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CSR in the UK Nanotechnology Industry: Attitudes and Prospects

Chris Groves, Robert Lee, Lori Frater
and
Gavin Harper

E·S·R·C ECONOMIC & SOCIAL RESEARCH COUNCIL

CARDIFF UNIVERSITY
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Abstract

This paper aims to provide a clearer understanding of the role which corporate social responsibility (CSR) currently plays in influencing the activities of companies involved in the nanotechnologies industry in the UK, and how CSR may contribute to building the material and social sustainability of the industry as part of a regime of adaptive and anticipatory governance. The paper employs a conceptual framework in which a model of continuous improvement and a classification of "modes" of CSR ("do no harm", "positive social force") are used to evaluate the extent to which nanotechnology companies report on their impact management activities (based on an online survey of 78 companies), and to interpret attitudes towards CSR (drawing on 15 semi-structured interviews with company representatives). It is argued that the general level of CSR reporting is low, although companies themselves often demonstrate awareness of the requirements of a "do no harm" model of CSR. It is suggested that, if CSR is to be positioned as contributing to an adaptive and anticipatory governance framework for nanotechnology in the UK, serious shortcomings and obstacles need to be addressed in order to move closer to the "positive social force" mode of CSR.

Keywords: corporate social responsibility, CSR, nanotechnology, risk, uncertainty, ELSI.

Introduction

It is often noted that emerging technologies can put extreme pressure on regulatory systems, given the difference in speed between technological innovations on the one hand and of regulatory responses on the other. Nanoscale science and technology (hereafter NST) represents one particularly notable example. Concerns about the human health and environmental risks which may be associated with the ever-widening number of uses for nanomaterials has led, over the least decade, to a growing number of research initiatives led by governments across various jurisdictions in conjunction with universities and private industry to assess whether these risks may be real, and if so, how adequate existing regulatory regimes would be in dealing with them.

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 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 (Lõsch et al. 2009). The potential role of nanomaterials as additions to a huge range of 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).

Consequently, governments have been faced with a serious problem: a lack of data and a consequent inability to fully assess whether existing risk assessment methodologies and regulatory systems are fit for purpose. Risk governance has to be shift ground, taking seriously the need to base decisions on judgements about the extent of uncertainty and ignorance in particular areas of concern. As a result, a general trend in the governance of emerging technologies has intensified in the case of NST. If innovation is to be allowed to proceed (and highly-restrictive, top-down legal measures like moratoria avoided) assessment and management of risk will need to, on the one hand, become adaptive and sensitive to "points of no return", and, on the other, shift into an *anticipatory* mode (Barben et al. 2007; Kearnes and Rip 2009; Rashba and Gamota 2003), takings it cue on models of anticipatory innovation from the IT industry (Byrne and Golder 2002).

Further, social science research has pointed out that the social legitimacy and public acceptance of new technologies often depends 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 depends, 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 (FIRA 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. 2006b, p. 54)
- "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)

Given these considerations, the contribution voluntary forms of regulation (such as codes of conduct, standardisation, certification, disclosure, communication with stakeholders etc.) could make to adapting governance for situations of ongoing and widespread uncertainty has therefore been of significant interest. Both the UK and US governments have undertaken voluntary reporting programmes for the NST industry, to gather information on the characterisation and extent of safety testing of materials currently being used in R&D and commercial product development (Environmental Protection Agency 2008; Government 2008). Both these programmes have met with limited levels of success.

Other approaches have also been explored. The UK Department for Environment, Food and Rural Affairs (DEFRA), who since 2005 have been instrumental in helping to oversee many of the regulatory efforts in the UK, undertook to investigate the potential of corporate social responsibility-based governance as a way of building values-based governance, foresight, data-sharing, public engagement and temporally-extended efforts at risk management into research and development practice in private industry and academia. Adoption of CSR practices is held to promote the development of a pro-active cultural shift within organisations towards ethical (as opposed to purely legal) models of responsibility (Carroll 1991). BRASS undertook research for DEFRA to investigate both the current extent of practices that could be

classified as "socially responsible" within the UK nanotechnology industry, and the potential there for further development.[1]

One of the key questions to be answered is how CSR needs to be conceptualised in order to capture what might be meant by "responsible innovation" that is genuinely "socially sustainable", i.e. commands trust and builds common and relied-on expectations about the future among a wide range of stakeholders, thus producing what could perhaps be though of as an inclusive form of what Knorr-Cetina (1999) calls an "epistemic culture". It has been argued that the emergence of *strategic* science within technological societies displaces the old division between basic and applied research (Ziman 2000), and leads to a culture in which science is increasingly held accountable – or at least scrutinised – for the social value of its results (Jotterand 2006). Some have argued that the legitimacy of emerging strategic technologies is connected to how (Groves 2009; Kearnes et al. 2006a; Kearnes and Wynne 2007) those responsible for developing and promoting them address issues of uncertainty – concerning risks certainly, but also deeper questions of what values and norms should be relied on in making decisions about intrinsically uncertain and unknowable futures. The institutions which drive technological innovation, on this view, need to become more reflexive about their assumptions, and not simply in ways which enshrine a reflexive culture firmly *within* an organisation, but by connecting it to wider society via institutions and practices which open it up to scrutiny, criticism and change. "A key condition for rebuilding trust and legitimacy in such institutions is that they must be experienced to be putting their own assumptions into dialogue with others." (Wynne 2006, p. 77) Such a view of responsible innovation sees adaptive management concerned to build governance structures designed to respond quickly to risks as only part of the equation: the extension of systematic "upstream" public engagement (i.e. in advance of commercialisation), moving eventually towards the institutionalisation of *participation in design* as part of a wider ideal of technological citizenship is required (Winner 1995, pp. 80-82). A positive vision of the social value of innovation drives this kind of CSR, as opposed to a desire to simply "minimise risk".

[1] The final report can be downloaded from the DEFRA website at http://randd.defra.gov.uk/Document.aspx?Document=CB0417_8234_FRP.pdf.

Conceptual background and methodology

Key concepts

The conceptual framework which informed the project identified a baseline understanding of CSR, one which conceptualises companies as social entities with a range of obligations, rather than as private entities with a duty to maximise 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. As this management goal is an ideal, one might look to how continuous improvement in pursuing it should be conceptualised. The following three steps might be considered as integral to an ideal type for any such programme.

Table 1: 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.

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.

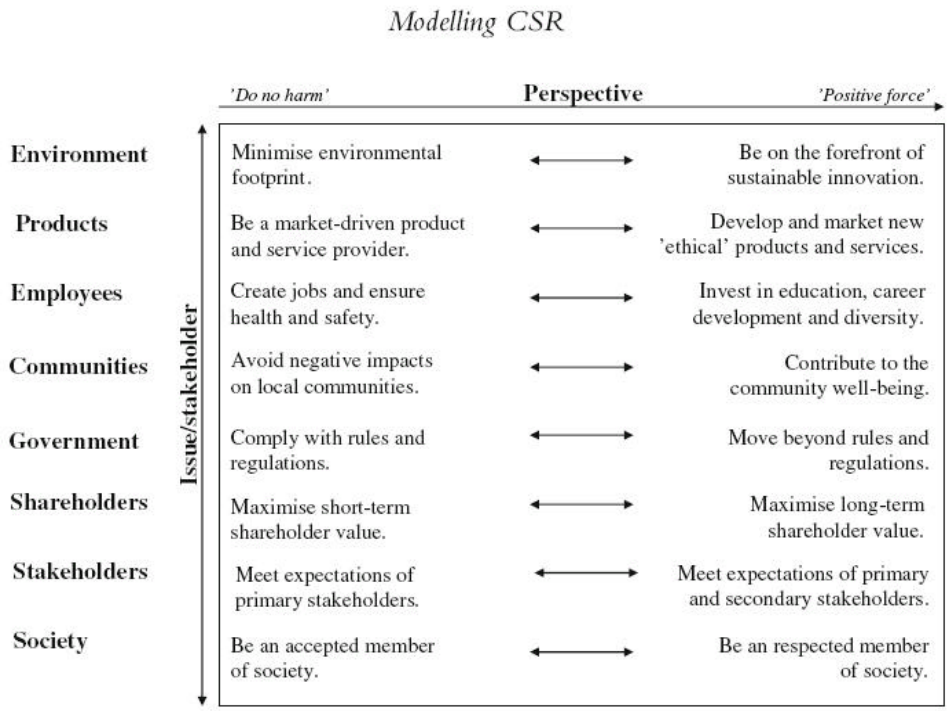
Table 2: Types of corporate commitment

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.

Aside from this processual component, we also need to be clearer about the substantive purpose of CSR, which can itself be conceived of in two contrasting ways, as we intimated at the end of the previous section and as the recent EU-funded RESPONSE study of firms' attitudes to CSR has shown. The research identified two main CSR orientations – on the one hand, towards minimisation of risks both to the business and to 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 below).

Figure 1: Corporate Social Responsibilities as a continuum (Pedersen 2009)



For example, aligning activities 1-3 above has long been viewed as a means of reducing business risk. 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 society 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 et al. 2005).

So, to understand the presence and influence of CSR practices within the UK nanotechnology industry, and attitudes therein towards CSR more generally, it was necessary to understand both substantive understandings of CSR and how far processes for continuously improving CSR performance exist.

Further, the importance of activity 3 above – reporting – must be especially emphasized (e.g. GRI 2006). Without an adequate reporting – and auditing – strategy, the legitimacy of any approach to continuous improvement is impossible to establish. Consequently, it is necessary to reflect this consideration in research design.

Methodology

As a result of these considerations, the research was designed to examine both to what extent the dynamic model of CSR outline above is evident within the UK NST industry, and also to examine where on the CSR continuum depicted in Figure 1 these practices can be located. The empirical research fell into three phases.

Phase 1

A literature review of academic, policy, and 'grey' literature relating to CSR was undertaken in order to indentify a set of material criteria which could be used to assess how far companies' activities could be said to have integrated a range of concerns relevant to NST innovation. These criteria are given below in Table 3.

Table 3: 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 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?[2]
Social acceptance and understanding	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?
Legal compliance and liability	What declarations are made about compliance with legal statutes, 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)?[3]

[2] This excludes corporate philanthropy, defined as direct sharing of profits via funding community projects etc.

Phase 2

The second phase was designed to assess how widespread public documentation of those CSR-related activities identified above in Table 1 was among 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,[4] all of whom advertise their interest in NST either through membership of industry associations or through their broader research and development programmes.

The sample of companies here totalled 78. 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 above in Table 2.[5]

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). Researchers recorded, for each document, the incidence of *declarative* statements containing information either about general commitments, specific policies, or quantifiable goals and measures of progress across the 7 material criteria listed in Table 3 above (for examples see Table 4 below). 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

[3] 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.

[4] "UK-based" is defined, for our purposes, as applying to companies with main headquarters within, or with substantial research and development capacity based within, the UK.

[5] 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.

b) They concerned the supply chain with which the company does business.

Table 4: Examples of declarative CSR statements

Examples of general declarative CSR statements	"We support efforts to improve access to medicines around the world, in both developing and developed countries." (*Access*) "We are committed to reducing our impact on climate change." (*Environmental Impacts*)
Examples of specific declarative CSR statements	"To help us better understand patient needs we have set up advisory boards in the US and Europe with representatives from a wide range of patient groups." (*Social Acceptance and Understanding*)
Examples of quantified declarative CSR statements	"We set new targets to reduce our climate change impact (CO_2 equivalent emissions) and energy use in operations, and transport from 2006 levels by 20 per cent per unit of sales (based on a constant exchange rate) by 2010 and by 45 per cent by 2015." (*Environmental Impacts*)

Once coded as "general", "specific" or "quantified", frequency statistics for these three categories of statement were used to provide "profiles" for different categories of company, one corresponding to each of the 7 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.

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

a) Micros (typically making use of university-originated IP, with <10 staff);
b) SMEs (>10 and <250 employees);
c) Large (over 250 employees but based in one country); or
d) Multinationals/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.

Phase 3

The third phase involved a series of 15 semi-structured interviews with private sector companies to examine attitudes towards and assumptions about CSR activities relevant to the material criteria listed in Table 3 above.[6] 50 companies were initially contacted, with contactees being identified through the foregoing Phase 2 CSR study, through previous research on current products, via personal contacts, and via further online research.[7]

Whereas a strict quantitative coding frame was used for Phase 2, based on the material criteria listed above in Table 3, interview data for Phase 3 was coded and analysed according to different but complementary analytical foci (see Table 5 below), which reflected the general stated aims and objectives of the research.

Table 5: Analytical foci for private sector interviews

1. ROLE OF FORESIGHT/ ANTICIPATORY RISK MANAGEMENT	2. NATURE AND EXTENT OF PRE-MARKET RESEARCH/ISOLATION OF EMPLOYEE RISK FACTORS	3. SOURCES OF INFLUENCE ON COMPANY PRACTICES FROM WITHIN THE INDUSTRY
4. External sources of pressure which influence practices	5. Technical questions about manufacture, use and disposal which influence product development	6. Temporal extent of risk assessment and research and actions resulting from these assessments
7. Extent and nature of	8. Extent to which monitoring	9. Influence of modes of

[6] 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, while 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 make 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.

[7] Some difficulties were encountered. 13 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 recently, 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. 15 (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 did not have accurate contact details on their websites.

stakeholder engagement practices	procedures for products containing nanomaterials differ from those not containing nanomaterials	governance on attitudes to CSR

Research Findings

Profiling Current Attitudes towards CSR

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

First, there is little evidence of any reporting of CSR activities among smaller companies, and comparatively little evidence among nearly all companies of a systematic linking of activities in a continuous improvement loop of the kind outlined above in Table 1. Even MNCs whose CSR documents include all three classes of commitments (see Table 2) generally do not have their reporting of performance indicators externally audited.

Secondly, the mode of CSR (see Figure 1 above) that is most accepted as normatively compelling by companies (both in public reporting and as documented by interviews) is that of "do not harm". 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.

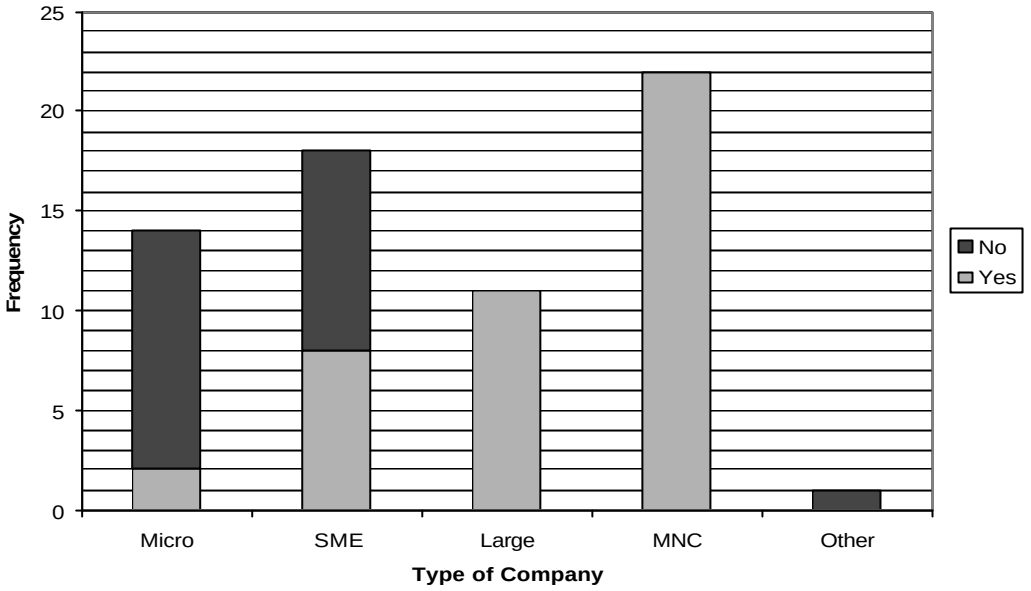
Let us examine the first of these findings, with reference mainly to Phase 2.

Levels and depth of reporting: mapping distinctions

General observations

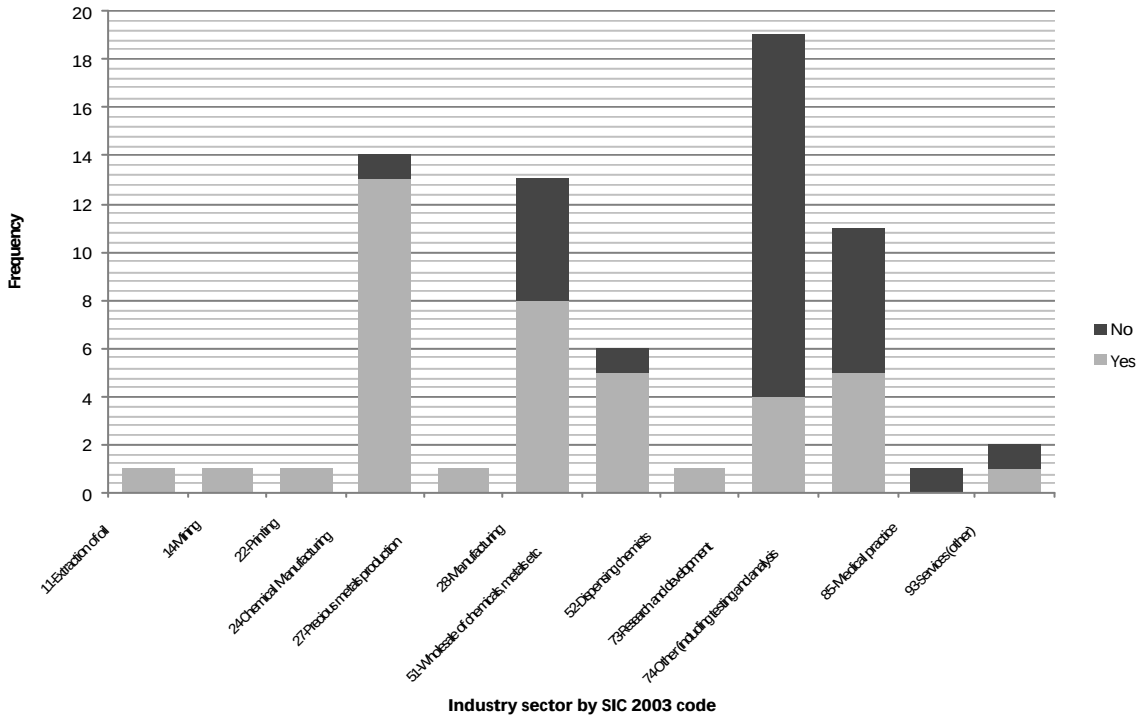
86% of micro-companies and 73% of SMEs failed to provide either a code of conduct, policy statement or annual report that addressed one or more areas of material general CSR concern identified in the survey (see Figure 2 below).

Figure 2: 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 among 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 in nature (see Figure 3 below).

Figure 3: Provision of CSR documents by industry sector (n=71)

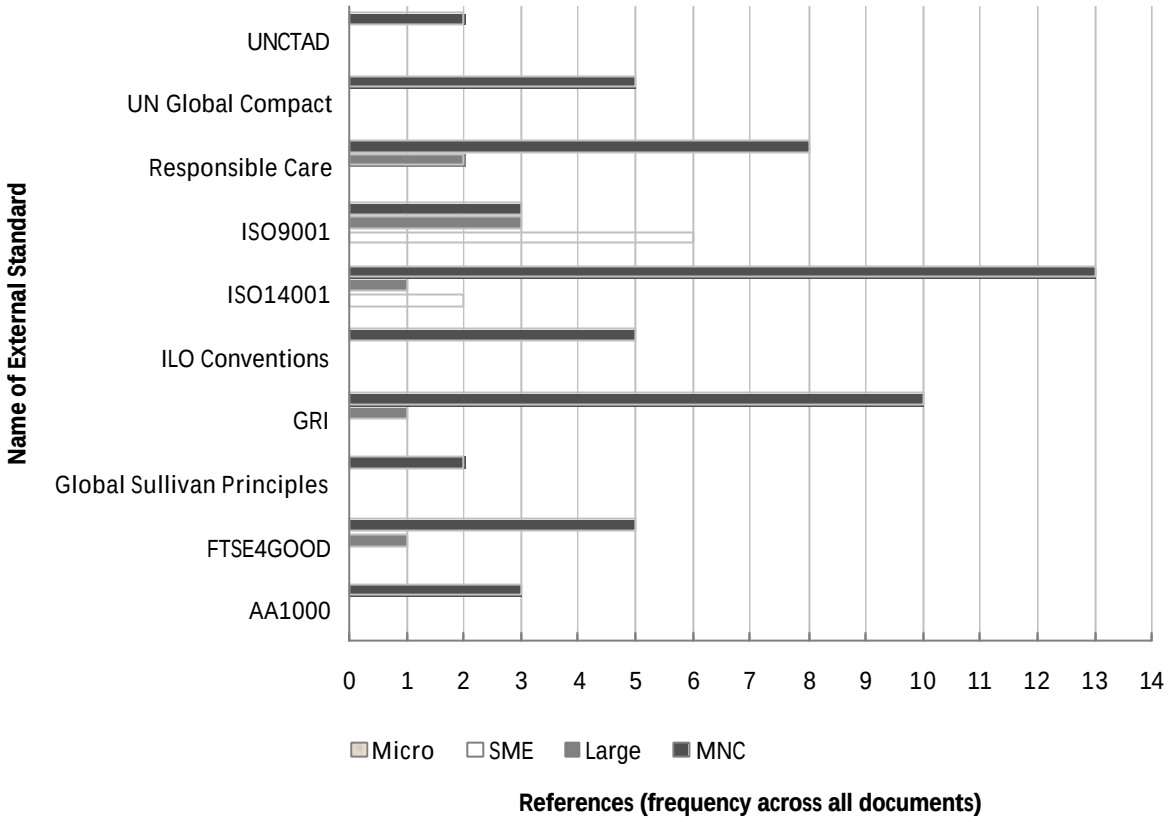


In general, micro-companies and SMEs who make submissions do not tend to refer to external CSR reporting standards or codes of conduct in order to indicate what criteria are being used for benchmarking their practices, except for the (auditable) general management quality standard ISO 9001. By contrast, submissions by MNCs regularly referred to external standards, although these tended to be references to the environmental management accreditation ISO 14000 (13 of the total 68 submissions) as opposed to auditable CSR standards which cover a wider range of material criteria (see Table 6 and Figure 4 below). There is some evidence of external auditing among MNCs, but is still relatively low (6 out of 22 companies, 27%).

Table 6: Use of External Standards in Reporting by Company Type (includes all documents, n=68)

	NAME OF EXTERNAL STANDARD									
Company Type	**AA 1000**	**FTSE4 GOOD**	**Global Sullivan Principles**	**Global Reporting Initiative**	**ILO Conv.**	**ISO 14000**	**ISO 9001**	**Responsible Care**	**UN Global Compact**	**UNCTAD**
Micro	0	0	0	0	0	0	0	0	0	0
SME	0	0	0	0	0	2	6	0	0	0
Large	0	1	0	1	0	1	3	2	0	0
MNC	3	5	2	10	5	13	3	8	5	2
Total	**3**	**6**	**2**	**11**	**5**	**16**	**12**	**10**	**5**	**2**

Figure 4: Use of External Standards in Reporting by Company Type (includes all documents, n=68)



It should be remembered at this point that these figures on reporting are based on statements related to a company's CSR activities *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% (8 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 across 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 above in Table 3.

Health and safety/environmental impacts

Both these criteria were perhaps the most frequently reported upon amongst the companies who provided CSR documentation, across general, specific and

quantitative varieties of reporting scope. For both criteria, MNCs once again exhibited consistently higher levels of reporting, with 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 health and safety reporting, however, although once again, there was no evidence of quantitative performance target setting among either SMEs or spin-outs for either criterion.

Figure 5: Environmental impact profile by company type (n=68)

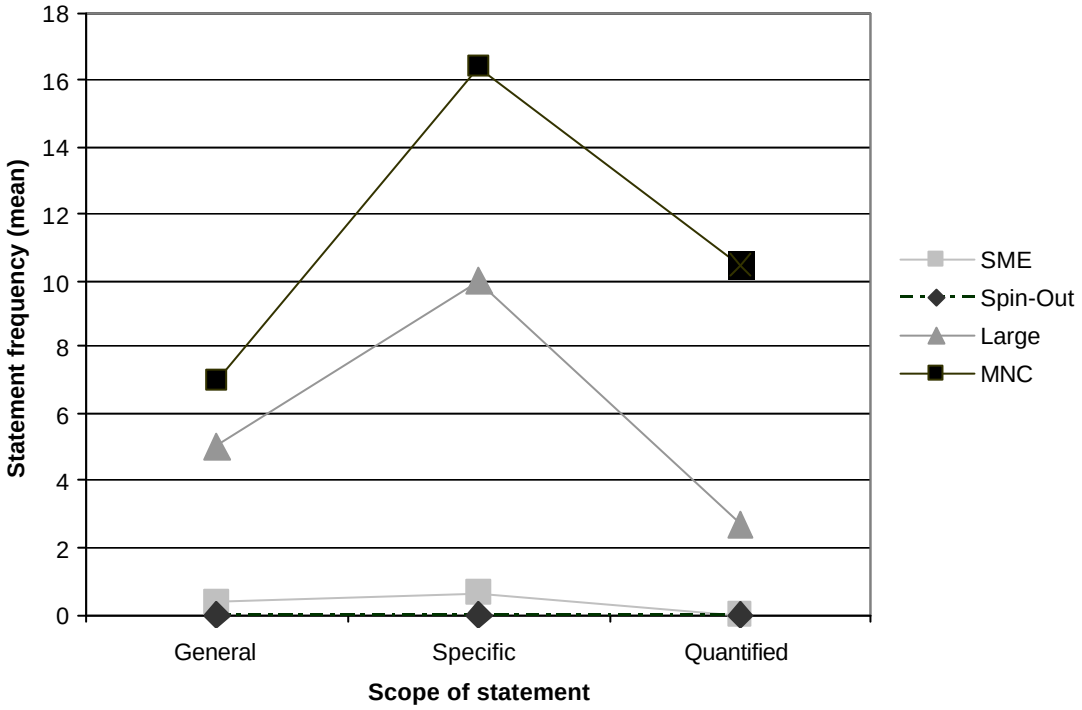
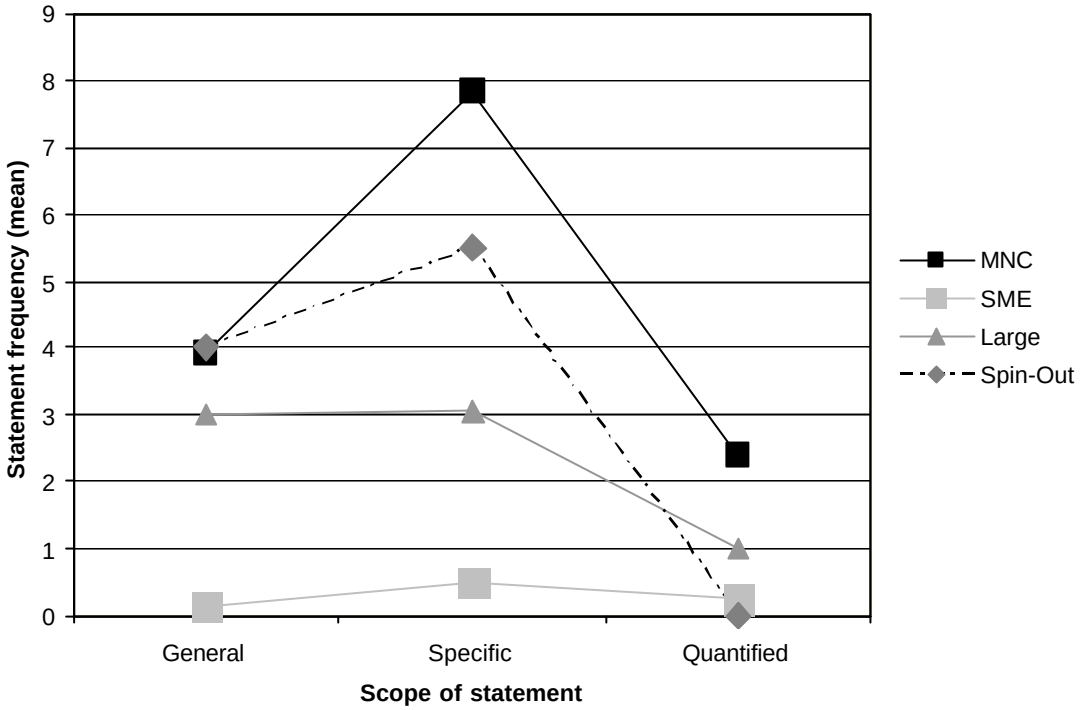


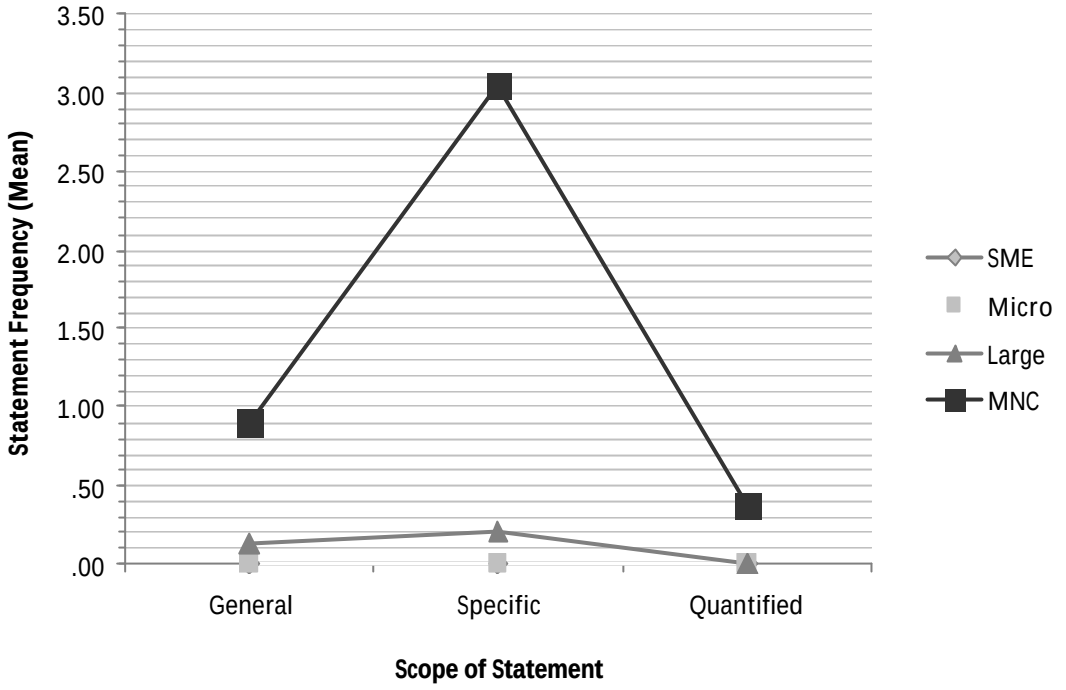
Figure 6: Health and safety profile by company type (n=68)



Access

When it comes to reporting on access (which may include measures like IP sharing, technology transfer, and so on), it is perhaps not surprising that a significant gap was evident between the frequency of reporting from multinational companies and that of smaller organisations. With the sample containing multinational pharmaceutical companies, it was not surprising that reporting on detailed policies was evident. These policies have often 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 intellectual property-sharing agreements.

Figure 7: Access/IP profile by company type (n=68)

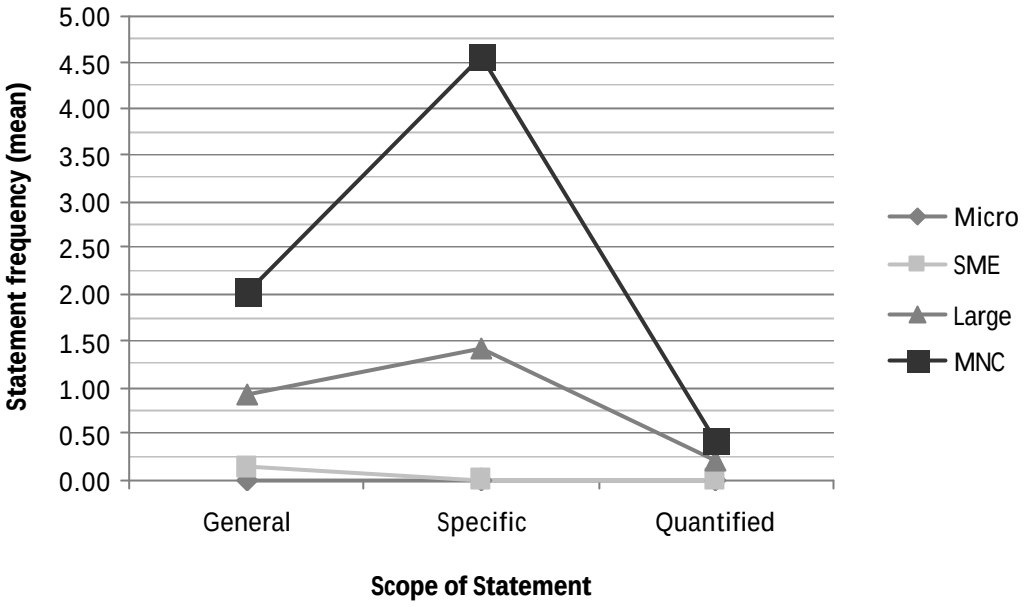


Social acceptance and understanding

There was little evidence of proactive and regular processes of stakeholder engagement being generally entered into by companies involved in NST activities, with a few exceptions. These are 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* engagement activities linked specifically to emerging technologies.

As with Access above, 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 8 below. 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.

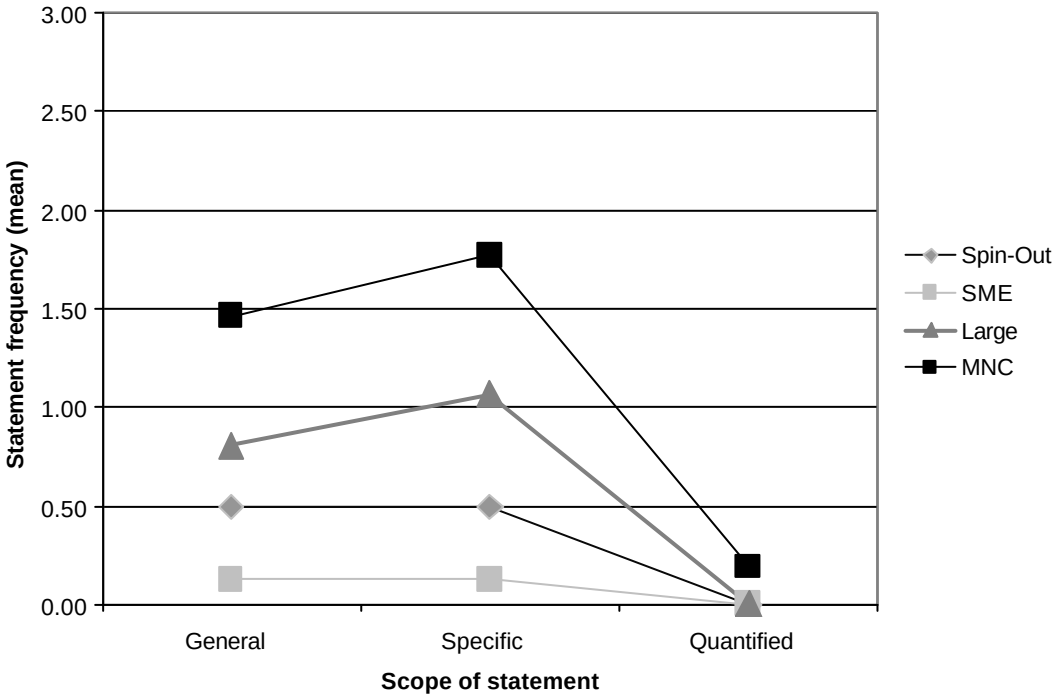
Figure 8: Stakeholder engagement profile by company type (n=68)



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

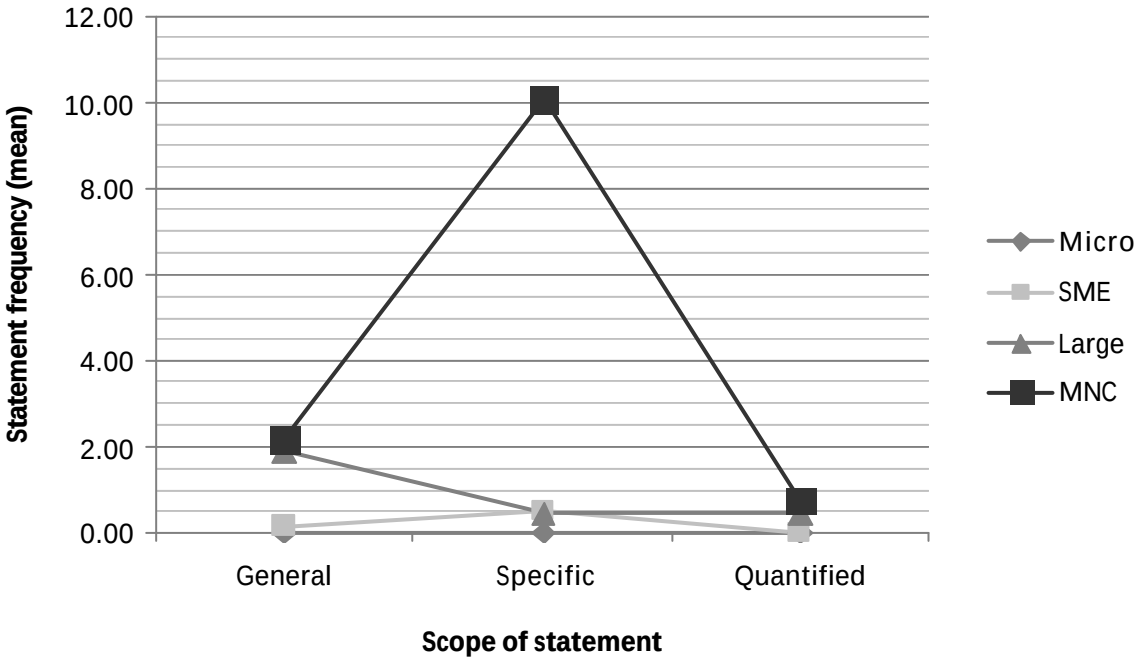
Figure 9: Legal compliance and liability profile by company type (n=68)



Risk management

Here we are concerned with how far a company has been concerned to put 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 employees, consumers, product users or 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. Other researchers have noted a low uptake of anticipatory and systematic approaches to risk management among smaller companies (Gunningham et al. 2005). This is reflected in our findings from Phase 2, which show that there is no specific reporting by smaller companies in our survey on risk management. Further, the evidence we collected shows very large differences between the number of 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 suggests that the setting of and reporting on performance targets regarding risk management is an area of CSR which is comparatively difficult to pursue.

Figure 10: Risk management profile by company type (n=68)



Analysis: Understanding Drivers and Inhibitors for Reporting

From this analysis, it can be concluded that the chief driver behind CSR reporting is company size, with another important factor being the position of a company in the supply chain, and/or its role. Research has indicated that companies tend to view CSR as separate from "core" economic functions and interests (Adams 2002). As an ancillary concern, CSR therefore requires both significant amounts of resources and a capacity to manage competitive pressures which, it is often argued, has tended to make it the province of larger and multinational companies (Porter and van der Linde 2000). Reporting and performance auditing are in particular regions of CSR activity which 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 there is a correlation between being removed from direct interactions with end consumers and a lack of CSR reporting. These companies tend to receive information about their wider impacts on society and environment from a range of sources. Consumer interaction 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 NST development is being done by smaller companies. Although they may not feel the need to sensitize 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 among MNCs, larger companies and SMEs, with ISO 9001 accreditation being particularly popular among SMEs and ISO 140001 among 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, while 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 GRI and AA1000 standards was less evident, however, even among the largest companies. Where it was undertaken, it occurred most often in relation to GRI, with 5 out of 11 companies (of which 10 were MNCs, 1 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 8) 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" (see page 30 below). 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[8] against the AA1000 independent accountability standard. 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.

[8] See www.bureauveritas.co.uk

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.[9]

In addition to factors which result in CSR in general not being a priority for smaller companies, it may also be surmised that, with specific reference to NST, there is a general reticence to report, due to sensitivities within the industry to the potential for negative publicity (see page 35ff. below for more discussion of this point, particularly with respect to the food sector).

Delving deeper: attitudes to CSR

In Phase 3, the interviews we carried out were both guided by overall project objectives and fine-tuned on the basis of findings from Phase 2, in order to investigate in more depth attitudes to CSR, irrespective of whether or not companies reported their activities in anticipating and responding to their wider impacts on society.

The interviews were concerned to explore further general attitudes to CSR among companies within our sample, as well as particular issues which had come to prominence as a result of Phase 2. Among these issues were the documentation of anticipatory (and precautionary) attitudes to risk among companies of all sizes, and particularly where in product lifecycles sensitivity to risk was focused. The role and nature of systematic approaches to risk was also singled out for further investigation, with the temporal reach of these processes being of particular interest, along with

[9] 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 2005-07 as a major failing (Council for Science and Technology 2007; Gavelin et al. 2007). The general problem of constructing an adequate interface between participation and policy or planning in institutionalised contexts is discussed by MacCallum (2008).

other similar issues (such as how companies take care of their legacies should they be dissolved, including orphan products). 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 the outcome. A breakdown of the sample is given below in Table 7.

Table 7: 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

Ten companies involved were SMEs or micros, and five were multinationals. The multinationals interviewed represented a cross-section of different key sectors, with

NST involvement in most cases (except for the food packaging and cosmetics companies interviewed) being restricted to R&D:

- food packaging
- speciality chemicals (with customers in e.g. the semiconductor industry)
- cosmetics and consumer health
- pharmaceuticals and consumer health
- coatings and composite materials

The profile of our sample of smaller companies arguably reflects key sectors among 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).
- Coatings and composite materials (one company)
- Manufacture of instrumentation for process technology (one company).

Taking the interviews together with the evidence from Phase 2, it is possible to characterise the prevalent understanding of CSR in the UK NST industry as being one of "do no harm" (see Figure 1 above), which takes demarcations of legal liability for occupational and consumer health, and for environmental damage, for its normative compass. Overarching values embedded within the culture of a company are often understood as driving commitment to the principle of "do no harm". For MNC companies, a change of CEO was seen as an event which could have an enormous influence on perceptions within the company. 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 (Company M).

Public sector interviewees tended to assume that reputation and publicity are two key drivers in causing companies to attend to their wider impacts, due to their effect on

company's position in the market. Companies tended to concur, interpreting these factors as necessary components of their "licence to operate", which required them to anticipate future shifts in regulation and to satisfy themselves 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).

Again, as in Phase 2, there is plenty of evidence that size, sector and position in the supply chain are drivers behind divergent attitudes towards CSR. As noted on page 21 above, the perceived need to survive in the short term may trump longer term views (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). Without extra capacity (such as might be provided by a department dedicated to dealing with CSR practice, for example), smaller companies face major difficulties developing adaptive, comprehensive and integrated approaches to CSR. Further, companies involved primarily in activities which do not have direct contact with consumers are much less likely in general to be involved in thinking about access, stakeholder engagement or longer-term risk management issues. However, smaller companies involved in R&D arrangements with larger companies 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 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 exceptions). 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).

Products incorporating nanomaterials are typically made to meet the same standards as apply to other comparable products, although in consumer-facing sectors, regulations are seen as stringent enough to ensure that adequate pre-market research is done. Existing PPE is generally treated as sufficient for protecting against accidental exposures should other containment measures be compromised.

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 at different stages of product life-cycles. Companies 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).[10]

Examples exist of specific and extensive pre-market human and environmental toxicology being developed by individual companies. 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.

Extended risk management: life cycle analysis, foresight and adaptivity

Although smaller companies tended, in interview, to represent CSR as relatively inaccessible to companies like them due to high costs, they often 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, life-cycle analysis and other related approaches like product stewardship, 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

[10] Note, however, that recent developments have demonstrated that how the issue of substantial equivalence is dealt with may vary in different regulatory contexts: while 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).

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"*.

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 in to 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.

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 page 4 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 (10 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 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. Along with this view comes an assumption that it is *individual products* that are the subject of acceptance and rejection, rather than *whole technologies*, unless these technologies are moved into the foreground as an object of specific public concern through e.g. the advocacy action of NGOs.

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

on page 4, among which the comparative balance of risk and benefit is typically not a priority.

If a market- and commercialisation-led innovation dynamic is widely accepted among 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 et al. 2006a; Kearnes et al. 2006b; Kearnes and Wynne 2007; Macoubrie 2006)

The problems of relying on 'product benefits' in order to "make the case" to support 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 corporate social responsibility, 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 among companies working with similar materials, and disclosure of data to regulators where this is viewed as not endangering commercial confidentiality.[11] CSR is therefore understood, for the most part, as a matter of "doing no harm" (see Figure 1 above), 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 above in Table 1. 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.

[11] 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 a SIEF (substance information exchange forum) in order to collate data on nanotubes considered as a novel material under REACH.

CSR as ancillary: The separation of CSR from "core interests" is one, from which the perception of CSR measures as imposing damaging costs (time and money) follows. Reporting on CSR (especially in a systematic fashion) 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: A perceived or real lack of relevant expertise includes a set of issues. 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 extra capacity.

It is not just CSR expertise that is felt to be lacking. 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 supporting *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), while 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 integrated, anticipatory and temporally extended approaches to risk management.

Regulatory obstacles: With respect to regulation, interviewees reported two problems. Among 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, 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 among 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 technolog:. 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 be leverage most influence in creating positive public perceptions, irrespective of any trust-building results of stakeholder engagement activities. Whilst recognising that public attitudes may well be characterised by ambivalence and a lack of trust, the view among smaller and larger companies tended to be that the promotion and subsequent 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, 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 (see page 4 above), public concerns which may affect the social legitimacy of a technology are not necessarily about the balance of risks and 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.

Conclusions and Recommendations

If voluntary regulation on the model of CSR is viewed as one way of making the impact management activities of companies more forward looking, adaptive and anticipatory, then what is at stake is more than simply being better at *predicting* impacts further down the line. Building resilience (material sustainability) in the face of unanticipated outcomes is one goal of anticipatory governance, but it must also contribute *symbolic* value, by helping to build the social legitimacy and social sustainability of technologies. As we suggested in the introduction, there is more to be taken into account than "risk" – in fact, using public concern (Renn and Roco 2006)

as a motor for engagement and deliberation is crucial to understanding the wider social impacts of technologies, as this allows public reflection upon their social constitution to occur. The responsiveness – or otherwise – of government and industry on material CSR issues like access (see Table 3 above) that social science research had demonstrated are central to public concern is thus a crucial determinant of how far the anticipatory management of impacts has developed.

As we have argued above in Section 0, understanding attitudes towards CSR requires that we differentiate between different ends of a continuum along which the meaning of CSR can be interpreted. The currently prevalent "do no harm" interpretation of CSR is far distant from the "positive social force" understanding which is arguably required to respond adequately to the need for anticipatory governance of NST. Within our Phase 2 and Phase 3 sample, only two multinational pharmaceutical companies demonstrated that their corporate governance structures included some elements of this understanding of CSR, with well-established stakeholder engagement programmes which had, in some cases, established formal feedback procedures that influence corporate policy and product development.

Elsewhere, as our interviews in Phase 3 suggest, assumptions about the purpose and value of public engagement tend to direct companies away from extending their activities towards a "positive social force" model of CSR. Changing these assumptions has been identified as a need across the nanotechnology industry, with the RCEP calling in 2008 for a move away from limited, government sponsored public engagement exercises to more established and networked models of "continual 'social intelligence gathering'" (RCEP 2008, p. 73) as an integral part of innovation processes.

To further promote CSR as a way of shaping governance that contributes to both the material and the social sustainability of NST, we recommend the following.

1) Promote an effective industry code of conduct: to assist in overcoming regulatory uncertainty, the promotion of an effective code of conduct (which provides both high-level and concrete guidance on how to address areas of material CSR concern) is essential. This is necessary in order to avoid the potential for competition between

different codes of conduct in the near future. Forms that such promotional activity might take might include:

- Setting 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);
- Promoting being benchmarked against the code as a condition which suppliers of goods and services to public organisations should meet; and
- Focusing on encouraging adoption by larger companies in order to exploit their supply-chain influence on smaller companies.

2) Facilitate access to CSR and wider technical expertise: it is essential that benchmarking against any such code should be adequately incentivised for smaller companies, with access to regulatory information, CSR consultancy expertise, toxicological/risk management expertise, and possibly financial assistance. Bodies such as NanoKTN could conceivably play a key role in encouraging the sharing of expertise.

3) Encourage sectoral differentiation: the development of principles and guidelines to make a code of conduct a concrete source of guidance for different sectors should be pursued, which may require the setting-up of sector-specific working groups to allow guidance to "crystallise" in forms suited to the specific conditions which obtain in different sectors. Companies who have already developed, or are developing positive models of CSR and/or technical risk assessment and management expertise should be used to energise activity.

4) Encourage sharing of CSR expertise within existing supply chains: it is not only pressure to be benchmarked against codes of conduct that should be exploited by regulators. Transfer of CSR knowledge and experience down the supply chain, with sharing of resources, should also be encouraged. Exemplar models of practice should be formulated.

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