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SPECIAL FOCUS: GOVERNANCE OF NANOBIOTECHNOLOGY

Nanotechnology, voluntary oversight, and corporate social performance: does company size matter?

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Abstract In this article, we examine voluntary oversight programs for nanotechnology in the context of corporate social performance (CSP) in order to better understand the drivers, barriers, and forms of company participation in such programs. At the theoretical level, we use the management framework of CSP to understand the voluntary behavior of companies. At the empirical level, we investigate nanotech industry participation in the Environmental Protection Agency's Nanoscale Materials Stewardship Program (NMSP) as an example of CSP, in order to examine the effects of company characteristics on CSP outcomes. The analysis demonstrates that, on the average, older and larger companies for which nanotech is one of the many business activities demonstrate greater CSP as judged by company actions, declarations, and self-evaluations. Such companies tended to submit more of the requested information to the NMSP, including specific information about health and safety, and to claim fewer of the submitted items as confidential business information. They were also more likely to have on-line statements of generic and nano-specific corporate social responsibility principles, policies, and achievements. The article suggests a need to encourage smaller and younger companies to participate in voluntary oversight programs for nanotechnology and presents options for better design of these programs.

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Introduction

Nanotechnology could have great benefits to society in the improvement of drugs, pesticide delivery, renewable energy systems, and the quality and safety of food. However, many nanomaterials also present special properties that are likely to require extra scrutiny to ensure human health and environmental safety. Nanomaterials may penetrate more readily in living systems and pose greater health effects at lower concentrations, given their smaller size, higher surface area to mass ration, and quantum and electric properties (Maynard 2006). Thus, many scholars have argued for the need for specific attention and regimes for the oversight of nanotechnology products (Davies 2007; Kuzma 2006; Macoubrie 2005, 2006; Marchant et al. 2008; Maynard 2006; Sylvester et al. 2009).

Until recently, much of the discussion on nanotechnology oversight has been focused on formal, mandatory, or "hard" regulation. The general conclusion of the discussion is that a formal regulatory system will be difficult to design given the uncertainty about the definition of nanotechnology, the difficulty in designing regulation in the absence of such definition, the breadth of products and applications and institutions that would be involved, the high speed of development of the new technologies, the complexities and shortcomings of existing laws to cover emerging products from nanotechnology, the slow pace of enacting formal federal regulations, and the uncertainties about the health and environmental risks presented by nanotechnologies (Davies 2008; Groves et al. 2009; Kuzma 2006; Lee and Jose 2008; Marchant et al. 2009; Paddock 2006).

As a result of the growing understanding of the limitations of formal regulation to control the risks of nanotechnology, more recent discussions of oversight included consideration of non-formal or "soft" regulatory mechanisms with voluntary and cooperative measures (Bowman and Hodge 2006, 2007; Breggin and Carothers 2006; Fiedler and Reynolds 1994; Forrest 1989; Kuzma 2007; Lin 2007; Marchant et al. 2009; Paddock 2006; Reynolds 2003; Segal 2004; Wejnert 2004; Wilson 2006). Such regulation is considered beneficial as a form of anticipatory and proactive management of emerging risks (Groves et al. 2009; Paddock 2006). However, there is increasing recognition that soft approaches alone will not be sufficient; thus, some proponents of soft regulation argue for a comprehensive system of oversight that would include both formal and non-formal approaches. Most recently, Ramachandran et al. (2010) have suggested a dynamic model of comprehensive oversight, which is based on the idea that not only is a combination of formal and informal approaches is important, but that it is also important that the mixture not be static and that it evolve as data become available and as new attitudes and analyses develop.

The interest in voluntary oversight approaches is growing not only in academic circles, but also among policy makers. Governments in the United States, the United Kingdom, and Australia have taken steps to elicit voluntary participation and cooperation of companies in oversight for chemicals, including nanomaterials. In 2006, the Australian Department of Health and Ageing (2006) issued a voluntary call for information on uses and quantities of nanomaterials imported, manufactured, or used in cosmetics and personal care products under the National Industrial Chemicals Notification and Assessment Scheme. In the same year, the UK Department of Environment, Food and Rural Affairs (2006) launched its Voluntary Reporting Scheme for engineered nanomaterials, and the US Environmental Protection Agency (EPA) planned its Nanoscale Materials Stewardship Program (NMSP), which was implemented 2 years later (EPA 2006). All three programs were calls to industry to voluntarily provide information on the uses, quantities, and features of nanomaterials being manufactured or imported for industrial purposes. The goals of the schemes were to gather information on health, environmental, and safety issues in advance of potential formal and mandatory government regulation.

The experience with these voluntary approaches was only marginally successful. For example, a small fraction of companies responded to calls for voluntary reporting of data on nanomaterials in the United Kingdom and the United States, and the ones who did provided minimal information (Paddock 2009). As a result, voluntary reporting has come to be viewed as only a temporary measure (Paddock 2009). In fact, the EPA has since taken steps to regulate nanomaterials through formal, mandatory approaches (EPA 2008a, b).

Another activity related to voluntary oversight has been in the area of standards or codes of conduct. In February 2008, the European Commission (2008) produced a "Recommendation on a Code of Conduct for Responsible Nanoscience and Nanotechnologies Research," which was circulated to all Member States. The code asked stakeholders to ensure that nanoscience and nanotechnology research is undertaken in safe, ethical, and effective ways, while supporting sustainable economic, social, and environmental development. Seven main principles were outlined, including precaution, inclusiveness, and accountability. In June 2008, the Royal Society of the UK, in collaboration with the Nanotechnology Knowledge Transfer Network, Insight Investment, and the Nanotechnology Industries Association, released its voluntary Responsible NanoCode (2008) and an accompanying series of examples of good practice. The goal was to "establish a consensus of good practice in the research, production, retail, and disposal of products using nanotechnologies and to provide guidance on what organizations can do to demonstrate responsible governance" (Responsible NanoCode 2008, p. 3). The effectiveness of "nano codes" has yet to be determined. In the past, corporate codes have been criticized as having only a declarative character and failing to provide any framework for public accountability. Corporations' efforts in implementing codes of conduct have been seen as "weak and haphazard, and usually too little or too late" (Sethi 2002, p. 319).

In June 2009 a report was issued by the UK Department of Environment, Food, and Rural Affairs, pursuant to the goal of improving understanding of voluntary behavior of nanotech companies (Groves et al. 2009). The study used a management theory of corporate social responsibility (CSR) as a conceptual framework. The theory is based on the idea of social contract, which "conceptualizes companies as social entities, not just private ones, whose responsibility to comply with certain norms of behavior extends beyond the expectation that it should make profits for its shareholders" (Groves et al. 2009, p. 8). It views a company as having a range of impacts on society through its profit-seeking activities, and, therefore, having certain obligations to contribute to the management of these impacts (Groves et al. 2009).

This UK study was guided by literature review on CSR and utilized a qualitative analysis of CSR-related documentation (e.g., statements, codes, and reports) that companies made available on-line. It also interviewed nanotech companies to determine the extent and depth of their public reporting on CSR practices, as well as to identify drivers, inhibitors, and motivational pressures influencing the practices of companies. One of the key findings of the study was that the scope of individual companies' current CSR activities is *significantly affected* by their *size* and *the degree of commercialization in their sector* (Groves et al. 2009).

One of the limitations of the UK study is that its conclusions are largely based on the analysis of companies' own perceptions of their CSR principles, policies, and outcomes. The problem with such an approach is that it does not allow one to distinguish wishful thinking from actual deeds. The fact that companies have policies and processes to implement them, as well as the fact that they report their CSR activities on-line, does not mean that they are responsible when it comes to deeds.

A theoretical framework that takes into consideration the deeds, when considering self-regulatory behavior of companies, is the theory of corporate social performance (CSP) by Wood (1991). Wood's theory takes an evaluative stance on self-regulatory behavior of companies and incorporates the prior analysis of corporate motives, principles, and behaviors, that is the previously untapped element of outcomes.

Wood argued that to assess a company's CSP the researcher should holistically examine:

> …the degree to which principles of social responsibility motivate actions taken on behalf of the company, the degree to which the firm makes use of socially responsive processes, the existence and nature of policies and programs designed to manage the firm's societal relationships, and the social impacts (i.e., observable outcomes) of the firm's actions, programs, and policies (p. 693–694).

One of the types of outcomes identified by Wood (1991) is programs that companies implement. Companies that adopt corporate social programs strive "to meet particular needs or ends through the investment of resources in some course of action seen by the company as socially desirable" (Wood 1991, p. 709). Conventional examples include the Coca-Cola Company's sponsorship of the Hands-Across-America fund-raiser or a cause-related marketing campaign, or institutionalized features of corporate structure and culture, such as youth apprenticeship programs (Wood 1991). Following Wood's (1991) argument, one of the primary goals of our analysis was to test whether company differences found by Groves et al. (2009) in CSR activities are observed at the level of CSP outcomes.

In this analysis, we treat the EPA's NSMP as an example of a voluntary oversight mechanism and industry participation in it as a programmatic outcome of CSP. First, we quantitatively and qualitatively examine industry participation in the NMSP to explore whether factors such as the size and age of companies influence CSP outcomes. Then, we assess whether participating companies of different ages and sizes also differ in the extent of on-line reporting of generic and nano-specific CSR principles, policies, and performance reports. Figure 1 depicts our conceptual model linking the NSMP to voluntary oversight, CSP, and CSR. Below we discuss our methodology and results and reflect on needs to encourage participation

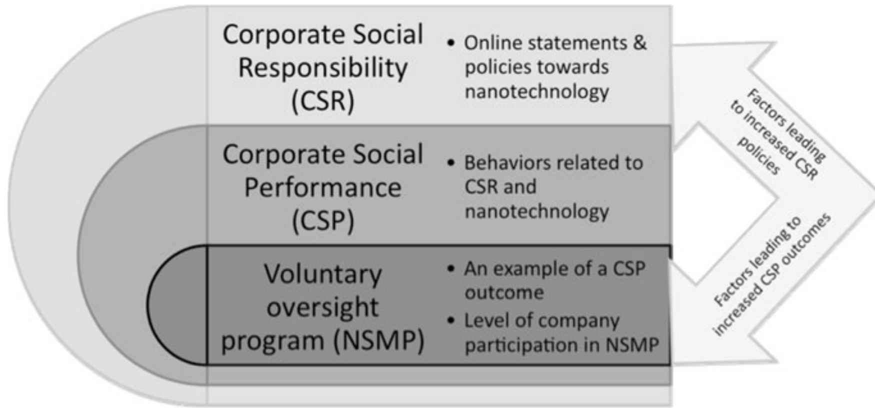


Fig. 1 Conceptual framework for analysis

in voluntary oversight programs like the NSMP. Our work is designed to contribute to a better understanding of factors that affect CSP behavior in nanotechnology companies with the goal of improving these programs in the future.

Methodology

A list of companies that participated in the NSMP was obtained from the website of EPA in June 2009. Internet searches were then conducted to categorize each company according to the following characteristics: (1) company size in terms of the number of employees, (2) company age in terms of the year of foundation, (3) company's scope of operation (local, national, global), (4) nature of company operation, and (5) the role that nanotechnology plays in the company's operation.

Due to the small number of companies participating in the NSMP, our analysis blends qualitative and quantitative approaches. First, companies were sorted into two groups—Type A or Type B—based on the number of employees, the scope of operations, the role of nanotechnology, and the age of the company. Revenue or sales were not used in determination of company size because these numbers could not be obtained for all companies in the list. A company was classified as Type A if it met most of the following characteristics: less than 200 employees, founded after 1950, focused on nanotechnology, and local in scope. A company was classified as Type B if it fit most of the following features: more than 200 employees, founded before 1950, focused on nanotech as only one of the production/research activities, and global in scope. One limitation of the analysis is that the classification of companies is quite broad, in that a company with 250 employees was placed in the same category as one with thousands. Ideally, if more companies would have participated, we could have used more specific categories. Table 1 summarizes how companies included in the analysis were classified.

We then set out to test the hypothesis that newer, smaller companies whose business activity is largely focused on nanotech tend to participate in the EPA NMSP to a lesser degree than larger, older companies with prior experience with CSR or CSP. This hypothesis was suggested by the work of Groves et al. (2009), as discussed in the introduction, and by other studies indicating that smaller companies have trouble navigating and finding the resources to comply with oversight systems (Kuzma et al. 2009; National Research Council (NRC) 2000). The difference in the CSP outcomes of the two types of companies was explored by examining the overall frequency of the program participation, frequency of completed reports being claimed totally as confidential business information (CBI), and the average percentage of information claimed as CBI in non-CBI reports. The average percent of information claimed as CBI in non-CBI reports was further broken down into three classes of information (nature of the material, production and use, and health and safety) and compared for the two types of companies.

Content analysis was implemented for all submitted non-confidential reports (that is, those reports available to the public on the EPA's NSMP website) in the following way. First, a table was compiled with each cell representing a standard item requested to be provided on the form suggested by EPA. Second,

Table 1 Characteristics and lists of Type A and Type B companies which participated in NSMP

	Type A	Type B
Characteristics	Most local, some national	Most global, some national
	1–200 employees	Over 200 employees
	Most founded after 1950s	Most founded before 1950 s
	Most specialize on nanotechnology	Most have nanotechnology as one of the aspects of production or research
Lists	1. Ahwanhee Technology	1. Arkema
	2. Altairnano	2. BASF Corporation
	3. Nano-C	3. Bayer Material Science
	4. Nanofilm	4. Dow Chemical
	5. Nanophase Technologies Corporation	5. Du Pont
	6. Nantero	6. Evonik/Degussa
	7. Pressure Chemical	7. General Electric
	8. Quantum Sphere	8. PPG Industries
	9. Selah Technologies, Inc.	9. Sabic Plastic Innovations
	10. South West Nanotechnologies Inc.	10. Sasol North America
	11. Strem Chemicals	11. Showa Denko KK
	12. Unidym	12. Swan Chemical

each company's report was analyzed to determine whether the company responded to the requested item and whether it claimed information submitted in the item as CBI. Third, the number and percentages of responded and CBI items were calculated for Type A and B companies. The average percentages were calculated in two ways: (1) as a portion of the total number of items responded by companies and (2) as a portion of items (whether responded or not) that were requested by the EPA. Next, all cells in the table were classified into those containing information on material properties, production and use, or safety. For each category of information, numbers and average percentages of responded items and of items claimed as CBI were calculated for Type A and B companies. Table 2 shows the classification and categories of company data and information that were used for content analysis.

In addition to the test of CSP outcomes, we explored whether companies of different ages and sizes also differed in the extent of on-line reporting of generic and nano-specific CSR principles, policies, and performance reports. We analyzed websites of all the Type A and B companies that participated in the NSMP program, looking for statements and evidence of CSR. Categories for this analysis are depicted in Table 4 and include generic statements of CSR principles, nanotechnology, or nanoscience-specific statements of principles, generic CSR policies, nano-specific CSR policies, generic CSR reporting, and nano-specific CSR reporting.

The NMSP participation levels and CSR web-statements of companies, together with the previous analysis of self-reported CSP by Groves et al. (2009), were used to interpret the results, examine our starting hypothesis, and reflect on improving voluntary oversight programs.

Results

Participation in voluntary oversight as CSP outcome

As of the starting date for our analysis (July 1, 2009), overall 31 entities submitted reports to EPA. Only companies were considered for this analysis: three entities were excluded because they were industry associations, and three companies were excluded because they did not provide their names. One company was of non-U.S. origin, and information needed for analysis was not found in English.

Among 24 companies included in the analysis, 12 (50%) were of Type A and 12 (50%) were of Type B.

Table 2 Categories for content analysis of submitted data

Nature of material	Production and use	Safety
Physical and chemical properties sheet	Byproducts IB7	Site identity IIA1a
Chemical class IB1a	Production volume IC1	Type of site IIA1b
Chemical name IB1b	Category of use IC2a(1)	Amount and duration IIA1c
Molecular formula IB1d	Production percent IC2a(4)	Optional pollution prevention info
Weight of polymer IB2a	Percent in formulation IC2a(6)	Physical and chemical properties sheet
Monomer chemical name IB2b(1)	Percent of substance expected per use IC2a(8)	Material safety data sheet
Monomer weight IB2b(3)	Generic use description IC2b	Diagram of operation steps IIA1d(1)
Maximum residual IB2b(6)	Hazard info IC3	Info on products and materials involved IIA1d(2)
Polymer CA name IB2d	State of manufacture IC4a	Points of release IIA1d(3)
Chemical structure diagram IB2e	First date of manufacture IC4b	Worker activity IIAB2(1)
Impurity name IB3a	State of commercial availability IC5a	Rationale for protective equipment IIAB2(2)
Impurity weight IB3b	First date of commercial availability IC5b	Cleaning, reuse and disposal of protective equipment IIAB2(3)
Synomyms for new chemicals IB4	Nanoscale properties IC6	Exposure monitoring data IIAB2(4)
Trade identification IB5	Explanation for nanoscaling IC7	Training IID1
Generic name IB6		Exposed individuals IID2
		Other mitigating equipment and procedures IID3
		Labeling and customer training IID4
		Other risk management IID5
		Description of activities IIA2(1)
		Protective equipment IIA2(3)
		Physical forms IIA2(5)
		Number of workers exposed IIa2(8)
		Duration IIA2(11)
		Amount of new substance released IIA3(2)
		Media of release IIA3(4)
		Control technology IIA3(5a, 5b)
		Water release dest IIA3(7)
		Number of workers exposed IIB2(2)
		Duration of exposure IIB2(4)
		Protective equipment IIB2(5)
		Percent in formulation IIB2(7)
		Amount of new substance released IIB2(10)
		Control technology IIB2(12)
		Byproducts IIB2(14)
		Rationale for selecting control technology IIAB3(2)
		Data of purification studies IIAB3(3)
		Lifecycle IIC(1)

Overall, few nanotech companies, relative to the total number of US-based or -operating nanotech companies, participated in the EPA's NSMP, as discussed in the introduction. The number of companies analyzed in this study ($n = 24$) reflects a small subset of over 1,000 nanotech companies in the United States (PEN

Table 3 Number of data submissions in NSMP for Type A versus Type B companies

Results	Type A	Type B
Companies included in the analysis	12	12
Companies which submitted completely CBI reports	9	5
Companies which submitted non-CBI reports	3	7
	Average number for Type A	Average number for Type B
Items provided (includes requested and not requested)	31	42
Provided items claimed as CBI	22	18
Items responded (out of 65 requested)	28	40
Requested items claimed as CBI	21	17
"nature of material" items responded (out of 15 requested)	8	9
"nature of materials" items claimed as CBI	6	2
"production and use" items responded (out of 14 requested)	8	10
"production and use" items claimed as CBI	5	5
"safety" items responded (out of 36 requested)	13	21
"safety" items claimed as CBI	11	9

2009). Thus, the quantitative results on NSMP are suggestive, but not confirmatory, and should be interpreted with caution. The examination of CSR web statements and use of previous theoretical work (Groves et al. 2009) helps to substantiate our analysis.

Out of 24 companies included in the analysis, 10 companies (42%) submitted non-CBI reports. Non-CBI reports included reports in which at least some of the material was not claimed as confidential. CBI reports were completely confidential (that is, not available to the public on EPA's NSMP website). Out of the 10 companies that submitted non-CBI reports, three (30%) were classified as Type A (smaller, younger, more nano-focused companies, Table 1). One of the three companies did not follow the format suggested by EPA and provided very little information, which made it difficult to interpret for our content analysis. As a result, only two reports of Type A companies could be used for the more detailed content analysis of types of data submitted (Table 2). Seven Type B company reports were used for the content analysis.

The results of the analysis showed that, on average, both types of companies responded to slightly more than half of the requested items (60% or 39 out of 65 requested items for Type A and B companies taken together). Type B companies (older, larger, and less nano-focused companies) surpassed Type A companies in the number of responded items: they responded on the average to 61% of the requested items (40 out of 65) versus 43% for Type A companies (28 out of 65) (Table 3; Fig. 2).

On average, 36% (18 items) of the information *supplied* by both types of companies was claimed as confidential. The average percentage was less when calculated as a percent of information *requested* (27% or 17 items).[1] Type A companies tended to treat a larger part of their submissions as confidential than Type B companies (32% compared versus 26% of *requested* information) (Fig. 3). This tendency was also exhibited when the average percentages were calculated as a portion of the total number of items *provided*, in which case the differences between Type A and Type B companies became even more pronounced (Fig. 4). Type B companies claimed about 40% of data items *provided* as CBI, whereas Type A companies claimed about 75% of data items *provided* as CBI.

Content analysis in terms of the types of the requested information showed that, on the average, both types of companies replied to a smaller percentage of safety items as compared to items on nature of materials or production and use (Table 3). Type B companies responded to a greater percentage of items in all three categories (Fig. 2). For example,

[1] Some companies provided more information than was requested by the EPA.

Fig. 2 Percentage of data responses compared to those *requested* from Type A versus Type B companies

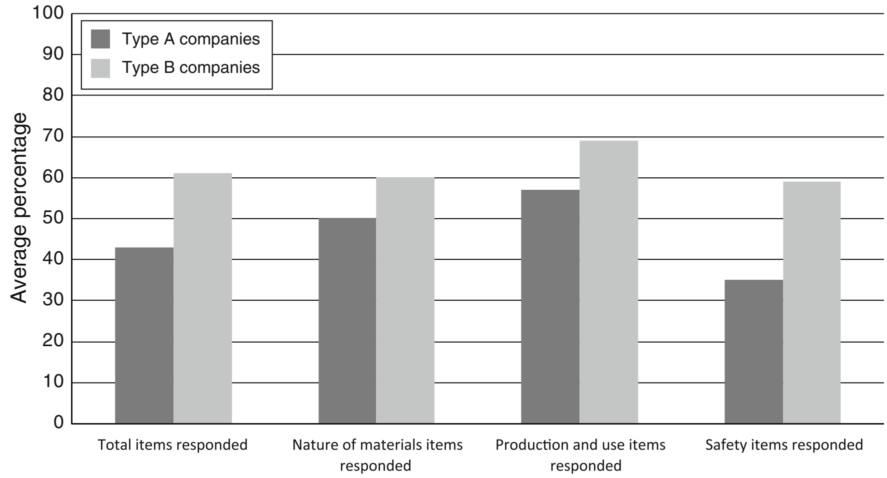
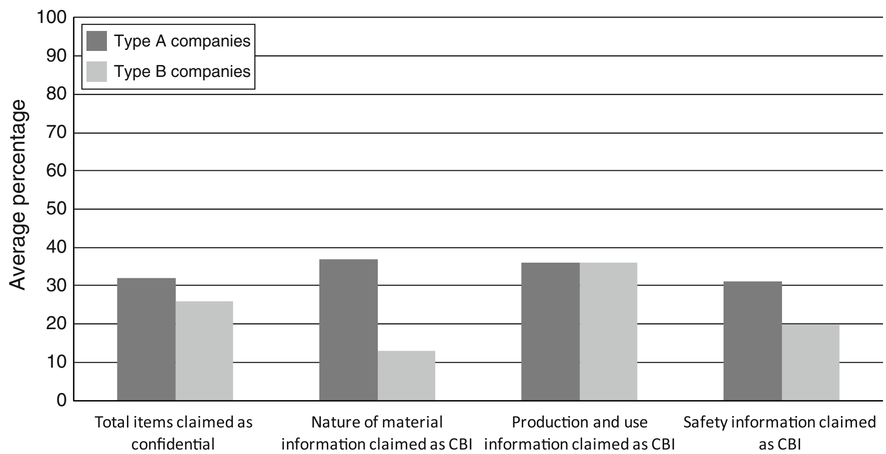


Fig. 3 Percentage of data responses claimed as CBI compared to total number *requested* from Type A versus Type B companies



they responded to 59% of safety items, while Type A companies responded to 35%. Type B companies responded to 60% of nature of materials items, while Type A companies responded to 50%. Finally, Type B companies responded to 69% of production and use items, while Type A companies responded to 57%.

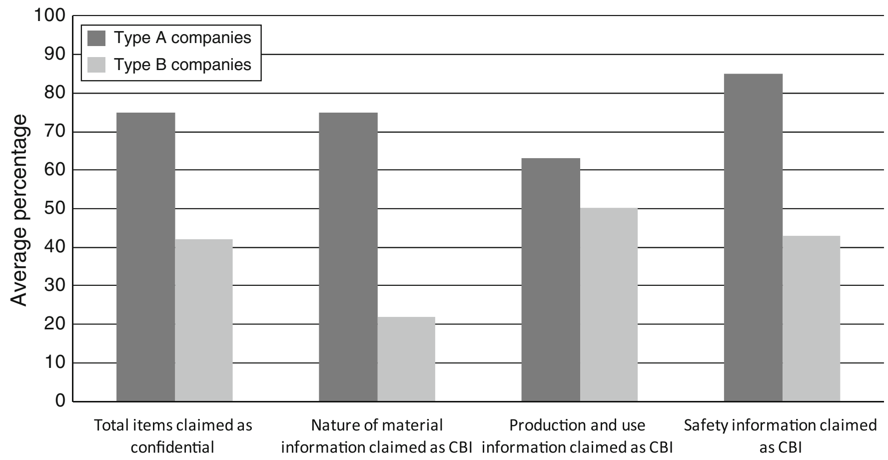
Type A companies claimed as confidential a greater proportion of *requested* information on nature of materials (37%) and safety (31%) than Type B companies (13 and 20%, respectively) (Fig. 3), although for production and use information the percentages were about the same (Fig. 3). Differences between Type A and B companies became greater when information claimed as CBI was compared to the number of data items *provided*: Type A companies claimed 75% of the nature of materials information as CBI and 85% of the safety information as CBI, whereas Type B companies claimed about 20 and 40%, respectively. Table 3, Figs. 3, and 4, taken together, suggest that nature of material and safety information is more sensitive for Type A companies, whereas production and use information is sensitive for both.

On-line reporting of CSR principles, policies, and performance reports

Websites of Type A and B companies that participated in the NSMP were examined for statements of general CSR principles, policies, and performance reports and those specific to nanotechnology. The analyses of company websites are summarized in Table 4. Companies of Type A had a smaller incidence of providing their general and nano-specific statements of CSR principles, policies, and reports on-line.

Only 27% of Type A companies that participated in the program had generic CSR statements of principles, such as codes of conduct, compared with

Fig. 4 Percentage of data responses claimed as CBI compared to total number *provided* from Type A versus Type B companies



100% of Type B companies. According to our observations, the codes of Type A companies were also more basic that the codes of the larger and older Type B companies. Fewer Type A companies (27%) than Type B companies (50%) had nano-specific statements of CSR principles. Even when they did exist for Type A companies, the statements were again more generic. None of the smaller, younger companies provided on-line information about their general CSR policies or reporting (evidence of concern about CSP), while 75% of larger older companies did so. Some Type A companies did provide information about their nano-specific CSR policies and reporting (27 and 36%), which mostly dealt with health, safety, and environmental issues; however, there were more Type B companies that did so (42% and 50%) (Table 4). For Type A companies, the nano-specific CSR reporting was more basic, compared with the more comprehensive reports provided by larger and older companies. Fifty percent of Type B companies provided statements of nano-specific CSP achievements.

Discussion

Participation in EPA's NSMP, and publicly available information through the NSMP, can be considered as indicators of companies' willingness to engage in voluntary oversight and to be transparent about it. These behaviors are important opportunities for nanotechnology companies to demonstrate CSR and CSP outcomes (Lee and Jose 2008). Government agencies are currently struggling with uncertainties in establishing mandatory standards for nanomaterials. At the same time, there is a growing body of information suggesting that nanomaterials pose greater risks than their larger counterparts, due to novel, size-dependent emergent properties such as increased reactivity and penetration in biological systems. Voluntary programs, such as the NSMP, were thought to be promising for gathering data and information, while uncertainties were being addressed. However, we and others have found that participation in voluntary oversight programs is minimal and not transparent. In our study, we found that information on safety was claimed as CBI at a high rate for all companies who participated in the NMSP. In this sense, our findings confirm the EPA's own assessment of the program, which also found that participating companies reported very minimal information pertaining to health and environmental safety and risks, such as information about toxicity of nanomaterials (EPA 2008c).

For the oversight of other emerging technologies, like genetically engineered organisms, transparency has been identified as a key criterion for oversight systems, necessary to engender public trust and confidence and to improve decision-making (NRC 2000; Macoubrie 2006; Kuzma and Besley 2008; Kuzma et al. 2009). For example, a lack of transparency can cause systematic bias in the interpretation of risk information. The foundation of good science rests on peer review and open dialog about results and their reliability and relevance. A continued lack of transparency in voluntary oversight programs for nanotechnology could create future problems for the quality of risk-relevant science and public confidence in nanotechnology products.

Table 4 Summary of results of website analysis

	Generic statement of principles	Nano-specific statement of principles	Generic CSR policies	Nano-specific CSR policies	Generic CSR reporting	Nano-specific CSR reporting
Type A						
Ahwahnee Technology	No info	No info	No info	No info	No info	No info
Altairnano	+	–	–	–	–	–
Nano-C	–	–			–	–
Nanofilm	–	+	–	–	–	+
Nanophase Technologies Corporation	+	+	–	+	–	+
Nantero	–	–	–	–	–	–
Pressure Chemicals	–	–	–	–	–	–
Quantum Sphere	+	+	–	+	–	+
Selah Technologies	–	–	–	–	–	–
South West Nanotechnologies	–	–	–	–	–	–
Strem Chemicals	–	–	–	–	–	–
Unidym	–	+	–	+	–	+
Percent who has:	27	27	0	27	0	36
Type B						
Arkema	+	–	–	+	–	–
BASF Corporation	+	+	+	+	+	+
Bayer Material Science	+	+	+	+	+	+
Dow Chemical	+	–	+	–	+	–
Du Pont	+	+	+	+	+	+
Evonik/Degussa	+	+	+	–	+	+
General Electric	+	+	+	+	+	+
PPG Industries	+	+	–	–	+	+
Sabic Plastic Innovations	+	–	+	–	+	–
Sasol North America	+	–	+	–	–	–
Showa Denko KK	+	–	+	–	+	–
Swan Chemical	+	–	–	–	–	–
Percent who has:	100	50	75	42	75	50

To our knowledge, we are the first to report evidence that smaller, younger nanotech companies are more likely to claim information on nanomaterials as confidential in voluntary oversight programs. Why is this so? Three potential reasons are discussed below: the value of intellectual property, capacity, and pressure.

Smaller, nano-focused companies are likely to have more at stake with intellectual property, which is often the most valuable asset of their enterprise. Smaller companies tend to focus on licensing patents to bigger companies that have more resources to manufacture products. Therefore, there are greater incentives to tightly protect intellectual property and claim CBI until these licenses are agreed to. Smaller and younger companies are also less likely to have strong legal teams to contest violations of intellectual property, so strong, upfront protection becomes even more important to them. These problems suggest the need for programs to help companies protect their intellectual property, while improving transparency, especially for safety information. There are considerable challenges to making this happen, and creative legal and policy approaches will be needed.

Smaller younger companies are less likely to have the capacity for developing CSR policies, programs, or activities. They might lack specific CSR-related expertise or financial resources to develop and support such expertise in-house. Larger and older companies, by contrast, are more likely to have special departments or staff responsible for CSR-related activities, as well as financial resources and prior experience dealing with social issues. Consistent with the findings of Groves et al. (2009), we found that older and larger nanotechnology companies display greater evidence of CSR, such as on-line statements of principles, policies, and practices. These studies, taken together, suggest a need to increase the capacity of smaller, younger, and nano-focused companies for CSR development.

Smaller, younger companies are not likely to experience as much external pressure from various stakeholders to be actively concerned about CSP outcomes. Larger and older companies with more global production may have greater and more widespread impacts on the environment, communities, and employees. Hence, they are perceived as having greater social responsibility and tend to be under more meticulous scrutiny than smaller and younger companies. It is unknown at this time whether public knowledge of the nanotechnology industry will increase, and public attitudes are thought to be still malleable and evolving (Satterfield et al. 2009). As such, a negative event triggered by a smaller company, for example a local environmental release of highly toxic quantum dots near residential areas, could evoke high public concern. In this case, the public is not likely to make a distinction about the company's size and maturity when evaluating its response. Smaller companies might be wise to address CSR and CSP outcomes upfront so that they are poised to prevent or appropriately respond to such an event.

Factors to explain the difference in CSR and CSP outcomes between small and large companies are a question for additional research. Future work should also examine the findings of Groves et al. (2009) suggesting that supply chain position of nanotechnology companies affects CSR reporting and policy. Under the assumption that combinations of multiple factors come into play, including the three factors above, we compiled a list of examples of past, current, and potential initiatives aimed at engaging companies in CSR and CSP activities (Table 5). The examples focus on addressing challenges in the three areas. CSR takes many forms and is expressed in many different ways, varying from firm to firm, and there are a number of different strategies that companies can pursue to realize their CSR and increase their CSP outcomes (Frederick 2008). Cross-sector collaborations or government programs for stimulating CSR behaviors and CSP outcomes dominate the examples in Table 5. The effectiveness of these collaborations and programs should also be the subject of future research.

In summary, this article suggests that nanotechnology companies in general, and smaller and younger nano-focused companies in particular, will need greater motivation, incentives, and assistance to overcome challenges of developing CSR principles

Table 5 Initiatives aimed at CSP and CSR promotion among smaller nanotech companies

Program description	Challenges addressed	Examples
Providing support to corporate associations for development of US or adoption of existing Nano-specific Codes (collaborative effort with a government agency)	Lack of awareness	Responsible NanoCode (UK)
	Lack of capacity	Code of Conduct for Responsible Nanoscience and Nanotechnologies Research (EU)
Promotion of nano CSR, environment management or other risk-related certification among smaller companies via industry associations and encouraging companies up the supply chain to require such certification from smaller companies (collaborative effort with a government agency)	Lack of external pressures	Assured Nano (UK), Nano Exchange INSCX™(global), CENARIOS®(EU)
Promotion of existing environment, risk and CSR management systems and frameworks (collaborative effort between an industry association and government)	Lack of capacity	NanoRisk framework (US), Responsible Care (global), CENARIOS® (EU), NanoSafe (EU), ISO 9001 (global)

Table 5 continued

Program description	Challenges addressed	Examples
Creation of nano-CSR rankings or awards (differentiated by company size) easily available to investors (via stock exchange or else) (collaborative effort between and industry association and a government agency)	Lack of external pressures	Index of Business Sustainability (Brazil), CR Reporting Awards (global, on-line), FTSE4Good Index(UK), DowJones Sustainability Index (US), Global 100
Development a nano-CSP toolkits and dissemination of best practices(collaborative effort between and industry association and a government agency)	Lack of capacity	KoMoRo Kit (EU), Mainstreaming CSR among SMEs guides and toolkits (EU)
Financial support of nano CSR uptake programs in small and medium size companies	Lack of capacity	Mainstreaming CSR among SMEs program (EU)
Establishment and support of multistakehodler forum on nano CSR and involvement of small businesses	Lack of capacity	The European Multistakeholder Forum on CSR (EU)

Future options to explore	
Encouraging companies to engage in nano-CSR reporting and to seek external review of their reports	Lack of external pressures
Encouraging collaboration among smaller companies on testing and risk assessment of nanomaterials and nanoproducts	Lack of capacity
Promotion of voluntary standards among smaller nanotech companies	Lack of capacity
Funding of NGO or consumer groups providing pressure for responsible conducts in nanotechnology	Lack of external pressure
Encouraging CSR cost-sharing among supplying and purchasing companies by subsidizing part of the cost or providing tax breaks	Lack of capacity
Encouraging larger companies to involve nano suppliers in stakeholder dialogs via CSR training, frameworks and toolkits	Lack of awareness Lack of capacity Lack of external pressures
Providing required free CSR training administered by NGOs or universities for management of smaller companies prior to issuing a license to operate	Lack of awareness Lack of capacity Lack of external pressure
Providing government sponsored external experts on CSR for smaller companies (via business incubators, NGOs, universities and etc.)	Lack of awareness Lack of capacity

and participating in voluntary oversight programs as an outcome of CSP and CSR. If voluntary oversight programs are to succeed, they should engage smaller companies that are the primary developers of nanomaterials used in multiple industries and sectors. How to do so effectively is an important question to address, as the CSR and CSP efforts of nanotechnology companies are likely to be essential for not only mitigating the risks of nanotechnology, but also for ensuring public confidence and the success of markets using nanotechnology.

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