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# SEEKING OUT PATHS OF RESPONSIBLE DEVELOPMENT: EXPLORING THE WICKED PROBLEM FACING INDUSTRIAL ACTORS<sup>1</sup>

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## ABSTRACT

This paper takes as its point of departure the pressure for industry to take up the notion of 'responsible development' of nanotechnology when there is little clarity as to what this might mean in practice. Due to increased complexity, actions to be taken cannot be simply specified. It is necessary to further articulate the issues of responsible development, as such, and through learning by doing; it is on this point that interview data with industrial actors, collected in an earlier project (Shelley-Egan, 2011) are presented as a means of understanding industry's response to the pressures for responsible development of nanotechnology, along with the articulation of further issues. The findings show that there is differential uptake of pressure for responsible development, and ambiguities and attempts at their resolution. However, in new developments related to the responsible development of nanotechnology, one sees new practices and interactions which may contribute to making the problem manageable at least.

**Key words:** responsible development - industrial actors - anticipation of societal embedding

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## 1. INTRODUCTION

For over a decade, an international policy debate has been under way concerning the appropriate mechanisms for the governance and regulation of advances in nanotechnology (Kearnes and Rip, 2009). Collingridge's dilemma of control - the problem of reacting 'too early' or 'too late' to an emerging technology - is an important element in the debate. Developers/companies must find a way of harnessing the enormous potential of nanotechnologies while also being mindful of potential environmental, health and safety issues (Krupp and Holliday, 2005). Equally, on the governance and regulation side, policymakers and regulators have to respond to the significant promise by regulating such that the innovative potential of the field is not restricted, while being sensitive to public concerns and to possible emerging risks to human health and the environment (European Commission, 2004). While this debate still continues, the debate has been broadened by reference to responsible development and cognate terms such as responsible innovation (cf. Davies et al 2009; Kearnes and Rip 2009; von Schomberg 2011; Owen et al., 2012).

"Responsible development" is an umbrella label and is not just about regulation; it is also about identifying opportunities to harness the *potential* of nanotechnology (cf. Kjolberg 2010; Kearnes and Rip 2009). Broadening the focus on regulation to include choices of innovation directions or innovation pathways (Robinson 2009, Robinson et al 2013) increases the complexity of the situation, not only for governance actors but for those who are actually *doing* the development and innovation.

The notions and principles beneath the umbrella label include responsibility, safety and being socially acceptable, which themselves are poorly articulated in the sense that there is no fixed consensus in relation to the meaning of the terms or how they should be applied in real-world situations (Davies et al 2009). Definitions of responsible development do exist; the definition of 'responsible development' which featured in a review of the US National Nanotechnology Initiative is illustrative:

*Responsible development of nanotechnology can be characterized as the balancing of efforts to maximize the technology's positive contributions and minimize its negative consequences. Thus, responsible development involves an examination both of applications and of potential implications. It implies a commitment to develop and use technology to help meet the most pressing human and societal needs, while making every reasonable effort to anticipate and mitigate adverse implications or unintended consequences (own emphasis).<sup>2</sup>*

The text is striking in that it does not offer any guidance as to how the practice of responsible development should be pursued. How can the balancing of efforts be achieved when little is known about applications and implications? Who defines the most pressing human needs? What kinds of efforts are necessary to anticipate and mitigate adverse implications and consequences?<sup>3</sup>

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<sup>2</sup> Committee to Review the National Nanotechnology Initiative, National Research Council. 2006. A Matter of Size: Triennial Review of the National Nanotechnology Initiative. Washington DC: The National Academies Press.

<sup>3</sup> Rip (2010) argues that this definition does invite promoters of nanotechnologies to consider broader issues and allows other actors to ask questions about the directions in which development might proceed.

## Structure of the Chapter

In order to begin to answer these questions, it is necessary to further articulate the issues of responsible development, as such, and through learning by doing. This chapter focuses attention on how industrial actors are *articulating* their thoughts and responses to the pressure for responsible development. This is a different approach to other studies, which report on what companies are actually *doing* (cf. Groves et al., 2011; Engeman et al., 2012)<sup>4</sup>. Information on articulation processes can be garnered by exploring positions taken, and strategies employed, in response to the pressures for responsible development. Although such an emphasis implies that the focus lies on what industrial actors *say* as opposed to what they *do* (“talking the talk” rather than “walking the talk”), it does offer an opportunity to understand issues and challenges in the effort to *operationalise* responsible development in a situation with little guidance or best practice. Moreover, while the data is from 2008-2009, the issues remain, and the patterns found in the articulations are important when considering responsible development of nanotechnology in the present day.

The remainder of this chapter will be structured as follows. Section 2 offers an overview of the situation which creates pressure for nanotechnology industrial actors, forcing them to act in relation to responsible development. This is done first by describing three areas of uncertainty which influence nanotechnology innovation decisions (both processes and directions) and second, by zooming in on two features which can already be identified in current industry activities in responsible development. Section 3 describes our research design and method. Section 4 presents the findings from the study, making use of many quotes from interviews. The data presented here shows that there is differential uptake of pressure to do something about responsible development and, if taken up, ambiguities and attempts at their resolution. Section 5 draws conclusions from the data analysis and opens up further discussions and reflections on responsible development and industrial strategies.

## 2. PRESSURES TO ACT

While the discourse of responsible development is primarily a policy discourse at present, and there are no specific, dedicated activities associated with it, companies nonetheless feel pressure to respond to the call for responsible development. Lee and Jose (2008) note the increasing demands for responsible behaviour on the part of industry, as a means of addressing the slow pace of regulation<sup>5</sup> and the complexity and rapid advance of the technology:

It is likely that the complexity of the issues and the rapid pace of development will outstrip the capacities of the regulatory agencies to frame effective policies and standards. In such a scenario,

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<sup>4</sup> Groves et al (2011) seek to understand how Corporate Social Responsibility (CSR) and Corporate Social Performance (CSP) are linked to concerns about the specific characteristics of NST applications, while Engeman et al (2012) examine how companies producing engineered nanomaterials are adapting practices for their safe development and use, with a view to understanding the governance implications of companies’ risk perceptions and safety practices.

<sup>5</sup> D’Silva et al 2012 show that, for medical applications of nanotechnology, nanotechnology innovation is currently operating within the framework of existing regulations, and in fact, the regulation and governance community is anticipating at early stages concerning potential challenges looming on the horizon and ways in which to manage them.

reliance on responsible corporate behaviour becomes a dominant rather than a transient consideration in devising regulatory structures (p. 117).

In addition, in a commentary on “policy considerations for responsible nanotechnology decisions”, a group of influential policymakers and regulators have argued that responsibility for addressing the information gap regarding nanomaterials “resides as much, if not more with those who produce nanomaterials as it does with those who regulate them” (Morris et al 2011).

The challenges facing industry in the responsible development of nanotechnology are significant given three areas of uncertainty which have been suggested will affect the successful commercialisation of nanotechnology (Sutcliffe 2008; Lee and Jose 2008).

### ***Three areas of uncertainty***

#### **(1) Technical uncertainties**

In the first instance, there are technical uncertainties; a *dearth of knowledge* exists concerning the eco-toxicological effects of nanomaterials (Handy et al. 2008). Nanomaterials and applications are being developed at a very rapid pace; however, a fundamental understanding of potential and environmental and human health risks resulting from exposure throughout the lifecycle of these materials has lagged behind (Thomas et al 2009). Indeed it has been estimated that costs for toxicity testing of existing nanoparticles available in the United States will range from \$249 million to \$1.18 billion and the time taken to complete testing will be significant (35-43 years) (Choi et al 2009). The properties of nanomaterials which make them so desirable may possibly lead to undesirable effects such as harmful interactions with biological systems and the environment, with the potential to generate toxic effects (Nel et al 2006). The exposure of nanotechnology workers and consumers using products containing nanoengineered nanoparticles is a near-term concern (Colvin 2003).

#### **(2) Commercial uncertainties**

Industry faces *commercial uncertainties* concerning the development trajectories of nanotechnology in different sectors (Davies 2009; Sutcliffe, 2008). In industries such as the semi-conductor industry, for example, uncertainty exists regarding the balance between ‘more Moore’ and ‘beyond Moore’<sup>6</sup> and the implications of this for new product-value chains and industry structure, while there are no concerns about the eventual acceptance of products (Le Masson et al. 2012)<sup>7</sup>. On the other hand, the food sector “is hooked on nano-tech’s promises, but it is also very nervous” (Renton 2006). Thus, as Kearnes and Rip (2009) observe: “The simple fact is that though nanotechnology is seen as heralding great promise in individual sectors, the innovation trajectory is, as yet, unclear” (p. 102).

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<sup>6</sup> The “More than Moore” domain refers to a set of technologies that enable non-digital micro/nanoelectronic functions such as radio frequency (RF) communication, power control, passive components, sensors, actuators. These technologies are based on, or derive from, silicon technology but do not necessarily scale with Moore’s Law. “Beyond Moore” refers to a set of disruptive functions – from progress in nanometre-sized functions - that, in the long term, will complement or replace conventional silicon technology

<sup>7</sup> In the International Technology Roadmap for Semiconductors (ITRS) this uncertainty is clearly recognised, but is managed through a variety of working groups and the partitioning of more uncertain and less uncertain technology development lines (See Le Masson et al.2012 for a study on how the ITRS community manages uncertainty).

An additional complication is that a technology can develop in completely unanticipated directions and be applied in ways that were not foreseen (Agogue et al. 2012<sup>8</sup>). In her analysis of commercial uncertainties, Sutcliffe (2008) focuses on specific questions arising from the commercialisation of nanotechnology-based products: such questions include the risks arising from the shape of future standards and regulation; the potential for litigation and the impact of complex intellectual property regimes on the development of less commercial but highly beneficial applications.

### (3) Social uncertainties

*Social uncertainties* centre mainly on uncertainties regarding public acceptance of nanotechnologies and concern about the potential for public concern to impede developments in nanotechnology (Kearnes and Rip 2009), including exaggerated concerns about public reactions to nanotechnology (Rip 2006). It is within this context that research into public attitudes to nanotechnology has flourished over the last decade. The research shows that, in general, lay people do not seem to have negative attitudes toward nanotechnology, although perceived benefits and level of acceptance vary across sectors (Siegrist 2010). However, in their characterisation of public responses to nanotechnology and the underpinnings of these responses, Davies et al (2009) found that lay reactions to nanotechnology are more complex: "... public concerns and enthusiasms cannot be categorised as 'pro' or 'anti' but encompass anything from the dangers of perfection to the problematic nature of controlling life" (p. 4). According to the authors, these findings serve to indicate "...the lack of clarity concerning how nanotechnology will be viewed by diverse European publics" (p. 25).

The combined force of technical, commercial and social uncertainties leads to a dilemma for industry; investing in development at an early stage presents a risk in terms of one or more of the uncertainties mentioned above, while waiting to use nanotechnologies is also a risk in terms of lost opportunities.<sup>9</sup> Given the huge opportunities enabled by the commercialisation of innovation from nanotechnologies, there is pressure to (at least partially) resolve this problem (D'Silva et al 2012).

It is not only these uncertainties which put pressure on industrial actors to respond to 'responsible development'. Insights from ongoing activities in industry<sup>10</sup> shed light on some

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<sup>8</sup> Agogue et al. 2012 was chosen as a useful reference for this type of uncertainty based on their exploration of design processes of firms in the extreme unknown. Their conceptual framework combines path dependency and path creation concepts (Garud and Karnoe 2001) and exploration and development where uncertainty is high (Le Masson et al. 2012).

<sup>9</sup> One resolution (albeit an unsatisfactory one) is the 'waiting games' that can be observed in some domains of nanotechnology in which interdependent actors wait for other actors to reduce uncertainties before they proceed to invest. However, waiting games are self-reinforcing mechanisms that can lead to a situation of innovation stalemate or stagnation, even when there is general acceptance that innovation is necessary (Robinson et al 2012).

<sup>10</sup> For example, the chemical company BASF has developed its own Code of Conduct for nanotechnology. Additional measures implemented by companies include spokespersons for nanotechnology and the establishment of issue management teams. Companies such as DSM and GSK have provided public position statements on nanotechnologies, while the chemical company Evonik has a company statement and a 'Nano Guideline'. The notion of 'responsible development' in Codes of Conduct and position statements is generally articulated in terms of dealing with environmental, health and safety issues, risk assessment and risk management. However, there is also some reference to dialogue with society in two chemical company initiatives (BASF and Degussa). The nano risk framework developed by DuPont and Environmental Defense was subject to a public consultation prior to its launch.

additional elements visible in the pressure for responsible development which are shown to influence industry's responses.

## **Responsible Development Today**

In order to understand what is happening with regard to the *pressure* for responsible development in industry, it is necessary to provide some analysis as to what is happening already in industry with regard to responsible development. Two main features - distributed responsibility and the need for companies to take other actors into account – can be identified. Following discussion of these features, we offer a diagnosis regarding the implications of these features for the response to the pressure for responsible development.

The notion of the responsible development of nanotechnology refers to 'responsibility' as a general governance framework for development. Thus the discourse becomes one of responsibility rather than one of accountability (Ferrari 2010; Kjolberg 2010). Such a change in discourse implies that companies can no longer fall back on laws and regulations alone but must position their actions and interactions in order to show that they are being 'responsible'. They then have to fill in what it *is* to be responsible. An emphasis on distributed responsibility is visible in the responsible development of nanotechnology (cf. Fisher and Rip 2013; von Schomberg 2010; Dorbeck-Jung and Shelley-Egan, 2013). Responsibility for the development and use of nanotechnology is distributed across myriad stakeholders. Thus the process of the responsible development of nanotechnology will include 'many visible hands' (Rip and Groen 2001), rather one invisible hand or firm steering the development. There is a collective, process-oriented (Malsch and Hvidfelt 2009) form of responsibility or as von Schomberg (2007) phrases it, a 'collective co-responsibility'. Responsible development, therefore, relates to the overall process of development and the additional item of being co-responsible. In more concrete terms, companies have to be able to manage the tension between their own self-interest in exploiting nanotechnology and exercising ethical choices to ensure the responsible development of nanotechnologies (Lee and Jose 2008).

This shift away from accountability towards responsibility is one new aspect in the development of nanotechnology. Another novel aspect in the development of nanotechnology relates to the opening up of the strategies and interactions of companies in their anticipation of the societal embedding of nanotechnology. Companies must work towards the societal embedding of nanotechnologies, that is, the integration of nanotechnologies in relevant industries and markets, their admissibility in terms of standards and regulations and their public acceptance (Deuten et al., 1997). Societal embedding can be carried out in an instrumental way, but can also be taken up as part of responsible development. Importantly, anticipating on the societal embedding of nanotechnologies implies that success cannot be realised within the traditional boundaries of the firm (Deuten et al. 1997). Companies are required to anticipate societal embedding in interaction with other actors – who should also be viewed as stakeholders - in wider society (consumer organisations, environmental groups and non-governmental organisations (NGOs)). Thus some of the goals that managers want to realise are out of their hands, that is, managers realise that they cannot control certain aspects and that they have to rely on other actors; it is this aspect which becomes important in responsible nanotechnology development. Traditional management structures within the firm will not be sufficient to realise a broader notion of success which refers to the societal quality of the product. Furthermore, the

process of the creation of societal embedding will depend on the strategies of external actors (ibid).

Taking these two features together, it is possible to offer some diagnosis of the *nature* of attempts to articulate responsible development. In a sense, attempts to articulate responsible development can be analysed in terms of a ‘wicked’ problem (Rittel and Weber 1973). A ‘wicked problem’ is a phrase originally used in social planning to describe a problem that is not easily controlled or manageable due to its being ill-defined, having many stakeholders and a dearth of ‘clarifying traits’ including a clear mission and clarity about whether or not the problems have been solved.<sup>11</sup> Due to complex interdependencies, the effort to solve one aspect of a wicked problem may reveal or create other problems. This paper seeks to foreground the complexity of the call for responsible development of nanotechnology through understanding industrial actors’ responses and interdependencies between different sectors’ responses.

### 3. RESEARCH DESIGN AND METHODS

In the original project, a number of approaches including dedicated interviews, document analysis and participant observation in meetings were employed in order to address the research questions. For this paper, we re-use the data which explored how responsible development of nanotechnologies is articulated by industrial actors across the three main domains in nanotechnology.<sup>12</sup> The difference between these three domains was expected to influence the articulation of responsible development because they comprise different industry structures and dynamics and comprise very different (ethical) issues (see below). For the question here, findings for the chemical sector will be used, given this sector’s visibility in the responsible development of nanotechnologies and the knock-on effects of their visibility on the other sectors’ articulations of responsible development.

The original interviews were carried out with companies across European nanotechnology industry between January 2008 and 2009 – out of 11 companies sampled, 7 were based in the Netherlands and Germany, 3 were based in Ireland and 1 in the UK.<sup>13</sup> Those major companies in the three sectors that were expected to have a stake in the development of nanotechnology –

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<sup>11</sup> Wicked problems often arise when organisations are faced with constant change or unprecedented challenges (Camillus, 2008). Wicked problems occur in a social context; in fact, it is the social complexity of wicked problems as much as their technical difficulties that make them difficult to manage (ibid). Classic examples of wicked problems include economic, environmental and political issues. Many standard examples of wicked problems derive from the areas of public planning and policy and include global climate change (Lazarus 2009), AIDS, healthcare and terrorism. A recurrent theme in research and industry literature is the connection between wicked problems and design. Design problems are often wicked problems because they are ill-defined, lack solutions that are ‘correct’ and involve stakeholders with varying perspectives (Conklin 2005). Thus wicked problems require creative solutions.

<sup>12</sup> An interview instrument was prepared and included general questions concerning companies’ strategies in relation to nanotechnology, views on activities and pressure for responsible development, industry’s perception of the perspectives and ethical views of lay people with regard to nanotechnology, industry’s views of the precautionary principle, and more specific items for industry such as the challenges that nanotechnologies pose to companies and the balancing of risks and opportunities of nanotechnology.

<sup>13</sup> The focus was on engaging with European industry; we did not carry out interviews with US or Canadian companies in order to derive their perspectives on responsible development (see Shelley-Egan and Davies (forthcoming) for an analysis of nano- industry operationalisations of responsibility in the US). Moreover, while we report on industry’s perspectives on NGOs and their activities, we did not carry out interviews with NGOs.



not all companies openly advertised that they had ongoing nanotechnology activities - were selected.<sup>14</sup> Thus, while the sample size is small, the findings are indicative of the larger picture.

The research question allows a number of topics around responsible development to be introduced, including the challenges nanotechnology poses to companies, approaches to dealing with these challenges, the risks and benefits of nanotechnology, activities dealing with responsible development at the collective level in the world of nanotechnology, the precautionary principle and hype.

A number of issues relevant to responsible development of nanotechnology were brought up and discussed by the respondents in the interviews. These included the stance of industry towards responsible development in nanotechnology, pressure to be visible in nanotechnology activities, and feelings of ambivalence towards NGOs. Discussion of these issues provides insight into industry's attempts to *articulate* responsible development of nanotechnology both within the company itself and in their presentation to and interactions in the outside world.

Indexing (or coding) was used to interpret the data. Following familiarisation with the data during which initial themes were identified, the next step was made to create a conceptual framework or 'index' which drew upon recurrent themes and upon issues introduced into the interviews through the interview instrument (Ritchie and Lewis 2003). Themes were then sorted and grouped under a small number of main themes and placed within an overall framework. Textual terms such as "Pressure to be visible in nanotechnology activities", "Transparency and the lack of public trust in industry", "Stance towards responsible development of nanotechnology", "Hype in nanotechnology", *et cetera*, were used to capture the essence of the theme or subtheme. This index was then applied to the data. Indexing was carried out manually (without the assistance of a data analysis programme) by applying references to the margins of the transcripts. The following step involved sorting the data by theme so that material with similar content could be grouped together. The final step involved synthesising the data so as to make the material manageable and to make the content coherent for presentation (Ritchie and Lewis 2003). 15 respondents from 11 companies located in the three broad domains in nanotechnology - micro/nano-electronics, materials and surfaces and bionanotechnology - were interviewed.<sup>15</sup> These domains were identified in preparation for the empirical research.

The three main domains in nanotechnology comprise different applications and dynamics. In the domain of nano-enabled materials and nano-structured surfaces, there are applications in ongoing development in the big incumbent chemical companies and in smaller companies. In

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<sup>14</sup> The author participated in a number of meetings at which responsible development of nanotechnology was a key item of discussion; this participant observation enabled opportunistic sampling so as to avail of *ad hoc* opportunities to enroll interview respondents.

<sup>15</sup> There were 3 companies in the micro/nano-electronics domain, 3 companies in the materials and surfaces domain and 5 companies in the bionanotechnology domain. The respondents were representatives from multinational companies (excluding one company) including 3 companies located in the materials and surfaces sector (chemical company A1, A2 and A3), 2 semiconductor companies (micro/nano-electronics company B1 and B2), a company with a broad technology product portfolio (micro/nano-electronics company B3), a beverage and food stuffs company (bionanotechnology company D1), a big conglomerate including a food company (bionanotechnology company D2), a medical devices company (bionanotechnology company D3), a corporate research organisation developing new technologies for the medical and healthcare sectors (bionanotechnology company D4) and a cancer nanotherapy company (a small and medium -sized enterprise (SME) (bionanotechnology company E). The respondents included 4 researchers, 2 product developers, a corporate research department representative, an R&D director, a technology manager, a manager for environmental and regulatory affairs, a communications and government relations representative, a company spokesperson for nanotechnologies, a CEO, a vice president and a public affairs manager.

the micro/nano-electronics domain, the big incumbents are active. In addition, new entrants are pursuing the “Beyond Moore” trajectory and large-area electronics and foils. In the bionanotechnology and nanomedicine domains, there are various activities and promises and many small and medium-sized enterprises (SMEs) involved (Rip 2008).

There are a number of considerations about nanotechnology which were expected to shape responses from interviewees. Nanotechnology is an enabling technology which adds new functionality to existing materials and components. Nanotechnology just improves performance and sometimes enables new functionalities (e.g. surfaces that repel dirt) but the constitutional effects derive from the system and how it is embedded and used. Still, nanotechnology can lead to major differences when a certain threshold is passed. For example, when RFID (Radio Frequency Identification Devices) becomes smaller and cheaper as a result of nanotechnology, and thus more widely usable and easier to implant, an “Internet of Things”, where all products can be traced individually becomes possible, in addition to the implantable and “readable” human (Rip 2009).

## 4. FINDINGS

### **Stance towards Responsible Development of Nanotechnology**

The first question addressed to the interviewees concerned whether their company’s stance towards responsible development of nanotechnology was part of their overall Corporate Social Responsibility or additional to it. The aim of this question was to find out whether industrial actors considered the development and use of nanotechnologies to be ‘ethically special’. This inquiry into the ethically special nature of nanotechnology in industry derives from the well-known debate in the ethics of nanotechnology which centres on whether ethical approaches developed in other contexts can be applied to nanotechnology.<sup>16</sup>

Most respondents replied that responsible development was a normal part of their Corporate Social Responsibility (CSR); this was tied up with the importance of being a ‘good firm’. This can be illustrated by a quote from the respondent from bionanotechnology company D2 who replied “That’s part of our DNA”. However, there was a striking difference between the three domains in relation to companies’ emphasis on responsible development of nanotechnology. Chemical companies were very conscious about responsible development of nanotechnology and somewhat pro-active, while responsible development of nanotechnology was not a salient issue for companies in the bionanotechnology and nano-electronics domains.

For companies in the bionanotechnology and nano-electronics domains, the reasons provided for viewing the development of nanotechnologies as “business as usual” included the role of nanotechnologies in product development, in addition to the existing regulatory and legislative frameworks under which nanotechnology can be subsumed.<sup>17</sup>

A respondent from bionanotechnology company E spoke about why responsible development of nanotechnology does not present any particular challenges to their business. One reason comprises the nature of nanotechnology for developments in nanomedicine, as he explained:

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<sup>16</sup> For a description of this debate, see Ferrari (2010)

<sup>17</sup> Discussion of existing regulatory and legislative frameworks is beyond the scope of this chapter.

Nanomedicine and working with nanomaterials is really not interesting for physicians and clinical people. They are always looking for solutions for a certain medical problem and if you use nanotechnology to offer them a solution for their problem, then they will say, “OK, nano helps us” but it’s not dependent on nano or whether it’s nano – it should solve the problem

A respondent from bionanotechnology company D3 further emphasised this point by explaining that the company was not going out deliberately to try to exploit nanotechnology, other than their interest in it as a solution to their development needs.

The second point about businesses in the health and medical sectors operating in an existing framework of responsibility which manufacturers of medical products have by law, was elaborated by bionanotechnology company D4:

Of course everything that happens in the area of nanomedicine, as with any application in medicine, comprises a framework of ethical and legal consideration... for instance, there are the same aspects surrounding privacy... [these] are no different for nanomedicine... we do research worldwide and there are considerations everywhere around medical experimentation and introduction of medical devices, which is very well regulated – nanomedicine is not an exception, it is no different to medical applications or other medical developments

Both respondents from the food companies reported that their companies did not have any nanotechnology applications but emphasised the importance of nanotechnologies in R&D, for example, the use of electron microscopy to study natural systems at the nano scale. With regard to the responsible development of nanotechnologies in particular, both respondents reported that responsible development was a normal part of their Corporate Social Responsibility.

In addition, one of the respondents stressed that nanotechnology applications fall under novel food legislation already in place. Interestingly however, at the time of speaking to the respondents in 2008, both companies were involved in nanotechnology initiatives including an R&D initiative and an initiative aimed at developing best practices for industry. Such participation indicates an awareness of the (special) potential of nanotechnologies for the sector in development and use.

The respondents from both semiconductor companies felt that there was a certain amount of hype surrounding nanotechnology. Similar to the companies in the health and medical sectors, nanotechnology provides a solution to a technical problem, as the respondent from company B1 explained. The respondent from company B2 explained that safety of workers is the primary concern for the company; the company is already working with hazardous materials, so if they move into working with nanomaterials, it will be business as usual.

At first hearing, the response of representatives from the chemical companies seemed to resonate with those from the two domains described above. All of the chemical company respondents commented that nanotechnology was just the next step in their development. The respondent from chemical company A1 described the nature of nanotechnology for his company as a “natural step in the development” when nanotechnologies are defined as “the next step to control materials at an ever smaller scale”. The “business as usual” status was also underlined by his next comment: “if you want to call it nano, fine, but it’s not necessary to do our job”.

This “business as usual” status extended to their stance towards responsible development of nanotechnology but only to a certain extent. Thus, responsible development of nanotechnology was viewed as

... part of the total philosophy...it’s a total attitude... it’s part of the total way we do business  
(respondent from chemical company A1)

Moreover, the responsible development of nanotechnologies is part of the chemical industry’s Responsible Care® programme.

The Responsible Care programme was launched in 1985 by the Canadian Chemical Producers’ Association. The creation of the programme signified recognition by the industry that improved performance among chemical companies was crucial to public acceptability and viability. A series of major chemical accidents, most notably the 1984 disaster in the Union Carbide plant in Bhopal, India, reinforced a perception that the chemical industry was unable to carry out its operations without harming human health and damaging the environment (Prakash 2000). For this reason, companies were keen to demonstrate eco-efficiency measures; however, companies were faced with a situation which could be said to have been characterised by a degree of ‘wickedness’. In the first instance, many companies did not have the resources with which to pursue environmental and human health measures, and second, they may have been hesitant to take the initiative or to “stick out their necks” when they could not be sure that other companies would make similar moves. The Responsible Care programme can be seen as a response to this wickedness. By participating in the programme, companies work *together* towards two objectives: to improve the environmental and safety performance of CMA members and to improve the public perception of the industry. The programme includes ten guiding principles and six codes of management practices (King and Lenox 2000). However, this is not to say that the chemical industry has closed the chapter on the Bhopal disaster. In December 2011, scores of survivors of the Bhopal disaster in India burned an effigy of the London 2012 Olympics organiser in protest at the sponsorship role of Dow Chemical (the company which has wholly owned Union Carbide Corporation since 1999), claiming that the effects of the leak continue until this day and that they have never received justice.<sup>18</sup> Notwithstanding this continuing struggle, the Responsible Care programme sets an important precedent that significantly shapes chemical companies’ stances towards the use of nanotechnology in development. Thus, one sees a tension between “business as usual” and the need to be seen to be open about their developments in nanotechnology. This is particularly pertinent for these companies, given the perceived lack of public trust in the chemical sector. This tension was evident in the following quote

People expect us to have a position on this topic but again it’s part of our normal business

A respondent from chemical company A3 elaborated on this tension. He explained that his company was working (at the time) on a Code of Conduct similar to that of another chemical company, although nanotechnology is not very different to the other materials they work with:  
... the people within coatings say that – and it’s more or less the general feeling I believe [within the company] – nanotech is not that much different than other dangerous materials.

<sup>18</sup> <http://www.bbc.co.uk/news/world-asia-india-16001266>

... I think the policy on how to deal with it is not very different than the policy that is used for using other chemicals or phasing out or introducing other new substances in the products we make... but on the other hand, we're working on a Code of Conduct, on a policy... so it's a bit contradictory to what I just said but it's also influenced by the discussion that's going on in society

Additional measures such as Codes of Conduct for nanotechnology comprise a means for chemical companies to deal with the problems that nanotechnology presents them with, namely the multiple uncertainties associated with development of nanotechnology and the pressure for responsible development. Nanotechnology is crucial for ongoing development in this particular sector, while at the same time, the uncertainties posed by the development and use of nanotechnologies foreground issues of transparency and a perceived lack of public trust in the chemical sector, which must be dealt with in a transparent and open manner. Chemical companies experience credibility pressure to maintain their image as "good" companies. There is now additional pressure to do something about the responsible development of nanotechnologies. Thus the chemical sector is required to go above and beyond its usual measures of Corporate Social Responsibility and the Responsible Care programme.

It appears that the chemical sector's endeavours to deal with the pressure for responsible development actually *generates* a wicked problem – illustrating interdependencies in the effort to respond to the pressure for responsible development - for the other two sectors, for whom the responsible development of nanotechnology is not a pressing concern. The respondents from the other sectors expressed views about the chemical sector's emphasis on responsible development of nanotechnology, asserting that while this emphasis on the *responsible* development of nanotechnology is necessary, it also has negative consequences, in terms of sustaining the argument that nanotechnology is somehow ethically special, warranting specific measures, and in contributing to the hype around nanotechnology.

### **Transparency and Lack of Public Trust in Industry**

In the interviews, transparency and trust in industry was intimately linked with companies' stance towards responsible development of nanotechnologies and was again particularly pertinent for chemical companies.

One respondent from chemical company A1 explained that the fact that the company has an official spokesperson for nanotechnology is a "response to the outside world":

I mean the outside world makes a lot of fuss about nanotechnology and so we need to have a contact where you can ask questions and that's the idea, nothing more than that

Another respondent from the same company spoke about their issues management team, set up to deal with nanotechnology, which was established

... because of the societal questions asked by NGOs, by the unions, etc.... that means that it is important for us to consider the topic in all its dimensions

Chemical companies have responded to the pressure to be visible in their activities as it is prudent for them to do so in order to create a better profile. However, transparency was not

only viewed in positive terms. While emphasising the track record of safety and environmental awareness amid continued concern with safety issues at his company, the respondent from micro/nanoelectronics company B3 expressed his concern that one effect of transparency might be the creation of an atmosphere of fear:

You engage with it but by raising issues that are so broad... for example, in our industry... calling us a nanotechnology industry when we're doing essentially the same thing we've done all along brings you under a somewhat dark-cloud umbrella, you know. So, here we are suddenly engaged in ethical conversations in things we've been doing for years, which have – as far as we're aware – nothing other than ordinary safety implications. You're sort of gathered into a growing pool of [mock panic] “should we be doing this stuff?”

Although this respondent is speaking in general terms, there is an implicit criticism of chemical companies and their endeavours to be visible and transparent in their development of nanotechnologies.

Transparency was also viewed as being double-edged. This was discussed in relation to the experience of a chemical company and the “nano-stigma” attached to the food sector.

A respondent from chemical company A2 explained why the company had decided to be so transparent in its activities. As a result of its experiences with other public debates, the company realised that it would be prudent to get involved at an early stage. However, this kind of early engagement with nanotechnology is difficult, as the respondent explained:

It is a risk and sometimes ends in reputational damage [of your company]. Those companies that are transparent are also the focus of NGO debates because nothing is known [of what other companies are doing]

Even though chemical companies are expected to be transparent in their development and use of nanotechnologies, efforts to be transparent can backfire on them; indeed companies may even suffer reputational damage. This problem arises as a result of actually operationalising or ‘doing’ responsible development.

This observation made by the last respondent about the difficulties associated with transparency prompted a further question about the respondent’s view of companies’ strategic considerations towards nanotechnology. In her response, she noted the lack of *visibility* of many companies in the debate around nanotechnology:

... you know [at a meeting in Brussels], someone said that nanotechnology is standard in R&D, so everybody who is not doing nanotechnology is not up-to-date... at the moment, I see only a few companies in the public debate. There are many companies that are not at all visible. ... I would assume that they also do nanotechnology... but they do not take part in the debate

Thus this respondent makes a clear link between visibility and transparency.

A nano-food expert we interviewed spoke about food companies’ reluctance to be transparent in their nanotechnology activities:

It may be the problem of the first company that starts to communicate getting all the publicity – negative publicity – regarding their products, so who is the first one to do it?

The chemical company's experience of the negative consequences of being transparent in its activities in nanotechnology is a concrete example of this problem. We followed up the response from the nano-food expert by asking whether the reluctance of food companies to be transparent in their activities may lead to a standoff between the big companies. He recognised this but hoped that one company would risk taking the lead and that others would follow:

Yeah, probably. If everybody was to communicate about it or if the first one started to communicate and was able to communicate the benefits over the risks effectively, then probably more companies, like in cosmetics... a lot of companies follow the lead of L'Oréal because they have been able to communicate that nanotechnology has specific benefits for skin products...

A link with the collective level was made by the respondent from chemical company A3 when he referred to what "we" must do:

... it's my feeling that we should open up because if we don't we get bitten in the tail and we are behind in the line and everything is arranged for you... not in a sensible way, it could hinder you a lot, I think, in the coming future, if you do not participate in the discussion and end up with very strict regulations for issues that are, from, say a toxicological point of view, not very sensible, which are costly and will limit the possibilities for further development also, so I think there's no other way than to open up

This was the argument of branch organisations of nanotechnology companies in the United States, who pushed their members to participate in the Environmental Protection Agency's Stewardship programme of voluntary reporting on nanotechnology-enabled products. This had little effect, so clearly the wicked problem around transparency remains.

The voluntary reporting schemes of Defra (UK) and EPA (US) (cf. Kearnes and Rip 2009) demonstrate that it is not just a matter of a new government initiative. It is prepared through actors moving in new directions. Such actors can include firms that realise that they need to proceed cautiously and perhaps assure credibility by being more transparent. Regulatory actors can recognise that there are opportunities for regulatory action but do not know exactly how to proceed. The combination of the two creates a situation where soft law (cf. Bowman and Hodge 2009) can be envisaged. However, even then, there may not be much receptivity; firms are reluctant to start reporting if they do not know how such data will be used.<sup>19</sup>

### **Ambivalence towards NGOs**

Before setting out the findings here, we offer a brief overview of the views and activities of NGOs concerning the development of nanotechnologies in order to provide a backdrop to industrial actors' views presented here.

NGOs have endeavoured to "move beyond a narrow discussion of 'benefits versus risks' to consider the broader social, economic and political dimensions of nanotechnology, to

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<sup>19</sup> By July 2008, only nine companies had registered with the Defra scheme and EPA had received four submissions under the basic programme (and commitments from 12 more companies), whilst no company has agreed to participate in the in-depth programme. Interestingly, some branch organisations, recognising the importance of the scheme for the credibility of the nanotechnology sector, tried to push their members to participate (see Kearnes and Rip 2009).

implement precautionary management of nanotechnology's health and environment hazards, and to involve the public in decision-making" (Miller and Scrinis, 2010, p. 409). For example, in 2007, a 'civil society-labor coalition' released a declaration on *Principles for the Oversight of Nanotechnologies and Nanomaterials* in which it expressed a wide range of concerns, ranging from health and safety of the public and workers to transparency and the inclusion of broader impacts.<sup>20</sup> The need for a precautionary foundation is a primary concern, with some environmental NGOs calling for a strong precautionary approach to the development of nanotechnologies and recommending a product ban<sup>21</sup> on all applications associated with releases leading to human or environmental exposure until evidence demonstrates that they are safe for both human health and the environment. Additional elements viewed as necessary include the need for premarket registration and a regulatory framework that can anticipate the safe management of future applications prior to their availability on the market (Broekhuizen and Reijnders 2011).

It was the issue of the call for a product ban to which we turned first. We asked the industrial actors for their view of the NGO call - specifically the ETC call - for a moratorium on nanotechnology R&D. This question elicited a strong response from all the respondents who argued that a moratorium would prevent progress, referring to the benefits that nanotechnology can bring to mankind and the environment. However, this expected negative response became ambivalent at a later stage of the discussion.

On the one hand, they felt that NGOs had the right to ask critical questions and indeed, that somebody should ask questions on behalf of the public<sup>22</sup>.

The respondent from bionanotechnology company D2 felt that NGOs are "entitled to their position" even when they call for a moratorium on nanotechnology development. He referred to NGOs' efforts to help inform consumer choice and stated "that's right", even if disagreeing on the solutions.

On the other hand, a distinction was made between what one could call "good" and "bad" NGOs (Rip and Shelley-Egan, 2010). In the interviews, "bad" NGOs appeared to be at the fore of the industrial actors' thinking.

The respondent from bionanotechnology company D2 positioned some NGOs as *agitators*:

People start to worry now about nanotechnologies, so the campaigners from the NGOs have done their jobs well... they are valid questions, most of them, they've done their sort of agitation work very well, so congratulations to them

This respondent went on to talk about US NGOs' focus on nano-cosmetics. His view was that US NGOs are using nano-cosmetics and *misleading information* as a means of calling for regulation of cosmetics in the US.

The respondent from the chemical company that had engaged in a dialogue with an NGO and had subsequently been criticised by the NGO for being a frontrunner in the development of nanomaterials (see previous section) positioned the NGO as *failing to act in good faith*.

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<sup>20</sup><http://www.iufdocuments.org/www/documents/Principles%20for%20the%20Oversight%20of%20Nanotechnologies%20and%20Nanomaterials.pdf>

<sup>21</sup> In 2003, the ETC Group, a non-governmental environmental organisation, called for a moratorium on the commercial production of new nanomaterials. For an overview of NGOs that have called for a moratorium on the commercial use of manufactured nanomaterials, see Miller and Scrinis (2010).

<sup>22</sup> This is the enlightened view - there are also industrial actors who are furious over the activities of NGOs.



The respondent from bionanotechnology company D3 was concerned about NGOs *failing to differentiate among different nanotechnologies*, in particular between free-floating nanoparticles and nanoparticles bound to a substrate.

Views about and interactions with NGOs indicate a particular resolution of “wickedness” in which the distinction between “good” and “bad” NGOs was elevated to a strategy to deal with a complex situation. The industrial actors recognised and to an extent, appreciated, the role of NGOs in the responsible development of nanotechnology while at the same time they criticised those “bad” NGOs who, they felt, were not playing the rules of the “game”, that is, “bad” NGOs were positioned as being “tricky” or even dishonest in their dealings with industry. This merges into an expression of frustration by industrial actors who are unhappy with those NGOs whose actions impede the pursuit of companies’ interests.

However, the respondents were reflexive about the situation. The respondent from bionanotechnology company D3 labelled the call for a moratorium “a bit of a knee-jerk reaction” but also conceded that “they’re right in one sense... there’s always a chance that we don’t understand [the risks]....”

The respondent from bionanotechnology company D2 was pragmatic about the situation and asserted that NGOs, as well as industry, must play fair:

So, talking about ethics, the controversy must be ethical on both sides

However, he was also reflexive (and again symmetrical):

Sometimes the industry is not very constructive, sometimes it is the NGOs who are not very constructive.... that’s the life that we are living

As is clear in the response from a respondent from chemical company A1, the “bad” NGOs won’t go away:

Will society – NGOs – be assured if industry says “You know, we’ve taken care of it, we’ve investigated – it’s OK, yes we need a specific Code, we need specific regulation, or not”... not everybody believes industry immediately and even when you speak about industry, there are levels of trust, if you speak about chemicals or petrochemicals or nuclear... But it’s very clear that there are certain groups who are very critical out there and you certainly need some sort of confirmation by other parties, including perhaps governments, to confirm what industry states. Or if you have certain rules, you need verification to see that people are practicing according to the regulations and that will give them some trust but that’s... part of this is about trust, and part of this is very much subjective and some groups will never be reassured. They will always be suspicious about what industry says

In other words, the good/bad distinction (here made by companies about NGOs but the distinction is also used, by firms themselves, to distinguish “good” and “bad” (“cowboy” firms) will not resolve the wicked problem; that is why it is a wicked problem, one could say.

## 5. DISCUSSION

We return here to our initial question concerning how industrial actors are articulating their thoughts and responses to the pressure for responsible development. We started to explore this question by first fleshing out two new features which characterise the current situation of responsible development of nanotechnologies for industry, namely, distributed responsibility and companies having to take other actors into account. The discourse of responsibility, along with the emphasis on distributed responsibility, played a particularly important role in the respondents' articulation of responses to the pressure for responsible development. While the chemical sector emphasises that responsible development is a normal part of its Responsible Care programme, the various other measures which have been implemented by companies in the sector show how they are linking up or connecting, in a practical way to the notion of 'responsible development'. These measures allow the chemical sector to *fill in* what it is to be responsible. The situation is noticeably different for companies in the nanoelectronics and bionanotechnology domains; responsible development of nanotechnology is not a salient issue for them. Even though the nano-electronics sector could be said to be similar to the chemical sector, insofar as both sectors work with hazardous materials, nanotechnology is viewed as business as usual, perhaps with some additional safety measures. Given the strict safety and regulation measures that are already in place in the nano-electronics and medical sectors, these sectors can afford to be forgetful of the responsible development of nanotechnology.

With regard to companies having to take other actors into account, this was again most relevant for the chemical sector which suffers to a greater degree from public lack of trust than do other sectors. The chemical sector appears to have recognised the need to open itself up to the outside world – for instance, with the establishment of an official spokesperson for nanotechnology - and to be transparent in its activities. Indeed its increased visibility has made it an industry leader in the responsible development of nanotechnologies. However, in the effort to be visible in the responsible development of nanotechnologies (as one solution to pressure and uncertainties), additional wicked problems emerge. Companies in the other two domains (nano-electronics and bionanotechnology) are concerned that this increased visibility will have a knock-on effect on their companies' position on the development and use of nanotechnologies. Thus while the other sectors are *aware* of the (chemical sector's) need to go beyond the boundaries of the firm, their concern lies with the possible negative effects of transparency and interactions for their sectors. There was an interesting contrast with the food sector here. On the one hand, the food sector shares the chemical sector's heightened awareness of the public's response to nanotechnology, given the public backlash against GM foods. However, their concern about the public's reaction has not been translated into greater transparency. Indeed the food sector is very reluctant to be transparent in relation to its development and use of nanotechnologies. If responsible development is somehow viewed as special, companies that currently reject the 'special' nature of responsible development will have to fall into line and develop new strategies. However, increased visibility can also have negative effects on chemical companies, that is, by virtue of being visible they will be first in line for criticism.

## 6. CONCLUSION

What do these findings imply for responsible development by industry?

## Differential Uptake of Pressures Leads to a Succession of Wicked Problems

One first-round conclusion is that, in the articulation of thoughts and responses to the pressure for responsible development, a *succession of wicked problems* is revealed, underlining the complexity of the situation for sectors and companies. This situation derives from differential uptake of the pressure for responsible development and the presence of ambiguities and attempts at their resolution.

We see complex interdependencies between sectors in the effort (primarily on the part of the chemical sector) to respond to the pressure for responsible development. Moreover, additional wicked problems emerge as a result of learning by doing, i.e. as a result of the chemical sector actually *operationalising* responsible development. Indeed, this last observation points to the importance of *articulating* the issues of responsible development, as such, and through learning by doing. As argued in the introduction, actions to be taken cannot be simply simplified, given the complex situation. In foregrounding the complexity of the call for responsible development of nanotechnology through understanding industrial actors' articulation of responses, an opportunity is afforded to explore opportunities for learning in the move from articulation to practice.

## Responsible Development and Learning

While we looked at a cross-section of industrial actors at a specific point in time, we can mobilise our empirical data, as well as general observations, to say something about the directions in which learning and new practices are moving. In new developments such as the responsible development of nanotechnology, in addition to distributed responsibility, there is increased interaction with stakeholders in the outside world, requiring new practices and further ethical stances.<sup>23</sup>

Companies have to anticipate societal embedding and interaction with other actors. Companies are forced to learn or "die" and it appears that companies are cognisant of this. A precedent can be found in the case of sustainable technologies. Hart (1995) shows that the motivating factor behind the emergence of new practices in the case of sustainable technologies and products is a combination of prudence and strategic positioning rather than considerations about public interest *per se*. However, the fact that a company addresses broader issues - even out of necessity - has implications for its future actions and interactions; the company cannot revert to earlier, more limited approaches without damaging its credibility (Rip and Groen 2001). Hart (1995) argues that this explains the gradual inclusion of broader and more proactive approaches by firms.

The development of Codes of Conduct for nanotechnology by companies may provide for such learning, in addition to an opportunity for the broadening of ethical stances (Rip and Shelley-Egan, 2010). The public space opened up by such codes does two things. One, it creates

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<sup>23</sup> This indicates the emergence of a new situation which business ethics will have to take into account. Pragmatist ethics is a particularly suitable ethical approach for emerging situations. Pragmatist ethics starts with a specific problematic situation and emphasises the manner in which actors address the situation and can develop novel constructs and vocabularies with which to approach emergent problems (Keulartz et al. 2004).

an opportunity where a subscriber to the code can be called to account by other actors referring to the code. Two, the public space can facilitate deliberation and “probing each other’s worlds” and can be used for learning by all parties (ibid). Such practices and learning can contribute to making the problem of how to articulate and operationalise responsible development manageable.

### **Operationalising Responsible Development within a Broader Context of Industrial Activity**

While the problem of how to “do” responsible development may not be resolved, it is the *process* of responsible development that is important. This process can stimulate critical reflection on issues that are often backgrounded, such as the direction of the development of nanotechnologies. Thus the responsible development of nanotechnologies may open up new avenues of moral practice for business practitioners. In other words, there are openings. The question is will they be taken up? Are there incentives? Is there enough space for interactive learning?

A productive entrance point could be not to limit oneself to the issues of responsible development as such but locate these issues within the overall landscape in which companies exist. The challenge of distributed responsibility outlined earlier can be located in a more general move towards distributed innovation (and distributed governance), including some transparency. A number of studies have endeavoured to do this; for example, within the EU context and as part of the Dutch TA NanoNed initiative, responsible research and innovation has been explored as part of the broader shifts in research and innovation processes through scenarios and constructive technology assessment workshops with diverse stakeholders such as industrial actors, labour union representatives, nanoscientists and social science and ethics scholars (Robinson 2009)<sup>24</sup>.

### **Open Innovation as another Learning Process**

One approach to the wicked problems faced by industrial actors, is to implement “open innovation” strategies (Chesbrough 2003).<sup>25</sup> Firms started to look to the new model of “open innovation” as a means of commercialising both their own ideas and the ideas of other firms and of bringing their in-house ideas to market by employing pathways outside their current business (ibid). In practice, open innovation is not so easy; companies have to deal with IP issues, they have to understand the needs and capabilities of their potential partners and there

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<sup>24</sup> There are a variety of activities and projects which, to a greater or lesser extent, approach these issues. Continuing with Robinson, there is the Forecasting Innovation Pathways approach (Robinson and Propp 2008, Robinson et al. , 2013). For a US example, there is the socio-technical integration research (STIR) activity led by Erik Fisher (Schuurbiens and Fisher 2009).

<sup>25</sup> According to the old model of closed innovation, successful innovation requires control. Thus companies had to create their own ideas that they would then develop, manufacture, distribute and service themselves (Chesbrough 2003). However, certain factors such as a dramatic rise in the availability and mobility of knowledge workers and the growth of the venture capital market necessitated new models of innovation.

can be failure to build trust. Similarly, for responsible development, its operationalisation may not be easy.

### **Closing Remarks**

This paper has shown an essential structure - the succession of wicked problems – in the pressure to respond to the call for responsible development. This structure will remain in the *implementation* of responsible development activities. Thus, there is a need for reflection, rather than jumping straight into activities and interactions around responsible development. A first step towards this would be the further characterisation and classification of industrial actors' articulations regarding the nature of responsible development - what is responsible development? – and approaches to implementation – how can it be implemented?

Another step would be to explore the proposed mechanisms for responsible development, in nanotechnology and other emerging technology fields, to see how they match the core activities of industrial actors – can industrial actors take up and incorporate aspects of responsible development in their existing regime of behaviour? This is not clear and requires further investigation. One entrance point would be to explore the incentives and disincentives for change in the ongoing practices of industrial actors, with a view to the potential inclusion of elements of responsible development. This is a line of investigation which the authors of this chapter have already begun.

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