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Is There Room at the Bottom for CSR? Corporate Social Responsibility and Nanotechnology in the UK

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ABSTRACT. Nanotechnologies are enabling technologies which rely on the manipulation of matter on the scale of billionths of a metre. It has been argued that scientific uncertainties surrounding nanotechnologies and the inability of regulatory agencies to keep up with industry developments mean that voluntary regulation will play a part in the development of nanotechnologies. The development of technological applications based on nanoscale science is now increasingly seen as a potential test case for new models of regulation based on future-oriented responsibility, lifecycle risk management, and upstream public engagement. This article outlines findings from a project undertaken in 2008–2009 for the UK Government's Department of Environment, Food and Rural Affairs (DEFRA) by BRASS at Cardiff University, involving an in-depth survey both of current corporate social responsibility (CSR) reporting in the UK nanotechnologies industry, and of attitudes to particular stakeholder issues within the industry. The article analyses the results to give an account of the nature of corporate social performance (CSP) within the industry, together with the particular model of CSR operating therein ('do no harm' versus 'positive social force'). It is argued that the nature of emerging technologies requires businesses to adopt particular visions of CSR in order to address stakeholder issues, and that the nanotechnologies industry presents specific obstacles and opportunities in this regard.

KEY WORDS: nanotechnology, CSR, CSP, stakeholder engagement, uncertainty, risk, innovation

Introduction

Corporate social responsibility (CSR), as a commitment on the part of companies to deal with the wider social impacts of their activities, is often argued to have the potential to contribute both to the environmental and social sustainability of business. Where the businesses in question are involved in emerging technologies, the role of such commitments in both anticipating and managing such impacts may be particularly important.

Nanoscale science and technology (NST) is increasingly thought of as providing a host of enabling technologies (Rip, 2006) which may lead to radical and even revolutionary innovations across a host of industrial sectors (from healthcare through electronics to sustainable energy) in the near or further future (see, e.g. Berube, 2006). Much attention has therefore been paid to the potential ethical, legal and social impacts of NST. Comparatively little work has been done, however, on the extent of efforts within the industry to extend efforts in corporate social performance (CSP) to address emerging concerns surrounding the specific characteristics of nanotechnologies. There remain significant knowledge gaps, for example, about the possible negative health and environmental effects of nanomaterials, mainly due to the potential for nano-engineered substances to manifest properties which are not shared by their bulk equivalents (Uskokovic, 2007). Properties such as enhanced reactivity, for which nanomaterials may be prized, may also lead to negative consequences in cases of accidental release and exposure.

The extent to which NST companies are concerned with CSP has not been left entirely unexamined by researchers. There have been a number of surveys on environmental, health and safety (EHS) practices in companies, including some data on life cycle issues such as how often guidance given by manufacturers to customers on how to dispose of nanomaterials waste safely (Australian National Nanotechnology Strategic Taskforce (ANNST), 2005; Conti et al., 2008; Gamo and Kishimoto, 2006). In addition, some research has been done in the EU on the extent of formal practices of risk assessment and management amongst NST companies which occupy various positions in the supply chain (Helland et al., 2008), and the contribution of nanomanufacturing to life cycle risk issues (Meyer et al., 2008). No study has been performed to date, however, which combines an in-depth examination of how far CSR in this emerging sector is communicated, with an equally in-depth exploration of how companies themselves see the role of CSR in their industry. We provide an account of just such a study, undertaken in the UK in 2008–2009.

Conceptual background

CSR may be variously defined in terms of specific obligations or other ethical expectations. In general, though, it represents companies as social entities whose behaviour should legitimately be expected to meet certain wider obligations, rather than as private entities with a sole duty, that of maximising profits for their shareholders. It follows from this understanding that, as a company can have a range of negative and positive impacts on society through its profit-seeking activities, it therefore has certain obligations to contribute to the management of impacts, wherever they levy external costs or harms on others.

Companies, considered as legal entities, are part of civil society alongside various other kinds of organisations and institutions, together with individual citizens. They can thus be thought of as possessing responsibilities that fall into four categories of 'issue': economic, legal, ethical and discretionary (Carroll, 1979). Economic responsibilities include being efficient and profitable, and providing goods which customers need. Legal responsibilities comprise compliance with applicable laws and statutes (including 'issues' such as accounting, environmental protection, employee health and safety, consumer protection and so on), whereas ethical responsibilities imply 'beyond compliance' measures that exceed what is required by statute (e.g. anticipate risks, protect human rights, act sustainably and so on), and discretionary responsibilities imply philanthropic activities, community support and involvement and so on.

The relationships from which these responsibilities derive can be conceptualised in various ways. To a great extent, how this is done will depend on *ontological* assumptions about the constitution of society – whether, for example, one should be a methodological individualist or collectivist about social reality, or assume that societies are based on consensus or conflict (and whether these basic social relations are single or multiple – overarching or overlapping consensus/es and fundamental or distributed antagonisms). Some have noted that these assumptions tend to privilege a reductive and individualistic sociological perspective in which companies are conceptualised as individual actors separate from society, and who need therefore to be somehow reconnected with it (Buchholz and Rosenthal, 2005).

Perhaps the most influential framework for thinking about the relationships between companies and the rest of society is stakeholder theory (Donaldson and Preston, 1995). This aims to understand the concrete *interdependence* of business and society, as opposed to positing a fundamental tension between them (Porter and Kramer, 2006, p. 83). Stakeholder theory proposes that CSR cannot be understood simply in terms of broader social *issues* and the response of business to them, but rather in terms of specific issues that concern the company's *stakeholders*, these being groups and individuals who are either affected by the company's activities or who can, through their own activities, affect the company's activities, often by restricting its 'license to operate'. The differing degrees of interdependence between businesses and other governmental and civil society groups can be conceptualised with the aid of a distinction between primary and secondary stakeholders, i.e. those without whom the company cannot exist and those who are affected by or influence the company's behaviour, but are not positioned in this kind of relationship with the company (Clarkson, 1995, pp. 106–107). Regulators, customers, peer companies, employees, local communities, non-governmental organisations (NGOs), civil society organisations (CSOs) or 'the public' at large can fit into either category, depending on the nature of an individual business' activities.

In addition, there is the question of CSP, or how companies actually *enact* social responsibility. An analysis of responsibilities needs to be coupled to an analysis of responsiveness (Wartick and Cochran, 1985), or the processes by which companies attempt to fulfil their responsibilities and communicate their efforts to stakeholders. Performance may be categorised on the basis of its strategic foundation and what is accomplished. Proactively making CSR part of a company's activities is clearly distinct from taking limited defensive measures in response to a scandal (Porter and Kramer, 2006, p. 84). This can be done using the kind of characterisation given in Table I.

Measuring performance brings its own difficulties, with non-financial performance metrics being an influential way of aligning managerial incentives with longer-term social value but also often being themselves of questionable value and quality (Chatterji and Levine, 2006, pp. 31–33). Further, the importance of reporting must be especially emphasised (e.g. Global Reporting International, 2006). Without an adequate reporting – and auditing – strategy, the legitimacy of any approach to continuous improvement is impossible to establish.

As this management goal is an ideal, one might look to how continuous improvement in pursuing it should be conceptualised. Thinking normatively about how such a process might work, we may assume it is necessary to establish a dynamic and mutually reinforcing relationship between different forms of commitment, which might be divided into three classes.

For example, the *values* expressed in a code of conduct might be linked to specific *policies* presented on a company website or in a shareholder report. Specific quantitative or qualitative indicators can then be translated into performance goals and the company's activities audited by an external agency, with the results being included in an annual report. These reports might then lead to pressure from the board, shareholders or other stakeholders for the company to change its policies and/or higher-level commitments in order to better guide performance improvements.

Aside from a processual understanding of how performance is to be subjected to continuous improvement, the question of what substantive CSR is in play needs to be answered. The ability to make accepting and anticipating responsibilities part of a strategic approach to CSR (Hockerts et al., 2008, p. 8) and thus positively increasing the social value of a company's activities produces a different vision of CSR than simply seeking to mitigate harm (Porter and Kramer, 2006). As the recent EU-funded RESPONSE study of firms' attitudes to CSR has shown, two main CSR orientations can be isolated – on the one hand, towards minimisation of risks both to the business and to the society across the spectrum of a company's activities – 'do no harm' – and, on the other, towards adding positive social value to the company's business activities – the company as 'positive social force' (see Figure 1).

Businesses with proactive CSR engage in managerial practices like environmental assessment and stakeholder management (Wood, 1991) that tend to anticipate and reduce potential sources of business risk, such as potential governmental regulation, labour unrest or environmental damage (Orlitzsky and Benjamin, 2001). On the other hand, where businesses are engaged in innovation, particularly in emerging technologies, there may be scope for the business to enhance social value beyond the provision of useful products, such as contributing more widely to sustainable innovation and development (Carpenter and White, 2004) or by adopting business paradigms like 'socially responsible design' (Davey, 2005).

Once a theoretical framework is in place that encompasses both performance-related and sub-

TABLE I

The reactive–defensive–accommodative–proactive (RDAP) scale [reproduced from Clarkson (1995, p. 109)

Rating	Posture or strategy	Performance
1. *R*eactive	Deny responsibility	Doing less than required
2. *D*efensive	Admit responsibility but fight it	Doing the least that is required
3. *A*ccommodative	Accept responsibility	Doing all that is required
4. *P*roactive	Anticipate responsibility	Doing more than is required

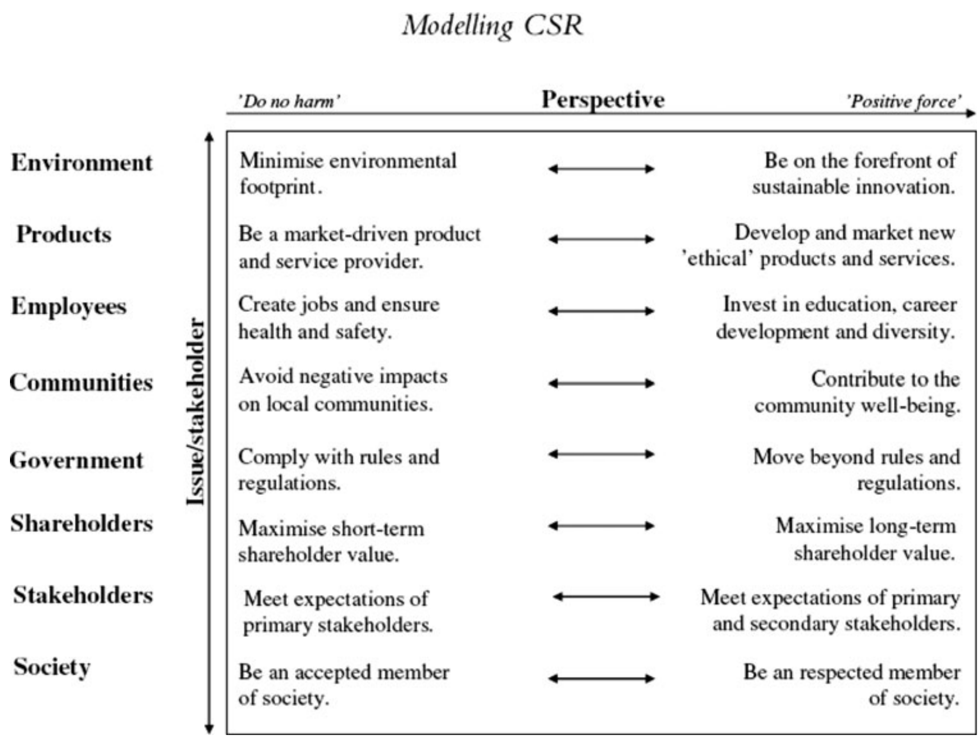

Figure 1. Corporate social responsibilities as a continuum (Pedersen 2010).

stantive goals, it is also necessary to adequately define stakeholder issues specific to the NST industry. This requires an analysis of the economic, legal, social and ethical responsibilities which may be relevant. These responsibilities have to be understood as inextricably connected with the uncertainties which surround the innovatory activities of nanotechnology companies. These uncertainties may be taken as representative of the broader social context in which emerging advanced technologies develop, one in which the majority of citizens of industrialised technological societies are heavily dependent on technological apparatuses of which they have little, if any, detailed knowledge (Alario and Freudenburg, 2003; Hennen, 1999, p. 306; Nordmann, 2005).

The pursuit of innovation in NST is driven by a number of long-standing factors. Some of these derive from processes which have a great deal of historical momentum behind them, such as the desire to continue miniaturising the building blocks of the information technology industry. Others are the result of assessments of the strategic promise of nanotechnology, in which strongly divergent promised futures (as opposed to simple continuations of past trends) play a performative role in forming and consolidating research capacity, institutional support, and financial backing (Brown and Michael, 2003). Tying together these two types of driver is the specific attraction of current NST, based on the discovery of the enhanced and/or novel properties possessed by some materials engineered on the nanoscale, of which carbon nanotubes and quantum dots provide two well-known examples.

However, that these properties cannot, in some cases, necessarily be predicted from what we know of how larger-scale versions of the same materials behave, means that there may be risks associated with the use of the nanoscale versions that are not associated with the macro-scale ones (Ludlow et al., 2007; RS/RAEng, 2004, p. 86). Coupled with this, there is a possibility that some current and emerging widespread uses of nanomaterials (in medical applications, in cosmetics and sunscreens, in antimicrobials added to clothing, cooking utensils and so on) may lead to long-term exposures of workers, consumers and eventually ecosystems to varying doses of free nanomaterials at various points along the product lifecycle (which, when disposal is taken into account, may need to be considered as stretching decades or even further into the future). Further, there are serious ongoing uncertainties surrounding just how far any potential dangerous contaminations might be traceable and measurable (Lösch et al., 2009). The potential role of nanomaterials as additions to a huge range materials or devices means that they may become pervasive in a way that challenges the reach of current regulations, based on threshold measurements and other criteria which may not be applicable to nanomaterials (Frater et al., 2006).

In such conditions, determining just what responsible action consists in has to be undertaken in the shadow of Collingridge's control dilemma (1980). Early on, little knowledge of the wider unintended consequences of new technologies is available. Later, knowledge may become available, but unwanted effects may, in the meantime, have become irreversible. In such conditions, it is often argued that classic command and control concepts of regulation are no longer appropriate, and that top down government has to be supplemented or even replaced by careful, incremental technological development and adaptive management (Lee and Jose, 2008), and a move towards *anticipatory* regulation (Barben et al., 2007; Kearnes and Rip, 2009; Rashba and Gamota, 2003). Where there are significant knowledge gaps about the potential hazards and attendant risks that might accompany the ever-growing range of applications of a technology (Aitken et al., 2010; Seaton et al., 2009), modes of governance begin to shift away from focusing on the anticipation of specific risks that fall under the remit of a given piece of legislation, and move instead towards the governance of innovation processes as such (Felt and Wynne, 2007) and, in some jurisdictions, towards distinguishing reflexive governance regimes from technocratic regimes designed simply to facilitate commercialisation (Kjølberg et al., 2008). Governance becomes conceived of in terms of 'responsible development' (Kearnes and Rip, 2009) or 'responsible innovation' (Owen et al., 2009). In the context of emerging technologies, it is therefore questionable whether assessments of CSR and CSP should limit themselves to criteria such as whether 'innovation brings reduced environmental impacts and/or improved health and safety outcomes', as in the comprehensive study of links between innovation and CSP/CSR carried out by Pavelin and Porter (2008, p. 712).

We can thus note legal responsibilities to comply with regulations applicable in the UK, and across the EU (such as REACh) on health and safety and environmental impacts, and an additional responsibility to maintain compliance with legal statutes, judgements and decrees more generally. But in addition, the new models of governance appear to impress on businesses the ethical requirement to take into account uncertainties and thus instantiate explicitly future-oriented responsibilities (Jonas, 1984), guided by an ethical compass appropriately calibrated to the 'timeprint' of technological innovation (Adam and Groves, 2007). This is evident in recent approaches to make 'codes of conduct' (including, e.g. guiding values and best practice across a range of stakeholder issues) prominent features of voluntary governance, 'thereby organising collective responsibility for the field' (Schomborg and Davies, 2010, p. 8). It is also demonstrated by the growing adoption of broad risk management systems as evidence of good corporate governance (Power, 2004).

So alongside legal responsibilities, another stakeholder issue (important for government, customers, NGOs/CSOs and the public) concerns the ethical injunction that increasingly applies to business to proactively anticipate wider impacts of its activities. The degree to which risk management systems are implemented, how they distribute responsibility within and without the organisation, and on what basis they mandate action (risk–cost–benefit analysis, precautionary models, risk banding, etc.) could therefore be used as a basis for assessment.

Given the significant complex and persistent uncertainties (Groves, 2009), which often surround new technologies, their widespread use opens up further ethical debates around the issue of stakeholder engagement. As scientific expertise is often vulnerable in the face of the complexities which are attendant on the actual use of advanced technologies (Nowotny, 2003, p. 152), whether a given application will be accepted as legitimate or not by stakeholders cannot simply be decided by a scientifically informed judgement about the balance of risks and benefits.

Indeed, recent discussion at UK government level (e.g. House of Lords, 2000) has concurred with social science critiques of the 'deficit model' (Wynne, 1991) of communication about science and technology, in which simply providing state-of-the-art information about risks and benefits is assumed to overcome any resistance in society to a new technology. Recent research on attitudes to nanotechnology has pointed out that the social legitimacy and public acceptance of new technologies often depend on how trusted governance actors are – including public agencies but also private industry and academic researchers. The public are aware that, beyond known risks, there will inevitably be uncertainties which surround the uses to which new technologies are put. Their judgements about whether a given technology is being used in legitimate ways depend, amongst other things, on whether they judge regulatory structures can be trusted to manage any problems which might emerge (Grove-White et al., 2000, p. 29; Macoubrie, 2006, pp. 235–236). Public participation and deliberation, as a form of technology assessment, has therefore been recommended as a means of assessing 'societal concern', alongside the need to anticipate potential health and environmental risks (Renn and Roco, 2006, p. 164). Deliberative engagement exercises in various jurisdictions have exposed several issues of concern, and which may affect the legitimacy of the technology either in the short or longer term:

- 'naturalness' concerns with respect to food uses, where naturalness is taken as an index of expectations that unanticipated risks should be of concern (Federal Institute for Risk Assessment (Germany), 2006).
- 'access' concerns, around equitable distribution of the potential benefits of the technology, especially relating to whether or not the development of applications to specifically benefit the developing world is likely (Gavelin et al., 2007, pp. 33–35, 40; Kearnes et al., 2006, p. 54; cf. Prahalad and Hart, 2002).
- 'trust' concerns, around whether private and public institutions are likely to handle any unanticipated risks in a responsible manner (Grove-White et al., 2000, p. 29; Macoubrie, 2006, pp. 235–236).
- 'transparency' concerns, particularly over whether experts (based within both private and public institutions) are prepared to acknowledge the limits of what is currently (and indeed *can* be) known about potential hazards (Gavelin et al., 2007, p. 29).

The legitimacy of technology is not just based on judgements about the balance of risks and benefits. Advanced technologies are, to some extent, unacknowledged legislators for societies that are dependent upon them (Winner, 1995), and value judgements about the acceptability or otherwise of a given application or even a whole technology can be voiced in terms which are fundamentally about power inequalities, unequal distributions of benefits, and questions of right (Sparrow, 2008). Questions of whether consent to bear uncertainties has been appropriately sought can thus be taken as characterising one characteristically moral dimension of debates about 'consumer issues' such as labelling (Groves, 2008; Shrader-Frechette, 2007). It has thus been argued that anticipatory governance necessarily means that the responsibilities of scientists, policymakers and industry should include organising and participating in engagement early, or upstream (Wilsdon and Willis, 2004), as well as continuing it systematically and iteratively in ways which have real impacts on technology policy and patterns of innovation (Gavelin et al., 2007; Joly and Kaufmann, 2008; Royal Commission on Environmental Pollution, 2008). How business handles public and other stakeholder 'legitimacy' concerns about trust, transparency and consent on the one hand, and about access and social justice on the other, can thus be taken as another relevant stakeholder issue.

Methodology

The conceptual model of CSR and CSP we employed thus included four elements. First, an overall guiding concept of responsibilities as grounded in relationships with stakeholders, leading to the definition of responsibilities in terms of specific stakeholder issues. Second, a characterisation of the *processes* involved in CSP. This is particularly important in relation to NST, given the uncertainties which surround emerging technologies. It assesses the extent to which responsiveness is proactive and extends beyond compliance, rather than being reactive. Third, the need to identify whether proactive responsiveness (where it exists) should be *substantively* classified as guided by a 'do no harm' or 'positive social value' agenda. Fourth and finally, to assess both processual and substantive aspects of CSP for a set of stakeholder issues, or material criteria, appropriate to the NST industry.

Our empirical research, designed primarily as a mapping exercise, was divided into three phases in which these elements were explored.

Phase 1

A literature review of academic, policy, and 'grey' literature relating to CSR and NST was undertaken in order to indentify a set of appropriate material criteria which reflect the stakeholder issues associated with the anticipatory governance of emerging technologies discussed in our 'Conceptual background' section. These criteria are given in Table IV.

Phase 2

The second phase was designed to assess how widespread public documentation of those CSR-related activities identified in Table II was amongst UK nanotechnology companies. This involved collating and subjecting to a quantitative content analysis documents available online during the period October 2008–January 2009 from UK-based companies,[1] all of whom advertise their interest in NST either through membership of industry associations or through their broader research and development (R&D) programmes.

The sample of companies here totalled 78 (see Table V). Researchers examined the websites of these companies for documents which fell into one of three broad classes: published codes of conduct, annual reports, and policy statements. These three types of document were taken to represent, respectively, attempts on the part of companies to codify the types of commitments listed in Table III.[2]

In performing content analysis of these documents, individual sentences were taken as the base unit of analysis, following an increasingly common practice in studies of CSR (Tilt, 2007, p. 196). Two researchers were assigned half the total number of documents each, and recorded, for each document they examined, the incidence of *declarative* statements containing information either about general commitments, specific policies, or quantifiable goals and measures of progress across the six material criteria listed in Table IV. The classification of these statements was further broken down to indicate whether, on the one hand, they

1. applied specifically and explicitly to NST-related activities, or
2. were more general in scope.

and whether, on the other

(a) they applied mainly to the company on whose behalf the statement was made, or
(b) they concerned the supply chain with which the company does business.

Once coded as 'general', 'specific' or 'quantified', frequency statistics for these three categories of statement were used to provide 'profiles' for differ-

TABLE II

A schematic outline of continuous improvement in CSR

1. Ensure compliance with legislation to the *fullest* extent
2. Anticipate and manage impacts *beyond* the level of compliance with existing regulation
3. Ensure that reporting on these activities takes place, preferably supported by external audits

TABLE III

Types of corporate commitment

(a) Commitments to high level values
(b) Concrete policies which express values
(c) Key performance indicators, against which policies are audited and which are then reported

TABLE IV

Material CSR criteria

Environmental impacts	Including statements around specific environmental impacts of current activities, but also definitions and programmes of sustainable development
Health and safety	What practical measures are undertaken to safeguard the safety of workers and the safety of consumers?
Access	Is IP shared with developing countries? To what extent are upstream commitments made to sharing other benefits and promoting development?[a]
Stakeholder engagement	To what extent are a range of internal and external stakeholders included informed about the company's activities and future plans? To what extent do these activities include a consultative element with real impact on a company's activities?
Legal compliance and liability	What declarations are made about compliance with legal statutes and regulatory regimes (including statements about judgements of liability made against the company)
Risk management	Is information provided about general approaches to risk management and responsible innovation within the company (such as LCA, product stewardship, precautionary approaches), and to what degree are these proactive and systematic?[b]

[a]This excludes corporate philanthropy, defined as direct sharing of profits via funding community projects, etc.
[b]This is in addition to specific statements about safeguarding consumers and employees, or the environment – it concerns whether specific *systems* of risk analysis and management are the subject of discussion.

ent categories of company, one corresponding to each of the six material CSR criteria. The aim here was to map the kinds of normative commitment documented by companies, and to indicate where the approach taken by companies to CSR reflect, to some degree, the model of continuous improvement outlined above. Only statements which related directly to the material concerns outlined above were recorded. No account was taken of philanthropic initiatives, or community initiatives which did not relate specifically to stakeholder engagement or access considerations as outlined above.

For Phases 2 and 3, companies were categorised as either:

(a) Micros (typically making use of university-originated IP, with <10 staff);
(b) Small- and medium-sized enterprises (SMEs) (>10 and <250 employees);
(c) Large (over 250 employees but based in one country); or
(d) Multinational corporations (MNCs) (with substantial production, research or distribution operations in more than two countries).

They were further categorised according to their positioning in the supply chain. In employing any content analysis method, an element of subjectivity is inevitable. To minimise subjectivity between coders, intercoder reliability tests were conducted, leading to a second round of coding after which a reliability coefficient of over 80% was attained.

Phase 3

The third phase involved a series of 15 semi-structured interviews with private sector companies to examine attitudes towards and assumptions about CSP activities relevant to the material criteria listed in Table IV. The interview sample, whilst including companies from a broad cross-section of the UK nanotechnologies industry, does not necessarily enable a comprehensive comparison between companies from similar sectors to be made. For example, whilst such comparisons are to some extent possible between companies engaged in producing specialty chemicals, the lower representation of, e.g. the food, cosmetics and pharmaceutical sectors makes comparison difficult. However, given that information from consumer-facing large and MNC companies in the cosmetics and pharmaceutical sectors is widely available online and has been documented under Phase 2, extrapolating from the available interview data to a broader picture of practices in these sectors is arguably justifiable, with caveats.

TABLE V

Companies included in online survey sample

#	Type	Role	Sector	SIC
1.	MNC	Nanomaterials manufacturer	24-Chemical manufacturing	2441
2.	SME	Nanomaterials manufacturer	73-Research and development	7310
3.	Micro	Characterisation services	00-Missing	
4.	MNC	Instrumentation	74-Other (includes testing and analysis)	7420
5.	MNC	Nanomaterials manufacturer	24-Chemical manufacturing	2413
6.	MNC	Nanomaterials manufacturer	24-Chemical manufacturing	2466
7.	SME	Nanoproducts manufacturer	51-Wholesale of chemicals, metals, etc.	5152
8.	Other	Other	74-Other (includes testing and analysis)	7414
9.	Micro	Nanomaterials manufacturer	73-Research and development	7310
10.	SME	Nanoproducts manufacturer	73-Research and development	7310
11.	MNC	Nanoproducts incorporating proprietary materials	22-Printing	2222
12.	Micro	Nanomaterials manufacturer	24-Chemical manufacturing	2414
13.	SME	Nanoproducts manufacturer	36-Manufacturing (other)	3663
14.	SME	Nanoproducts manufacturer	00-Missing	
15.	SME	Nanomaterials manufacturer	74-Other (includes testing and analysis)	7487
16.	Large	Nanoproducts manufacturer	74-Other (includes testing and analysis)	7481
17.	SME	Nanomaterials manufacturer	00-Missing	
18.	MNC	Nanomaterials manufacturer	24-Chemical manufacturing	2413
19.	Large	Nanoproducts distributor	74-Other (includes testing and analysis)	7481
20.	MNC	Nanomaterials manufacturer	14-Mining	1422
21.	Micro	Characterisation services	00-Missing	
22.	Micro	Nanoproducts manufacturer	00-Missing	
23.	Large	Nanomaterials manufacturer	74-Other (includes testing and analysis)	7487
24.	SME	Characterisation services	74-Other (includes testing and analysis)	7430
25.	Large	Nanomaterials manufacturer	73-Research and development	7310
26.	SME	Nanomaterials manufacturer	28-Manufacturing (metal products)	2875
27.	MNC	Nanoproducts manufacturer	24-Chemical manufacturing	2466
28.	Large	Nanomaterials manufacturer	27-Precious metals production	2741
29.	SME	Nanomaterials manufacturer	73-Research and development	7310
30.	MNC	Nanoproducts manufacturer	24-Chemical manufacturing	2452
31.	SME	Nanomaterials manufacturer	93-Services (other)	9305
32.	MNC	Nanomaterials manufacturer	24-Chemical manufacturing	2414
33.	Large	Nanomaterials manufacturer	24-Chemical manufacturing	2430
34.	SME	Instrumentation	29-Manufacturing (spec. purpose machinery/engines)	2956
35.	SME	Nanoproducts manufacturer	73-Research and development	7310
36.	Micro	Nanomaterials manufacturer	29-Manufacturing (spec. purpose machinery/engines)	2951
37.	Micro	Instrumentation	73-Research and development	7310
38.	SME	Nanoproducts manufacturer	51-Wholesale of chemicals, metals, etc.	5155
39.	SME	Instrumentation	33-Manufacturing (precision instruments)	3320
40.	Micro	Instrumentation	73-Research and development	7310
41.	SME	Nanomaterials manufacturer	73-Research and development	7310
42.	Micro	Nanomaterials manufacturer	73-Research and development	7310
43.	SME	Nanomaterials distributor	00-Missing	
44.	SME	Nanoproducts manufacturer	73-Research and development	7310
45.	SME	Instrumentation	85-Medical practice	8512
46.	SME	Nanoproducts manufacturer	73-Research and development	7310

TABLE V

continued

#	Type	Role	Sector	SIC
47.	SME	Nanomaterials distributor	00-Missing	
48.	SME	Nanoproducts manufacturer	73-Research and development	7310
49.	Micro	Nanomaterials manufacturer	73-Research and development	7310
50.	SME	Nanoproducts manufacturer	73-Research and development	7310
51.	Large	Nanomaterials manufacturer	33-Manufacturing (precision instruments)	3320
52.	Large	Nanoproducts incorporating proprietary materials	51-Wholesale of chemicals, metals, etc.	5151
53.	MNC	Nanoproducts manufacturer	51-Wholesale of chemicals, metals, etc.	5190
54.	MNC	Nanoproducts incorporating proprietary materials	00-Missing	
55.	Micro	Nanomaterials manufacturer	24-Chemical manufacturing	2466
56.	Micro	Nanomaterials manufacturer	73-Research and development	7310
57.	Micro	Nanomaterials manufacturer	74-Other (includes testing and analysis)	7487
58.	Large	Nanomaterials manufacturer	73-Research and development	7340
59.	SME	Nanomaterials manufacturer	73-Research and development	7310
60.	MNC	Nanoproducts manufacturer	29-Manufacturing (spec. purpose machinery/engines)	2911
61.	SME	Nanoproducts incorporating proprietary materials	29-Manufacturing (spec. purpose machinery/engines)	2924
62.	Large	Nanomaterials manufacturer	24-Chemical manufacturing	2416
63.	SME	Nanomaterials manufacturer	32-Manufacturing (electron. components)	3210
64.	MNC	Nanomaterials manufacturer	11-Extraction of oil	1110
65.	MNC	Nanoproducts manufacturer	24-Chemical manufacturing	2416
66.	MNC	Nanomaterials manufacturer	51-Wholesale of chemicals, metals, etc.	5155
67.	SME	Nanoproducts manufacturer	33-Manufacturing (precision instruments)	3310
68.	MNC	Nanoproducts manufacturer	24-Chemical manufacturing	2466
69.	Micro	Instrumentation	29-Manufacturing (spec. purpose machinery/engines)	2956
70.	SME	Nanomaterials manufacturer	28-Manufacturing (metal products)	2811
71.	SME	Nanomaterials manufacturer	93-Services (other)	9305
72.	Large	Nanomaterials manufacturer	24-Chemical manufacturing	2466
73.	MNC	Nanoproducts incorporating proprietary materials	24-Chemical manufacturing	2452
74.	MNC	Nanoproducts manufacturer	34-Manufacturing (auto accessories)	3430
75.	SME	Nanomaterials manufacturer	74-Other (includes testing and analysis)	7487
76.	SME	Nanomaterials manufacturer	74-Other (includes testing and analysis)	7487
77.	MNC	Nanoproducts incorporating proprietary materials	51-Wholesale of chemicals, metals, etc.	5146
78.	MNC	Nanoproducts incorporating proprietary materials	52-Dispensing chemists	5231

Fifty companies were initially contacted, with contactees being identified primarily through the foregoing Phase 2 CSR study. Some difficulties were encountered. Thirteen companies (26%) declined to participate, with business confidentiality being widely cited as reason for not participating, along with time and costs for SMEs of participating (several companies have been contacted by a number of researchers involved in other projects, as the industry does not comprise a large number of companies). Four companies (8%) responded by stating that they were not, technically speaking, involved in nanotechnology. Fifteen (30%) companies did not respond despite various attempts to contact them, with a majority of these being companies involved in manufacturing consumer products containing nanomaterials, some of whom had not published accurate contact details on their websites. Nonetheless, the response rate of 30% compares favourably with other recent studies, e.g. Conti et al. (2008), Australian National Nanotechnology Strategic Taskforce (ANNST) (2005), Gamo and Kishimoto (2006).

Whereas a strict quantitative coding frame was used for Phase 2, based on the material criteria listed in Table IV, interview data for Phase 3 were coded and analysed according to complementary analytical foci which reflected the material criteria. Our analysis was guided by the following model (see Figure 2), which draws on the conceptual framework outlined above, and the classification of material criteria provided in Table IV. Our results from this phase rely on the integrity of individuals interviewed.

Results and discussion

Profiling current attitudes towards CSR

Based on Phases 2 and 3 of the research, there are three important headline findings to be noted.

First, there is little evidence of any reporting of CSR activities amongst smaller companies, and comparatively little evidence amongst nearly all companies of a systematic linking of activities in a continuous improvement loop of the kind outlined in Table II. Even MNCs whose CSR documents include all three classes of commitments (see Table III) generally do not have their reporting of performance indicators externally audited.

Second, the processual mode of CSP favoured by companies tends to vary for the different material criteria with which the study was concerned. The increasingly accepted need for NST governance to enter an anticipatory mode may place special responsibilities, and with them, stresses on companies. The need to 'do more than required' (rating P, see Table I) becomes increasingly defining for CSR in relation to emerging technologies. Some companies might achieve a P rating for their activities in workplace safety, but if the understanding of proactive, future-regarding responsibilities set out in the section on 'Conceptual background' is adopted, then many companies may well find accepting responsibility in relation to life cycle risk management or stakeholder engagement very difficult.

When it comes to the substantive goals of CSP (see Figure 1), the vast majority of companies (both in public reporting and as documented by interviews) clearly engage in activities designed to 'do no harm', as opposed to adding positive social value. Most companies who engage in CSR see it as a tool to reduce risks and operational cost; only companies with very high social performance rankings – a subset for the most part of the set of all large and multinational companies – think about CSR as a means to drive product innovation and to contribute to social values beyond those with a financial dimension.

We now elaborate on these findings, beginning with the first (which is addressed with reference to Phase 2 of the research).

Levels and depth of reporting: mapping distinctions

General observations. 86% of micro-companies and 73% of SMEs failed to provide either a code of conduct, policy statement or annual report that addressed one or more areas of material general CSR concern identified in the survey (see Figure 3).

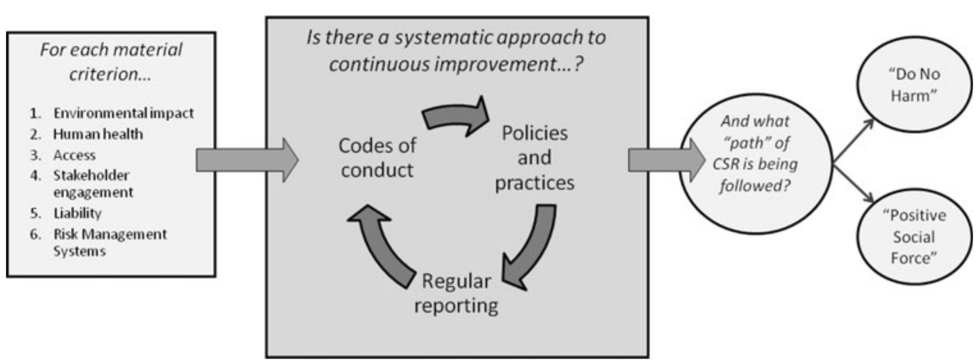

Figure 2. An analytical model of the relationship between material criteria, continuous improvement in CSP and forms of CSR.

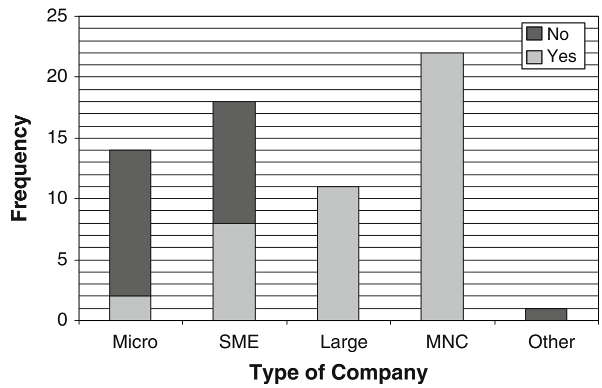

Figure 3. CSR statements available online by company type.

If we consider the reporting profile of the sample by sector (based on SIC 2003 division), then it is apparent that the lowest level of reporting was amongst companies engaged primarily in R&D, including research on nanomaterials and nanostructures. This sector sees a heavy representation of micro-companies, and is predominantly business-to-business (B2B) in nature (see Figure 4).

Further, micro-companies and SMEs who do make submissions about their CSP do not tend to refer to external reporting standards or codes of conduct in order to indicate what criteria are being used for benchmarking their practices, except for the (auditable) general management quality standard ISO 9001. By contrast, submissions by MNCs regularly refer to external standards, although these tended to be references to the environmental management accreditation ISO 14000 as opposed to auditable CSP standards which cover a wider range of material criteria (see Figure 5). There is some evidence of external auditing amongst MNCs, but the number involved remains relatively low (six out of 22 companies, 27%).

It should be remembered at this point that these figures on reporting are based on statements related to a company's CSP *in general*, that is, which do not mention NST. Many of the MNCs in the sample maintain an interest in NST as part of a portfolio of technology-related investments. If we turn to NST-specific reporting, then we find that only 12%

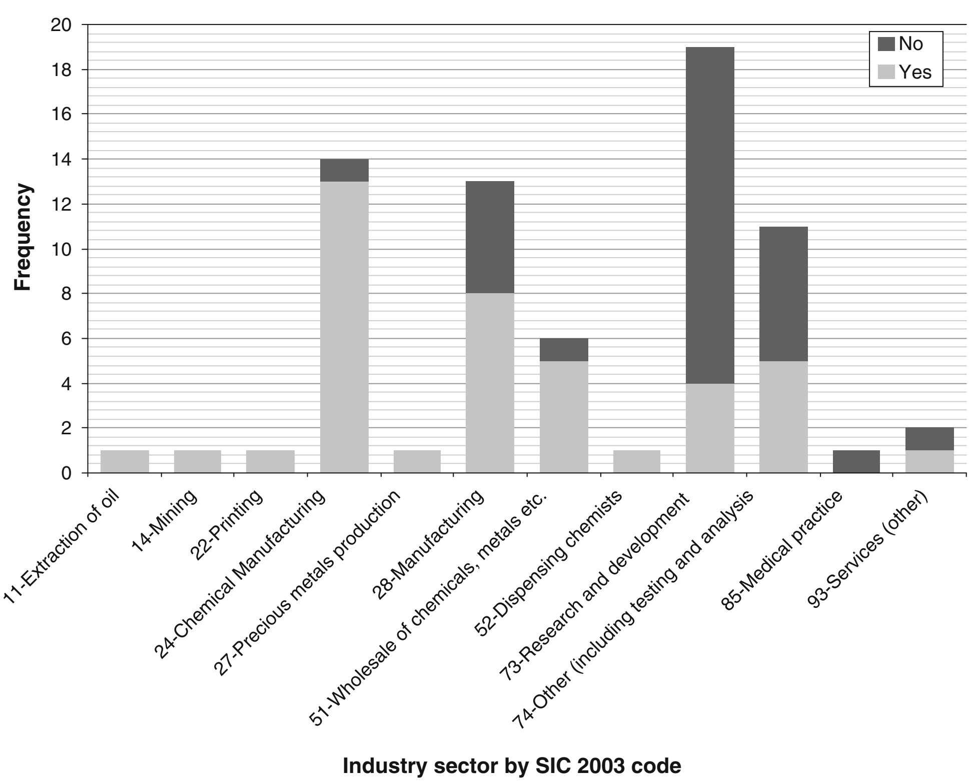

Figure 4. Provision of CSR documents by industry sector (n = 71).

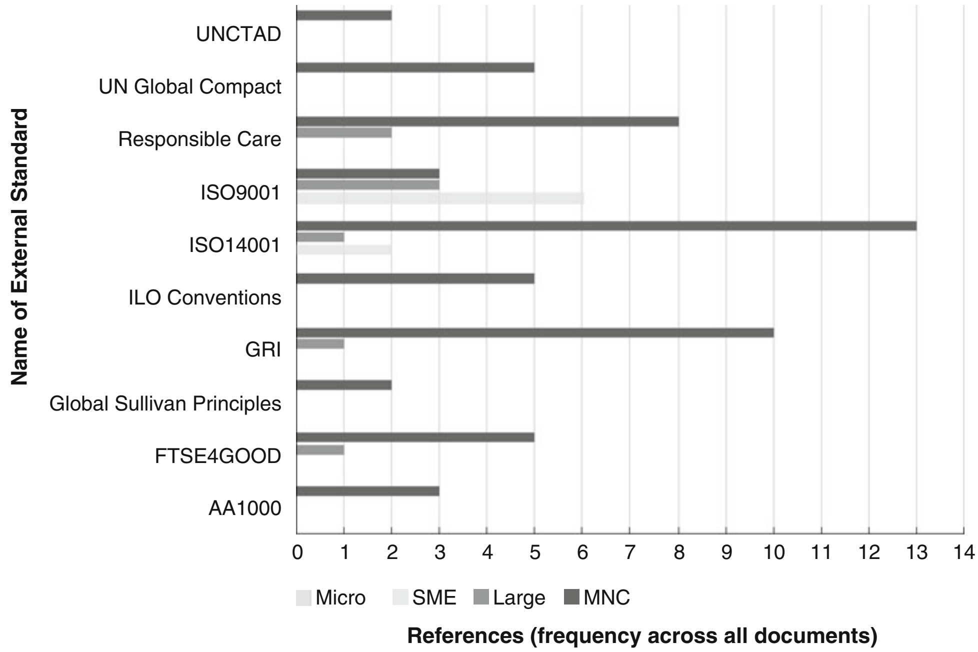

Figure 5. Use of external standards in reporting by company type (includes all documents, n = 68).

(eight out of 68 submissions across 43 submitting companies) of documents make any explicit reference to a company's nanotechnology activities. None of these documents featured any explicit and detailed discussion of nanotech-related activities in relation to any of the material CSR criteria on which the survey focused.

We now examine some reporting profiles across different classes of company for the material CSR criteria listed in Table IV.

Health and safety/environmental impacts

Both these criteria were perhaps the most frequently reported upon amongst the companies who provided CSR documentation, across all varieties of reporting statement – general, specific and quantitative. For environmental impact, large companies and MNCs exhibited consistently higher levels of reporting, with MNCs demonstrating a significantly higher level of reporting on quantitative performance targets in relation to environmental impact. It is interesting that spin-outs performed better than large companies with respect to workplace health and safety reporting, however, although once again, there was no evidence of quantitative performance target setting amongst either SMEs or spin-outs for either criterion (Figures 6, 7).

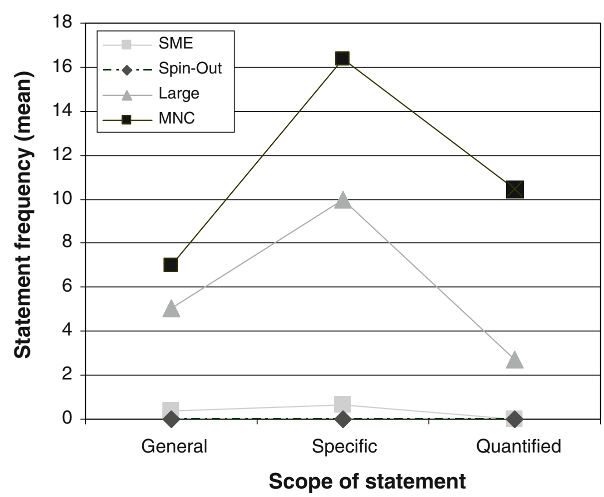

Figure 6. Environmental impact profile by company type (n = 68).

Access

As noted above in our Conceptual background section, access – who gets to benefit from new technologies and how – is a persistent public concern registered through opinion surveys and public engagement exercises. Responses to concerns about access may include measures like IP sharing, technology transfer and so on. Given that such concerns are more likely to be present and relevant to com-

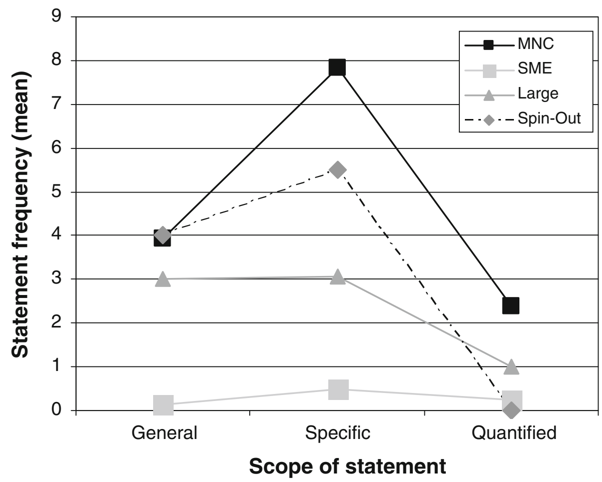

Figure 7. Health and safety profile by company type (n = 68).

panies with global reach, it is perhaps not surprising that a significant gap was evident between the level of reporting achieved by MNCs and that of smaller organisations. As our sample contained multinational pharmaceutical companies, it also was not surprising that some reporting on detailed policies was evident, as a number of these companies have relevant policies that have been developed against a backdrop of pressure from stakeholders, particularly on the pricing of drug treatments in the developing world and generic medicines. At the same time, however, there was some evidence of policies being developed by larger companies on broader intellectual property-sharing agreements (Figure 8).

Stakeholder engagement

There was little evidence of proactive and regular processes of broad stakeholder engagement being generally entered into by companies involved in NST activities, with a few exceptions. Larger companies may have policies on dialogue with regulators and peer companies. Companies which engage in broader dialogue are, again, typically multinational pharmaceutical companies who engage regularly with, for example, patient groups in order to understand side effects of drug treatments. There are no specific instances of reporting which concern regular and ongoing *upstream* and/or systematic and ongoing engagement activities linked specifically to emerging technologies.

As with Access, there is a significant divide between smaller and larger companies on stakeholder engagement. This is particularly the case in relation to reporting on specific measures, as is apparent from Figure 9. However, there is much less of a divide when it comes to producing indicators and measuring performance on engagement activities. This may indicate, as for other criteria in which we were interested, that mechanisms for continuous improvement – such as systematic implementation of engagement, including regular contact, feedback and assessment processes – are generally lacking.

Legal compliance

Here again, the level of reporting was once again related to the size of company, with the one variation – as with health and safety reporting – being

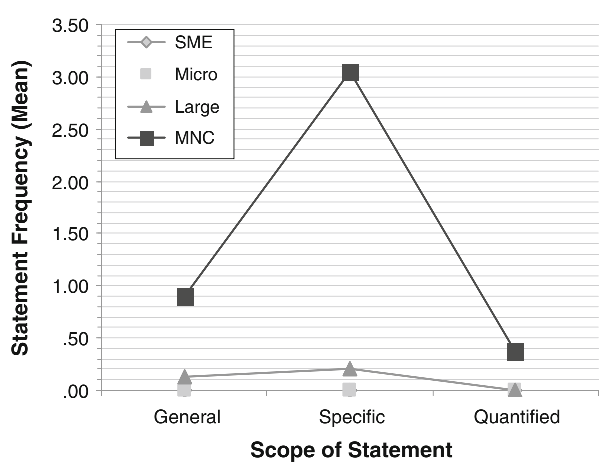

Figure 8. Access/IP profile by company type (n = 68).

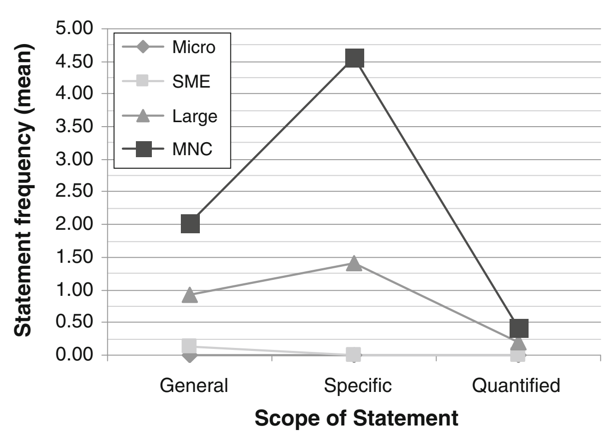

Figure 9. Stakeholder engagement profile by company type (n = 68).

that micro-companies typically outperformed SMEs by a small margin (Figure 10). The lack of quantitative reporting here can perhaps be explained by the 'all or nothing' nature of commitments to legal compliance.

Risk management

Here we are concerned with how far a company has reported on putting in place systematic approaches to risk anticipation, assessment and management – where these risks may arise in relation to the impacts from the business' activities either on stakeholder such as employees, consumers, or product users, or on the environment. An example of such a systematic approach might include a life cycle impact assessment for a chemical, in which assessment and management procedures feed back into R&D and production processes, or a 'product stewardship' based approach. This criterion is particularly important if we are to assess how far voluntary initiatives have gone in moving industry towards an anticipatory understanding of risk governance (implying a P rating for performance in this category as per Table I). Other researchers have noted a low uptake of anticipatory and systematic approaches to risk management amongst smaller companies (Gunningham et al., 2005). This is reflected in our findings from Phase 2, which show that there is no specific or quantified reporting by the smallest companies in our survey on risk management, and almost none at all amongst SMEs (Figure 11). Further, the evidence we collected shows very large differences between the number of

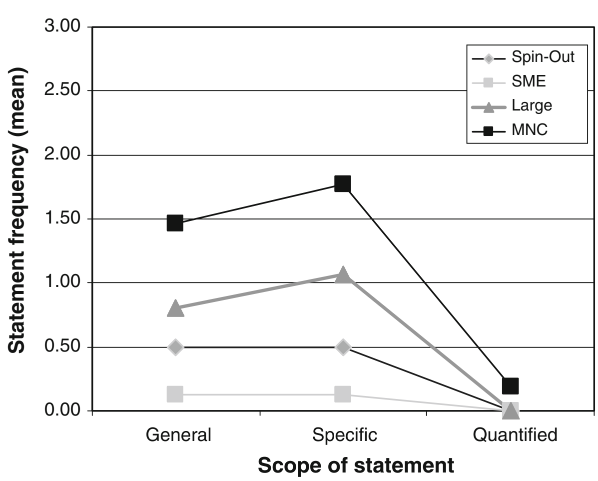

Figure 10. Legal compliance and liability profile by company type (n = 68).

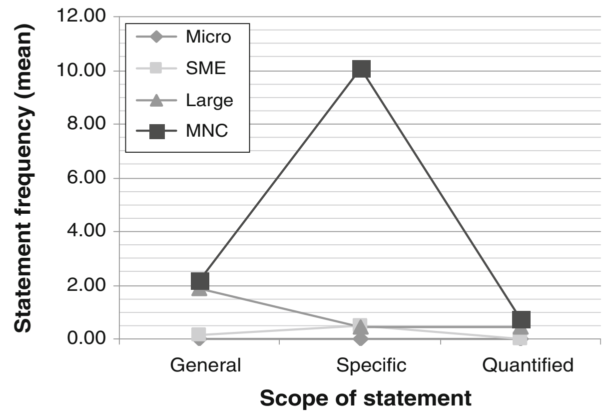

Figure 11. Risk management profile by company type (n = 68).

statements made by multinational organisations and the number made by even large companies on specific risk management measures. There are, however, relatively few quantitative statements provided even by multinationals, which suggest that the setting of and reporting on performance targets regarding risk management is an area of CSR which is comparatively difficult to pursue.

Analysis: understanding drivers and inhibitors for reporting

From this analysis, a central driver behind CSP reporting appears to be company size, with another important factor being the position of a company in the supply chain, and/or its role, as shown in Figures 3 and 4. Research has indicated that companies tend to view CSP and CSR as separate from 'core' economic functions and interests (Adams, 2002). As ancillary concerns, they are therefore understood as requiring both significant amounts of resources and a capacity to manage competitive pressures which, it is often argued, has tended to make them the province of larger and multinational companies. Reporting and performance auditing are aspects of CSP which are understood to require substantial investment. Further, it has been noted in the literature that the short-term economic perspective which smaller companies typically take in assessing what is in their 'core' interests also militates against them taking into account longer-term considerations such as are involved in pursuing CSR objectives (Gunningham, 1995, pp. 65–67).

When it comes to the role and/or position of companies in the supply chain, it is evident that B2B companies, e.g. those who manufacture speciality chemicals or engage primarily in industrial R&D, are less likely to report on their CSP (see Figure 4). Direct interaction with consumers means a more obvious public profile, and so impression management and public relations inevitably become more important and are more likely to be seen as part of the core business. However, much of the R&D work central to short-, medium- and longer-term NST development is being done by smaller companies. Although they may not feel the need to sensitise their antennae to detect signs of their wider impact on society and environment in the present, they may play a crucial role in shaping near and further-future NST applications. As a result, their role in anticipating and communicating about future developments, potential risks – and possible obstacles to constructing regulatory frameworks which would be adequate to deal with these risks – may therefore be expected to be significant. Whether there is any readiness 'behind the scenes' in smaller companies to extend their CSR profiles is something we address in the next section looking at Phase 3 of the research.

With respect to the low frequency of external auditing, it is evident that accreditation via international standards such as those provided by ISO is relatively well-represented amongst MNCs, larger companies and SMEs, with ISO 9001 accreditation being particularly popular amongst SMEs and ISO 14000 amongst multinationals. The need, given increasing NGO and public scrutiny, for MNCs to manage environmental impact across a range of installations in different countries probably accounts for the value placed on ISO 14000, whilst the need for SMEs to represent themselves as meeting management quality standards to customers in the supply chain may lend significant competitive advantage. More comprehensive CSR auditing, such as is available under the Global Reporting International (GRI) and AccountAbility (AA1000) standards was less evident, however, even amongst the largest companies. Where it was undertaken, it occurred most often in relation to GRI, with five out of 11 companies (of which ten were MNCs, one large) being audited to some degree, although none was fully audited as recommended under the GRI guidelines.

One company was audited against the AA1000 standard, which covers stakeholder relationship management (AccountAbility, 2005). If CSR activities tend to be viewed as ancillary, then this tends to be even truer of external stakeholder engagement. Again, it was evident that multinational companies (see Figure 9) were most able to allocate resources to engagement activities. It is also interesting that definitions of engagement by these companies tended to view it as 'information sharing'. Exceptions, which positioned engagement in a more consultative mode, included pharmaceutical companies such as the aforementioned subject of AA1000 auditing, in which issues like access to medicines in the developing world and drug effectiveness had been made the subject of regular and ongoing engagement with patient groups, NGOs and so on, in response to past negative publicity about company activities. Two examples were recorded, which we now briefly discuss.

The company whose annual report was audited under AA1000 was audited by Bureau Veritas.[3] Another had produced a self-assessed system of stakeholder engagement, which it had prepared in accordance with the AA1000 guidelines. This presented a systematic approach to engagement, covering the mapping of stakeholder groups, identification of material issues, analysing stakeholder perceptions of these issues and planning engagement activities at a variety of scales, beginning with activities undertaken by management at individual facilities.

Neither of these cases contained much evidence of wider engagement at an 'upstream' stage in the innovation process. The former, Bureau Veritas-assessed report noted that the company had held a stakeholder workshop in the USA in 2007 with representatives of retail customers, regulators, environmental interest groups, health interest groups and academia. Here, nanotechnology was one of the emerging issues identified as a priority for environment, health and safety policy. However, whether this was just a one-off and how exactly input could be used to inform policy was not stated in the company's report. Further, the framework for holding such events was not explicitly detailed here, and it was not made clear how engagement processes might feed into or influence research, development and innovation.[4]

Delving deeper: attitudes to CSR

In Phase 3, the interviews we carried out sought to investigate in more depth attitudes to CSP, irrespective of whether or not companies reported activities which related to our six material criteria. Here, information was sought on what approach to CSP and substantive goals are being pursued in relation to different material criteria. We thus turn to consider the second and third of our headline findings (see *Profiling current attitudes towards CSR* above).

The interviews also pursued further particular issues which had come to prominence as a result of Phase 2. Amongst these were: to what extent anticipatory (and precautionary) attitudes to risk could be documented amongst companies of all sizes; where in product lifecycles sensitivity to risk was greatest; assessments of the value of systematic approaches to risk; the temporal reach of risk management processes (including how companies take care of their legacies, such as orphan products, should they be dissolved). Finally, it was also decided to examine attitudes to stakeholder engagement in some depth, in order to understand companies' assessments of the value of these activities, their assumptions about the purposes of engagement, and whether or not they had been involved in such exercises, along with any outcomes. In this way, it was hoped to cover in more depth the normative CSR issues arising from the need for anticipatory NST governance discussed in the section on 'Conceptual background'. A breakdown of the sample for Phase 3 is given in Table VI.

Ten companies involved were SMEs or micros, and five were multinationals. The multinationals interviewed represented a cross-section of different key sectors (food packaging, speciality chemicals, cosmetics and consumer health, pharmaceuticals and consumer health, coatings and composite materials), with NST involvement in most cases (except for the food packaging and cosmetics companies interviewed) being restricted to R&D.

Our sample of smaller companies arguably reflects key sectors amongst the growing number of small players in the industry.

- Providers of specialty chemicals to larger industrial customers, mainly for purposes of industrial R&D (five companies).
- R&D activities in the field of medical diagnostics (two companies).
- Research services to food companies of varying sizes (one company).

TABLE VI

Private sector companies interviewed

Company Identifier	Category	Role	Sector	SIC (2003) code
A	SME	Instrumentation	Process technology	2956
B	MNC	Nanoproducts w. supplied NMs	Pharma/consumer health	5146
C	MNC	Nanoproducts w. supplied NMs	Pharma/consumer health	2452
D	SME	Nanomaterials manufacturer	Coatings and composites	7310
E	SME	Nanomaterials manufacturer	Speciality chemicals	2466
F	SME	Characterisation services	Food	9305
G	SME	Nanoproducts w. supplied NMs	Speciality chemicals	5151
H	MNC	Nanomaterials manufacturer	Speciality chemicals	7430
I	MNC	Nanoproducts w. supplied NMs	Food	2466
J	MNC	Nanoproducts w. supplied NMs	Coatings and composites	2911
K	SME	Nanomaterials manufacturer	Speciality chemicals	7340
L	Micro	Nanomaterials manufacturer	Speciality chemicals	2466
M	SME	Nanomaterials manufacturer	Speciality chemicals	7310
N	Micro	Nanoproducts w. supplied NMs	Medical and diagnostics	7310
O	SME	Nanoproducts w. supplied NMs	Medical and diagnostics	3310

- Coatings and composite materials (one company).
- Manufacture of instrumentation for process technology (one company).

As noted at the beginning of this 'Results' section, the research conducted under Phase 2 and Phase 3 has led us to characterise the prevalent substantive understanding of CSP in the UK NST industry as being one of 'do no harm' (see Figure 1), which accepts responsibilities to stakeholders on the basis of existing demarcations of liability for occupational and consumer health, and for environmental damage. Overarching values embedded within the culture of a company are often understood as being behind a fundamental commitment to the principle of 'do no harm'. For MNCs, a change of CEO was seen as an event which could have an enormous influence. Smaller companies traced the influence of experienced directors or other members of senior management within working practices in the company. This was particularly apparent in relation to the implementation of precautionary measures in the workplace, where attitudes were also buttressed by the natural orientation of 'overcautious' scientists (e.g. Company M).

Policies intended to translate a commitment to not do harm into concrete action were often explicitly proactive, however, going beyond the level of acceptance of existing responsibilities established under the law. Self-interest is often acknowledged as a key factor in developing such anticipatory policies. Companies tended to understand reputation and publicity as necessary components of their 'licence to operate', requiring that they anticipate future shifts in regulation along with potential impacts of their products through use and disposal, in addition to ensuring that their products and practices complied with current regulations. Proactive attitudes to environmental and health implications were seen as bringing key benefits to the industry, by helping to head off the threat of costs being imposed through future legislation, and other business risks:

> […] being ahead of the game and understanding what the issues area in terms of both our customers and our staff, that's far better than being told later. (Company K)

When it comes to anticipatory nano-specific risk management measures, some researchers have found that there is little evidence of a firm relationship between position in the supply chain and whether nano-specific risk assessment issues for nanomaterials and nanomaterial-enabled products, as in Helland et al.'s quantitative study of 40 Swiss and German companies (Helland et al., 2008, p. 645). However, evidence from Phase 3 suggests some reasons why such a relationship might be difficult to establish. The interviews tend to back up evidence from Phase 2 that company size is a major factor in shaping how much attention is paid to CSR issues, particularly where these are explicitly related to longer-term risk management and social acceptance, a finding reflected in other studies (e.g. Burningham et al., 2007). SMEs and micros interviewed tended to affirm that the need to survive in the short term may trump longer term priorities (cf. Baker, 2003): 'one of the real challenges for CSR is specifically for small companies where a long term – a long timeframe is six months' (Company G). Consequently, formal reporting and systematic approaches to risk management may be difficult for smaller companies to pursue (Russo and Perrini, 2010, p. 211). Nonetheless, where specialist expertise (e.g. toxicology) is available to smaller companies, either in-house or through business networking, there are notable instances of anticipatory and life cycle focused risk assessment work being done, even where the focus of the business is B2B (Wakefield et al., 2008). The suggestion is therefore that there is a negative relationship between the smallness of company and attitudes to CSR, but that it can be made more positive should a company have access to specific technical capacities useful in addressing some of the difficult risk management issues well known to the NST industry. This suggests that the reported lack of awareness of CSR amongst many SMEs (Jenkins, 2004) may be ameliorated amongst companies involved with emerging technologies, who are often sensitised to the significance of social and technical uncertainties.

Another way in which adventitious relationships affect attitudes to CSR amongst smaller companies concerns their relationships with larger companies. Small companies engaged in NST R&D are often very sensitive to the need to manage health and environmental impacts, thanks to the influence of their larger partners (often these partners being companies from Japan or South East Asia). Exchanges of staff and expertise between companies in such situations are common, and this can include some communication of values and practices from larger companies with more established and systematic approaches to CSR, along with pressure to conform to particular standards, some of which is aimed at encouraging accreditation under, e.g. ISO14000. The experience of, e.g. Company M, with links to Japan, is typical:

> We basically have a range of material that doesn't use any cadmium and that really is a big deciding factor for Japanese companies to work with us because they just don't like any heavy metal in their products.

We now turn to explore some of the particular issues which Phase 2 had exposed and which we treated in depth in the interviews.

Precaution the order of the day: workplace health and safety

In the workplace, companies of all sizes tended to treat nanomaterials largely in accordance with existing risk management protocols developed in response to existing regulation, although in some companies they are treated according to additional precautionary protocols (smaller companies) and/or with extra in-house toxicology and risk assessment being done (in general, larger companies with some contingent exceptions, as noted in the previous section). Where this additional attention was paid to nanomaterials, it was accompanied in all cases by affirmations that not enough was known about the possibility of novel hazards to treat nanomaterials as substantially equivalent to their bulk forms (cf. Conti et al., 2008, p. 3161). In all cases of companies employing production processes where operators may come into contact with nanomaterials, precautionary occupational health risk protocols, focused on minimisation and monitoring of exposure within the workplace, were cited. Five of the smaller companies we interviewed (and two of the multinationals) attributed their precautionary commitments in part to values and attitudes held by directors or senior management which reflect their experience in larger technology companies or university research centres, which have become embedded within the working practices (the 'DNA', Company K) of the company. Larger companies tend more to describe well-established systems, e.g. 'risk banding', that have evolved across the full range of their operations in response to existing regulations (e.g. Companies B, H).

Existing personal protection equipment (PPE) is generally treated as sufficient for protecting against accidental exposures should other containment measures be compromised. Models of prudent practice, including measures such as 'minimizing chemical exposures, avoiding underestimation of risk, providing adequate ventilation, implementing chemical hygiene programs, and attending to permissible exposure limits' (Conti et al., 2008, p. 3160) tend to be referred to.

Extended risk management: life cycle analysis, foresight and adaptivity

Despite the relatively low levels of reporting on systematic approaches to risk management found in Phase 2, interviews revealed several cases of smaller companies who, despite not reporting on their activities, demonstrated sensitivity to the potential of their business for producing unanticipated hazards iat different stages of product life cycles. Compainies recognised the issue of novelty, with some involved in producing nanomaterials directly and in researching products using nanomaterials claiming that they avoided assuming that such materials are 'substantially equivalent' to their bulk counterparts (Companies E, G, N).[5]

As noted above, examples exist of specific and extensive pre-market human and environmental toxicology being developed by individual companies (cf. Wakefield et al., 2008). Company G described how tests on their product had looked at a number of environmental hazard scenarios (including the effect of their products on the toxicity of other airborne particulates) and had produced risk profiles based on particle size, none of which gave them cause for concern. Some companies (E, K) suggested that existing toxicology protocols tend to be unsuitable for NST purposes, and better ones would encourage more pre-market research.

Although smaller companies tended, in interview, to represent CSR as relatively inaccessible to companies like them due to high costs, they often therefore undertake anticipatory assessments of the risks and uncertainties which surround potential product development options in a way similar to that taken by larger companies. Some companies we interviewed (e.g. B, D, G) distinguished explicitly between:

1. Products with established benefits which are expected to be accepted by consumers or business customers;
2. Products surrounded with known uncertainties which can be dealt with by established precautionary protocols; and
3. Products where persistent and difficult to resolve scientific uncertainties make them unacceptable business risks.

Nonetheless, systematic life cycle analysis (LCA), though increasingly recognised as essential to the effective regulation of NST (e.g. Bauer et al., 2008; Environmental Defense Fund–DuPont Nano Partnership, 2007), presents specific and serious barriers to smaller companies, in terms of both financial cost and lack of research capacity. The early, pre-commercial stage of much work in NST in the UK means that there are a daunting number of knowledge gaps which affect the feasibility of LCA for many products, particularly in relation to data and modelling, even for larger companies. Nonetheless, although they may not typically report on their activities in this regard, our interviews show that approaches to product stewardship are being explored by smaller companies, especially those who have experience of industry codes such as Responsible Care.

For larger, consumer-facing companies, temporally extended risk management is typically seen as essential to the company's business. LCA is seen as extremely important, and bespoke analytical tools are often available for the assessment of products, often developed by industry associations. Nonetheless, even for larger companies, gaps in toxicological data, together with the early stage of product development in many cases, are seen as major – if not insuperable – obstacles for the use of LCA in nanotechnological contexts. LCA was seen as a goal which can only be achieved through data sharing agreements and collaborations between companies which are often competitors: as one cosmetics company (C) noted, 'nobody has been able to put all of the pieces together'.

There is little official guidance available internationally on safe disposal of nanomaterials (Conti et al., 2008, p. 3161). To enable wider uptake of LCA throughout the industry, several companies recommended more collaboration between small companies and larger ones to share appropriate expertise and data, with the Government assisting, either through helping to coordinate research efforts and collaborative arrangements, or, as one company, already extensively engaged in LCA for its products suggested, actually 'put[ting] some seed money into allow companies to start to do some work' (Company G).

With respect to product stewardship as the basis for a temporally extended view of risk management, attitudes were often ambivalent. One multinational saw the only way to deal with this issue as legislation to bring together companies involved in different stages of a product's life cycle (Company I). But for smaller companies, such legislation was thought to present significant cost problems, with a full take-back model being particularly damaging. Traceability (rather than full take-back by originators) was seen as the best model for product stewardship, and one for which some parts of the industry are already prepared (Company E).

Discussions of orphan products and successor liability were marked by little evidence that companies had considered this issue in depth. Some smaller companies dealing with innovations in electronic components or spun out from universities interpreted this issue in relation to IP arrangements (Companies D, N). In the event of the company's dissolution, D saw IP and liabilities returning to the university. N saw them as being on by larger customers who had incorporated N's proprietary technology in their mobile devices, textiles, etc.

In this connection, we should compare the findings of other recent studies on CSR in the nanotechnologies industries in Europe, e.g. 'the majority of the industry representatives in this survey expressed their opinion that no release, or subsequent uptake, was possible throughout the life cycle of their products' (Helland et al., 2008, p. 644). Evidence from our interviews suggests that this view was not shared by company representatives in our sample, with widespread acknowledgement that there are significance lifecycle uncertainties for some materials.

Views of stakeholder engagement: is it good to talk?

The results from Phase 2 which suggest that stakeholder engagement is not seen as a priority in the NST industry were borne out in many ways by the interviews. There was little evidence of awareness of the public concerns about NST which social science research has explored (see our Conceptual background section above). For example, only one pharmaceutical company we interviewed in Phase 3 indicated that public perceptions of inequalities in access to products have influenced how they manage innovation and IP.

Most companies interviewed (ten out of 15, 66%) interpreted stakeholder dialogue as an activity that primarily involves peers, customers, employees and to a lesser extent, regulatory agencies and government. From the interviews, it is evident that business-to-business companies, small and large, tend to view stakeholder engagement as difficult, costly, and as being best undertaken through intermediaries (media, government, industry bodies). Across all sectors represented in the interviews a frequent assumption appears to be that the rapid commercialisation of beneficial products is seen as much more effective than public engagement in producing positive public perceptions. Although companies from different sectors saw general benefits for the NST industry as a whole from public engagement, they conceptualised the role of engagement as essentially being about sharing information on the promised benefits of new products with the public, rather than being about addressing the specific concerns cited above in our section on Conceptual background, amongst which the comparative balance of risk and benefit is typically not a priority.

If a market- and commercialisation-led innovation dynamic is widely accepted amongst companies as the primary mode through which societal concerns get alleviated, or at least neutralised, then there is less incentive for smaller companies in particular to extend their CSR activities beyond risk minimisation in the workplace and compliance with standards in the supply chain. However, there is a growing body of evidence to show that rapid commercialisation is part of the problem when it comes to dealing with issues of social legitimacy, not the solution (e.g. Cobb and Macoubrie, 2004; Kearnes and Wynne, 2007; Kearnes et al., 2006a, b; Macoubrie, 2006).

The problems of relying on product benefits to 'make the case' for NST are perhaps best illustrated by the case of the food sector. Company F made the following point about typical business attitudes towards public engagement on nanofood:

> The problem is that they can't talk about it. If they are doing it they can't talk about it for commercial sensitivity really. They don't want to talk about it to give their competitors an advantage [...] It is very difficult for them to say anything. If they don't say anything then people will think they are doing it anyway, and if they say well, we are not going to involve ourselves in this nanotechnology thing then I don't believe that – with all these benefits of course they are looking at it. So they are on a lose-lose in many ways. (Company F)

Company F indicated that food companies were particularly sensitive to the prospect of negative publicity for nanofoods, in the wake of controversies over GM technology. With food, it is true that studies have indicated that people feel more suspicious of NST applications in this area than in many others (Halliday, 2007). Companies perhaps justifiably feel that engaging too early opens them to negative publicity and loss of commercial advantage. Nonetheless, engaging too late may make it impossible to recover social legitimacy. Public scepticism about how far industry and regulators can be relied upon to be transparent about uncertainties, and to manage them, may fatally undermine the legitimacy of food products. This risk is particularly pronounced, given the complexities involved in any lifecycle approach to studying nanofoods (Chaudhry et al., 2008). Company F's remarks express, in effect, a public engagement version of Collingridge's control dilemma (Collingridge, 1980), one which – based on our interviews – may be taken as indicative of attitudes towards upstream public engagement shared across other sectors too.

Analysis: points of progress and persistent obstacles

Overall, it can be concluded that companies see value in CSR, understood as taking an active stance towards minimising risks both to themselves, and to the society and environment in which they operate. This is CSR interpreted in a relatively limited sense: it includes full compliance with regulations covering occupational health and environmental matters, and data sharing amongst companies working with similar materials, and disclosure of data to regulators where this is viewed as not endangering commercial confidentiality.[6] CSR is therefore understood, for the most part, as a matter of 'doing no harm' (see Figure 1), and is also understood as a matter of possessing specific policies motivated reactively by regulations rather than by the need to anticipate potential impacts.

The interview data demonstrates that, nonetheless, in some areas of concern, some companies see a real connection between different forms of commitment. Precautionary risk management policies and practices in the workplace, extending to some forms of special treatment for nanomaterials, are often connected to high level values, whether or not these are available in codified form. Nonetheless, there are real barriers to extending this awareness of self-governance towards the adoption of a continuous improvement-based understanding of CSR, of the type outlined in Table II. These could be separated out under four headings:

1. Perceptions of CSR as an ancillary dimension of corporate activities.
2. Obstacles arising from lack of scientific/organisational expertise.
3. Obstacles arising from current regulation.
4. Assumptions about public attitudes towards technology.

CSR as ancillary

The separation of CSR from 'core interests' supports judgements that formalised CSR tends to impose damaging costs, in terms of both time and money (cf. Lepoutre and Heene, 2006; Spence et al., 2000). In particular, reporting on CSR is undoubtedly seen by many smaller companies as outside their competence, too expensive, and often having little impact in comparison to more coordinated attempts to promote transparency via government or institutions like the Royal Society: 'how many people read annual reports?' (Company E).

Lack of expertise

Some smaller companies see a need to incorporate more anticipatory and temporally extended forms of governance into their values and practices, but feel that they need more advice and guidance, whether on individual material concerns like stakeholder engagement, systematic risk management, EHS issues, or integrating these issues in a framework which can drive subsequent reporting. There is a perceived lack of coordinated support from government and other institutions, in terms of information, guidance and help to develop the extra capacity needed by SMEs.

A more widespread concern relates to technical – especially toxicological – expertise, and data on the characterisation of nanomaterials and products. Companies are conscious of the need, regularly pointed to by regulators and governments, for more lifecycle analysis and *in vitro* and *in vivo* studies, but see a lack of coordinated efforts on the part of regulatory agencies, industry and academia to remedy this. These persistent gaps have been widely noted, most recently by the ENRHES study (Aitken et al., 2010), whilst a shortfall in toxicological expertise has been noted by both the Royal Commission on Environmental Pollution (RCEP, 2008) and the more recent House of Lords Select Committee report on nanofood (House of Lords, 2010, p. 76). The cost of undertaking studies makes companies dependent on collaborations with other firms, generally MNCs, with whom they have contractual or more adventitious relationships. Without these contacts, many companies may be unable to develop more systematic, anticipatory and temporally extended approaches to risk management.

Regulatory obstacles

With respect to regulation, interviewees reported two problems. Amongst smaller companies, there was a perceived lack of engagement with industry on the part of regulators. Noting that there may be around 4.5 million small companies in the UK economy, one interviewee wondered

> how many of those companies actually have a comprehension or understanding of what the regulations really mean and how they affect their business. There's not enough education done I think on engaging people to actually help them understand what their obligations really are. (Company N)

Recognising that voluntary codes of conduct may well have an increasing role to play in an environment characterised by continuing and persistent uncertainty, other companies of various sizes and from different sectors expressed significant concern about the emergence of diverse codes of conduct or accreditation standards, such as AssuredNano (AssuredNano, 2008) or Responsible Nanocode

(Responsible NanoCode, 2008) in an uncoordinated fashion. It was widely thought that perceived or actual competition amongst these frameworks might slow down the take-up and implementation of best practice in nanomaterials risk assessment and management. A collective action problem might result, with companies waiting to see which of the available standards would become the most widely accepted and respected. It was thought that the industry and public profile of any standard or code would be the key to its success, with the Government helping to give guidance on which forms of voluntary code or standard would be best for different companies or sectors.

Assumptions about public attitudes towards technology

The views interviewees expressed about wider stakeholder engagement, and the reticence that companies in the food sector (and further afield) may feel about communicating with the public in an upstream mode about current and future developments, may be accounted for with respect to certain underlying assumptions. As we have seen, across all sectors represented in the interviews a frequent assumption appeared to be that the rapid commercialisation of high-uptake consumer products would leverage most influence in creating positive public perceptions, irrespective of any trust-building results of stakeholder engagement activities. Whilst they acknowledged that public attitudes may well be characterised by ambivalence and a lack of trust, the view amongst smaller and larger companies tended to be that the success of individual products would open a breach in this 'wall' of ambivalence, making subsequent innovations more acceptable.

This assumption represents a survival of the much-criticised 'deficit' model of public understanding of technology (cf. Burningham et al., 2007), in which the public's negative attitudes are conceptualised as the result of a lack of understanding either of the science behind the technology, or of its promised benefits (Wynne, 1991, pp. 112–113). Research has suggested, however, that the provision of information by itself does not necessarily change attitudes, if they are based on strong value judgements about, e.g. the 'unnaturalness' of a technology (Cormick, 2009, pp. 168–169; Kearnes et al., 2006b, pp. 55–56). Further, as noted previously, public concerns which may affect the social legitimacy of a technology are not typically about a future balance of risks versus benefits. Interviewees on occasion (Companies E, G) used the example of mobile phones as an instance of a technology where persistent uncertainties about possible health effects of use were overcome by perceptions of benefits, and contrasted this example with GM foods, where no consumer benefit was visible. However, the patterns of concern traced in the social science literature referred to above (e.g. Gavelin et al., 2007; Grove-White et al., 2000; Kearnes et al., 2006b; Macoubrie, 2006) can be better accounted for by referring to the differences between the *social constitutions* of different technologies (Grove-White et al., 2000, pp. 30–32), that is, the power relations, values and priorities, and distributions of regulatory obligations that underlie and shape their development. At question is not simply a calculation of 'risk versus benefit', but a complex process of interpretation in which people engage as part of trying to understand issues of transparency, responsibility and power.

Conclusion

Our study has contributed to filling the two gaps identified at the outset in research on CSP/CSR and the nanotechnology industry. These were, first, the lack of scholarship on how CSP/CSR connects to emerging concerns surrounding the specific characteristics of NST applications, and secondly, on how, on the one hand companies in this industry communicate about their CSP, and on the other, how they themselves understand CSR as a component of their strategic orientation. In terms of the various models of risk and uncertainty communication examined by Priest (2009), the assumptions about CSR and CSP which predominate in the sample focus on goals of regulatory compliance and supporting commercialisation, rather than on wider issues regarding the need to seek from stakeholders some form of informed consent to bear risks and uncertainties, or regarding the need to shape innovation in accordance with agreed-upon societal priorities. The range of material CSR concerns which are relevant to NST encompass both how companies carry out their business activities, and for what purposes their activities are undertaken. It is necessary, therefore, to consider the relationships between weaknesses in CSP, and the arguable necessity, in this industry, of taking seriously a 'positive social force' model of CSR. In other words, to address stakeholder concerns, it would not be enough to seek to 'do no harm' by improving responsible management of risk and pursuing transparency: it would be necessary to change the shape of NST innovation in ways which meet with wider approval by demonstrably meeting wider societal goals.

With respect to risk management, an integrated and systematic approach is arguably recognised as necessary by the industry itself, as interviews in Phase 3 indicate. However, promoting this, together with a model of continuous improvement, requires an equally integrated and systematic programme of support, especially for smaller companies. As various commentators have argued, it is necessary to distinguish between the motivations for engaging in CSR which typically characterise larger and smaller firms, as well as between the different strategic approaches they generally adopt (Perrini et al., 2007; Preuss and Perschke, 2010; Russo and Perrini, 2010). Our study confirms that a distinction needs to be made between the consolidated and to some degree formalised approach to CSR often adopted by large companies and the more informal approach often adopted by smaller companies who do not necessarily identify and seek to manage a wide network of stakeholders, but instead attempt to build social capital by networking amongst a range of stakeholders (Russo and Perrini, 2010). Nonetheless, it identifies some areas in which the informal orientation of some SMEs and micros, involved in emerging technologies, towards wider stakeholder issues may form the basis for moving towards greater formalisation.

To assist in helping companies to deal with the regulatory uncertainty which persists around NST, the promotion of an effective code of conduct by government would be a useful step. This is necessary in order to avoid the potential for competition between different codes of conduct in the near future. Government might, for example, set out requirements that any such code should include (both in procedural terms, e.g. being developed by multiple stakeholders, and substantive terms, e.g. to include reporting requirements, regular external auditing, adoption of proactive and systematic models of stakeholder engagement), and promote being benchmarked against the code as a condition which suppliers of goods and services to public organisations should meet. Being benchmarked against any such code would allow access to detailed regulatory information, CSR consultancy expertise, toxicological/risk management expertise, and possibly financial assistance. Industry bodies such as the NanoKTN (Nanotechnology Knowledge Transfer Network) could conceivably play a key role. Although it has been noted that formalised approaches such as codes of conduct may be ineffective in encouraging CSR amongst small companies (e.g. Russo and Perrini, 2010), it is perhaps questionable whether this may always be the case for companies involved in emerging technologies. For example, several companies interviewed in our study saw a positive role for codes of conduct in helping deal with the technical and regulatory uncertainties surrounding NST. There may be a role for sectoral (e.g. food, ICT, medical) codes of conduct, developed through a bottom-up, multi-stakeholder engagement process involving small companies, in bridging the gap between an informal orientation towards social responsibility and a more formalised approach, characterised by shared understandings of best practice that, in turn, inform regulators' approaches to risk governance. As we saw in the previous sections, SMEs and micros involved in NST are often precautionary in orientation, and are also aware of the need to be proactive in helping to define and manage risks. The viability of approaches which seek to use active networking and information-sharing between emerging technology companies to build consortia and working groups that aim at formalising best practice should be further investigated. As well as opening up this avenue for future research, our study has developed a framework for understanding attitudes towards CSP/CSR within the nanotechnology industry which can serve as the basis for designing questionnaires for a larger-scale quantitative study of attitudes within the nanotechnology industry across the different regions where it has developed a significant presence (e.g. EU, USA, Japan and Asia, Latin America). This framework may also be useful in helping design studies which compare attitudes across different emerging technology industries (including, for example, biotechnology and synthetic biology).

As noted earlier in this final section, however, our study also suggests that encouraging proactive and anticipatory attitudes towards risk management *within* companies, even if these take a long-term view, are arguably not enough. The social purposes of innovation remain central to public concerns about the legitimacy of emerging technologies, yet there remain, as we noted above under *Views of stakeholder engagement*, significant negative attitudes within industry towards the kinds of engagement which has been promoted as a means of 'extended peer review' (Funtowicz and Ravetz, 1990; Ravetz, 2004), deliberative technology assessment (Vig and Paschen, 2000), or reflexive innovation (Fogelberg and Sandén, 2008). The possibility that wider stakeholder engagement might help shape NST innovations which address wider social needs has been a major driver behind the development of ForumNano in Germany.[7] Responsible innovation here is taken to mean the 'positive social force' model of CSR, rather than seeking to develop products which may, in the last analysis, not meet essential social needs but which are subjected to, e.g. stringent risk assessments. Without building in ethical and political concerns about equity, social value and social values to CSP efforts, the potential for CSR to contribute to the social sustainability of emerging technologies will remain limited.

Notes

[1] 'UK-based' is defined, for our purposes, as applying to companies with main headquarters within, or with substantial R&D capacity based within, the UK.

[2] This is not to suggest that more than one type of commitment may not be present in a given document: an annual report may contain performance indicators, policy statements, and affirmations of guiding values.

[3] See www.bureauveritas.co.uk.

[4] The lack of clear connection between engagement or participation activities and the formation of policy or planning was highlighted by reviews of the UK Government's programme of public engagement activities in 2005–2007 as a major failing (Council for Science and Technology, 2007; Gavelin et al., 2007; Jones et al., 2006). The general problem of constructing an adequate interface between participation and policy or planning in institutionalised contexts is discussed by MacCallum (2008).

[5] Note, however, that recent developments have demonstrated that how the issue of substantial equivalence is dealt with may vary in different regulatory contexts: whilst some smaller producers have collaborated to register carbon nanotubes under the EU REACH regulation as distinct chemicals, other larger producers have come together to register them as bulk graphite (Milmo 2009).

[6] For a recent example of how NST companies have collaborated to share data, see Milmo's (2009) account of how some small companies within the EU producing carbon nanotubes have set up an SIEF (substance information exchange forum) in order to collate data on nanotubes considered as a novel material under REACH.

[7] See http://www.forumnano.org/.

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