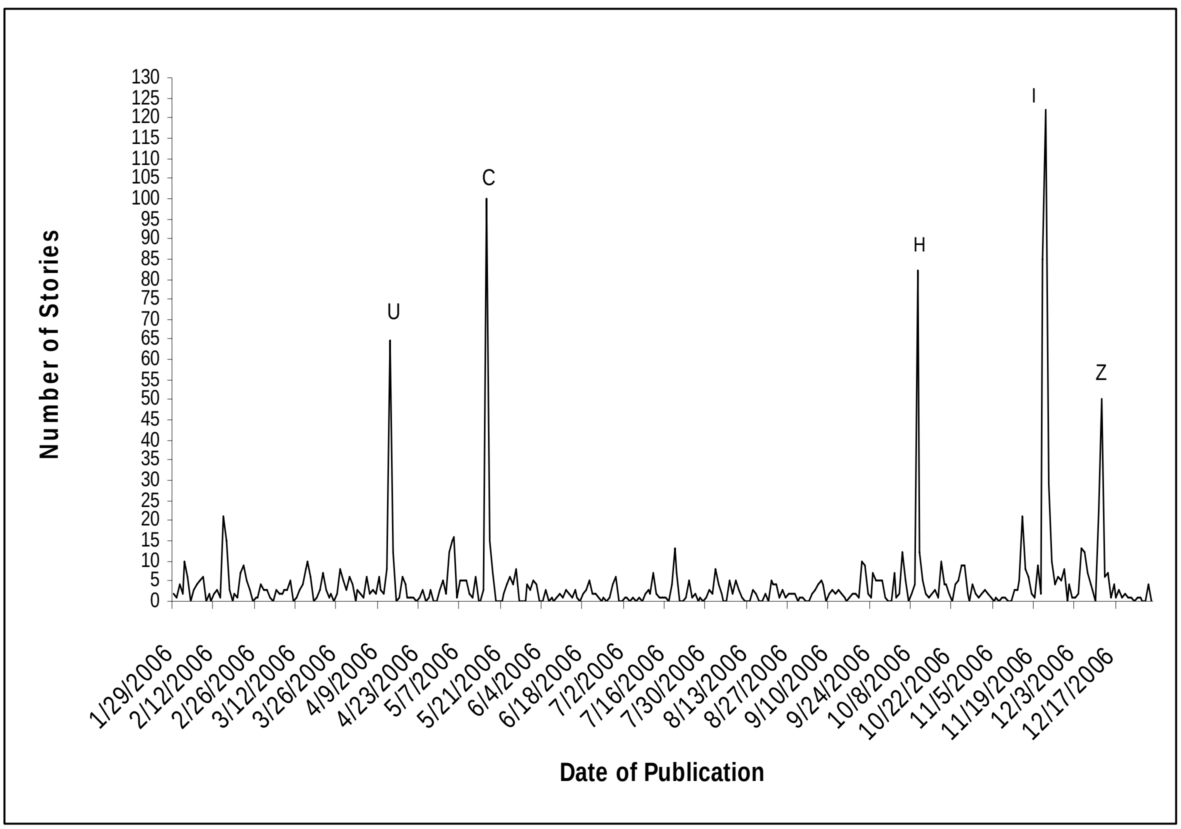

Figure 3. 2006 News Events by Number of Stories--All News Outlets--From Google News. Source: Weaver & Bimber 2007 (in press), Figure 3b. Event Labels: U= FDA announces nano-related meeting; C= Petition to FDA by a citizen group; H= FDA meeting; I= EPA pesticide announcement; Z=Berkeley Nano Ordinance.

Number and Content of the First Round of Reports. Berkeley officials used their existing business contact information lists and word of mouth to select a group of local businesses to send the BNO requirements announcement to in March of 2007. Six businesses in total were contacted, including LBNL and UC Berkeley. Of that group, the City received BNO replies from Bayer, two "partial" replies from LBNL and UC Berkeley, and claims from two businesses that they do not use nanomaterials.

Influence on Other Governmental Activities. Members of the Berkeley CEAC have been contacted by other cities (Cambridge, MA; San Francisco, CA) and other entities such as the Wyoming Business Council for information about the ordinance. Presumably, officials from these institutions heard about the BNO through the media and then sought further information. We would like to follow up with these "responders" as well as a convenience, hopefully well-matched, sample of "non-responders" to see what motivated the type of follow-up actions they did or did not initiate.

Interestingly, just months after the BNO was passed, the EPA opened for public comment a reporting framework for manufacturers and users of nanomaterials with recommendations on important nanomaterial characteristics and risk management measures that should be taken. This framework is broader than the BNO but is quite obviously related to it; more information would be reported, a standardized reporting form will be used, and the EPA will reserve the right to recommend risk management strategies to manufacturers rather than accepting whatever safety plans the respondent purports to be using. It is still, however, a reporting framework and not a regulatory one; the EPA is still claiming that TSCA and other relevant hazardous materials statutes continue to govern the use of nanomaterials. As with the BNO, it is unclear how EPA will enforce or assess the validity of industry reports and the agency is particularly interested in exploring incentives for participating. Whether or not the City of Berkeley will be able to claim credit for pushing federal regulators into action on nanotechnology risk management and informational reporting is something we hope to be able to shed light on through our interviews.

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