Working Paper Series

#2009-063

Assessing risk discourses: Nano S&T in the Global South

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Assessing risk discourses: Nano S&T in the Global South[1]

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Abstract

Nano science and technology (nano S&T) has potential to change our lives for the better, but at the same time, it causes also a significant amount of concern in terms of related health, environmental, ethical and societal risks. It is increasingly recognized that addressing these concerns requires appropriate governance of nano S&T, which should arguably involve a number of different stakeholders, including various publics. Nano S&T is seen as having particular positive and negative implications in the Global South, and it appears that discourses around such issues in the South have not yet been systemically researched. This paper will therefore investigate nano S&T discourses in South Africa, India, Hong Kong and Kenya by analysing newspaper media in these countries. Most nano S&T media studies done previously in the Global North have looked at the risk-opportunity dichotomy, but here a somewhat different approach is taken by testing concepts such as risk actions and complexity in the context of media discourse analysis. Using both qualitative and quantitative methods, this paper will examine which risk actions are prominent in the newspaper stories, analyse the complexities included in the discourse, as well as the general framing of nano S&T. Trends over the last decade will also be investigated. Finally, the results from the included countries will be compared with each other, as well as with similar studies done in the North. This paper will argue, firstly, that, although they share some features, media discourses around nano S&T in the South and the North vary considerably. Secondly, a more methodological argument will also be made. Looking at risk actions and complexities included in various discourses is potentially an interesting analytical method, which could contribute to analysing risk discourses and to successful and inclusive risk governance in general, also regarding other global risk issues.

Key words: nano S&T, governance, Global South, risk, ignorance

JEL codes: O30, O32, O33, O38, O53, O55, O57

[1] This paper is based on a Master's thesis for the Faculty of Arts and Social Sciences, Maastricht University. Acknowledgments are due to Dr. Ragna Zeiss and Prof. Dr. Ir. Wiebe E. Bijker, co-supervisors of the thesis.

UNU-MERIT Working Papers
ISSN 1871-9872

Maastricht Economic and social Research and training centre on Innovation and Technology, UNU-MERIT

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1. Introduction

This section will first introduce the context of the study, namely nano science and technology (nano S&T) in general, and the meaning of nano S&T to the Global South, as well as clarify the focus of this study. The relationship between media, risks and science, will also be looked at, as well as a number of studies on nano S&T discourses in the Global North. Finally, this section will explain the further structure of this paper.

1.1 Nano S&T, risks and the Global South

1.1.1 Nano S&T and its potential

According to one common definition, nano S&T comprises:

> The understanding and control of matter at dimensions of roughly 1 to 100 nanometers, where unique phenomena enable novel applications. Encompassing nanoscale science, engineering and technology, [nano S&T] involves imaging, measuring, modelling, and manipulating matter at this length scale. (US National Nanotechnology Initiative)

At the nanoscale, materials behave differently than otherwise, and they have different properties, mainly due to quantum effects and the much larger surface to mass ratio of nanomaterials (Allianz AG and OECD, 2005).[2] The basic sciences of chemistry, biology, electronics, physics, materials science and engineering start to converge on this scale, and, therefore, also the applications of nano S&T are so varied. Together with advances in biotechnology, information and communication technologies (ICTs) and cognitive science (together called NBIC), nano S&T has quickly become the standard for advanced science and technology in most industrialized countries, to the extent that a number of established areas of S&T have be re-labelled as nano S&T. The excitement about current, probable and possible applications is considerable, and the share of global manufacturing output incorporating nano S&T - including products where nano S&T has been used only in the manufacturing phase - has been estimated to reach 15% by 2014 (Allianz AG and OECD, 2005) with also countries in the Global South contributing to this.

More promising in their general utility than the current sunscreens or stain-resistant clothing, the predicted near future applications of nano S&T include: huge improvements in data storage capacity and processing speeds of computers, catalysts that greatly increase the combustion efficiency of motor vehicles, new drug delivery systems within human bodies, material for bone and tissue regeneration, new more efficient ways to produce clean energy, membranes for filtering environmental contaminants, or salt from water, significant reductions in materials and energy use in industrial manufacturing, reduced sources of pollution and better detection and detoxification of chemical and biological weapons (Allianz

[2] Wikipedia gives the following examples of the different behaviours and properties: opaque substances become transparent, inert materials become catalysts, stable materials become combustible, solids turn into liquids at room temperature and insulators become conductors (http://en.wikipedia.org/wiki/Nanotechnology, accessed 20 July 2009).

AG and OECD, 2005). Within molecular manufacturing, some foresee possibilities for building almost any structure from bottom-up, utilizing nanoscale machines ('nanobots').

Importantly, in the Global South, nano S&T is seen as potentially being able to solve a number of serious problems. The particular opportunities for countries suffering from the effects of poverty and underdeveloped institutions[3] include cheap water filtering systems, cheap photovoltaic films, simple medical diagnostic test units, faster internet connections, affordable computers, cheaper food, and more efficient and sustainable food production (Meridian Institute, 2005).

1.1.2 The risks and what to do with them

However, both the changed behaviour and characteristics of nanoscale materials and the possibilities within molecular manufacturing also bring new risks that may or may not be predicted or mitigated. Potential risks include those related to human health and safety, environment, society and ethics, and are briefly outlined in Box 1.1.

The main current problem regarding nano S&T risk assessment as regards nanoparticles is that existing toxicological studies on various materials are not useful for predicting the toxicology of these same materials on nanoscale. Therefore, for example, a report by the UK Royal Society and the Royal Academy of Engineering (2004) has recommended that nanomaterials should be treated as new chemical substances, rather than smaller quantities of existing and familiar substances. Moreover, a scientific committee (SCENIHR)[4] consulted by the European Commission (2006b) has concluded that current risk assessment methods are not adequate for dealing with the hazards related to nano S&T. SCENIHR also warns that there are major gaps in the knowledge necessary for risk assessment. Finally, European Commission (2006a) outlines the major challenges related to achieving safe nano S&T, which range from developing new detection instruments, evaluation methods and impact models to strategic research programmes.

The societal risks associated with nano S&T are also difficult to assess, as we cannot know how the nano S&T industry will develop, in what sectors or countries it will concentrate, how quickly, how far it will go and what the precise impacts will be.

[3] This includes both formal and informal institutions, see e.g. North (2005) or Cantwell et al. (forthcoming) for more on institutions and issues related to development.
[4] Scientific Committee on Emerging and Newly Identified Health Risks

Box 1.1 Possible risks related to nano S&T

Possible health risks may come from free nanoparticles being inhaled, swallowed, absorbed through skin or injected into the body, subsequently crossing barriers that would normally protect our organs from foreign particles. These nanoparticles could then, for example, accumulate in the brain or in the lungs causing damage to cells there. A number of animal studies as well as human tissue culture studies have indeed shown such toxicity (see e.g. Scientific American articles 'Do nanoparticles in food pose a health risk?' by David Biello, 13 Mar 2008, and 'Study says carbon nanotubes as dangerous as asbestos' by Larry Greenemeier, 20 May 2008). Additionally, already existing nanoparticles – either from human or natural pollution, for example, soot – have been shown to be toxic. Free nanoparticles can also accumulate in the soil, water or plants, when being released either during production, use or disposal of nanotechnology products. They can then either cause damage at their original location or be further incorporated into natural cycles or the food chain (see a press release by IPEN, an international coalition of NGOs in http://www.wecf.eu/download/2009/FINAL-OECDenvironmentalBrief130709.pdf, accessed on 21 July 2009 which draws together recent related research). They may also interact with other environmental contaminants causing further risks (European Commission, 2008b). Specific to the concerns in the Global South, there is also some evidence that certain carbon nanomaterials can, for example, significantly reduce the yields of rice crops (Lin et al., 2009).

Further, there are increasing concerns regarding the overall energy, water and other resource consumption required for nano S&T, casting doubt on the claims by industry that nano S&T will save energy and resources instead of increasing their use or wasting them (see Sengül et al, 2008 or Khanna et al., 2008). These concerns increase the importance of life-cycle assessment of nano S&T applications and their risks.

The societal impacts of nano S&T are mostly not immediate, but many of them may be relevant in the next decade or two. If nano S&T will continue to develop rapidly, and bring about not just novel products, but also new ways to do old things, their impact on the economy and industrial and societal structures may be rather disruptive, for example to the manufacturing industries. Additionally, in this case, the 'nano-divide' between countries able and not able to embrace nano S&T could become very significant. Not only might certain countries in the Global South be unable to benefit from the technologies, but their position in the marketplace could be severely affected, if many of their raw materials or other commodities were no longer wanted. Further, some nano S&T applications, such as water filtration, could further decrease the control local communities have over their resources, as the control would be transferred to patent-holding private firms (Barlow, 2007).

Finally, security related issues include the possibilities for building new classes of chemical or biological weapons using molecular manufacturing, or even the threat of the 'gray goo', that some fear could be within the realms of possibility.

Despite all these unknowns described above, and the existing studies that raise concerns about risks related to nano S&T, no country currently has specific regulations regarding existing or future nano S&T applications (IRGC, 2009). The first steps in this direction, however, include the consideration the European Union has recently given to nano S&T regulation, e.g. regarding potential inclusion of nanoparticles within the European REACH,[5] and the setting up of the new voluntary EU code of conduct for research within nano S&T (European Commission, 2008a), as well as the US Environmental Protection Agency's (EPA) recent position regarding regulating carbon nanotubes.[6] In Europe, these steps have mostly taken place, at least until recently, without much pressure from the civil society, as the

[5] Regulation on registration, evaluation, authorisation and restriction of chemicals

[6] Meridian Institute news, posted 13 July 2009 on http://www.merid.org/NDN/more.php?id=2021, accessed on 20 July 2009.

European public seems to be either not aware[7] or not very concerned about nano S&T (Gaskell et al., 2006), and, apart from organizations in the UK, few European non-governmental organizations (NGOs) have taken a position on nano S&T (Lee, 2006).

There are arguments for and against explicit regulation of nano S&T, but it seems that some consensus is gradually starting to form on the importance of at least some nano S&T regulation and governance.

From the point of view of the Global South, there are at least two concerns pointed out by the Meridian Institute (2005): public awareness in the South is generally at an even worse level than in the developed world, and regulatory capacity in these countries is not ready for nano S&T, as their regulations are lacking in general, and the existing regulations are not adequately enforced or monitored.[8] One way to create national legislation is to adopt international regimes, and Chowdhury and Srivastava (2008) argue that international institutions are increasingly seen as efficient and effective sites of regime creation. This could also apply in the South, for example, in India, where the domestic nano S&T regulation is still "at a nascent stage and essentially reactive in nature" (Chowdhury and Srivastava, 2008). The International Risk Governance Council (IRGC)[9] is one such international institution which has taken nano S&T governance as one of its focus areas. Related work by IRGC will be discussed further in Section 2.

1.1.3 Focus

From the above discussion, it becomes clear that although nano S&T may be bringing many benefits to both the Global North and the Global South, there are still many crucial issues that need to be addressed. This paper focuses on countries in the South, as both the benefits and the risks may be more fundamental to them, and because of their perceived greater vulnerability regarding the risks, for example, threatening the South's role as the producer of raw materials for industries in the North.

The main research questions in this paper are: How is nano S&T constructed in different countries in the Global South, and as compared to countries in the Global North? Are there any country-specific themes? What elements of a discourse on risk can be found? Are the discourses on nano S&T balanced, in terms of covering both risks and benefits? Further, this paper will analyse the risk discourses by using the concept of 'risk action' (discussed further in Section 2), and will try to find out which are the most prominent risk actions in these discourses. The complexity of the discourses will also be explored.

It is interesting to, on the one hand, investigate whether the discourses in the Global South would be fertile ground for a public debate about nano S&T, and on the other hand, test risk discourse analysis (risk action analysis in particular), with the idea that such analysis could

[7] For example, the UK consumer advocate group Which? found that 61% of UK adults had not heard of the term 'nanotechnology' (see article 'Consumers unaware of nano-revolution', 20 Dec 2007, www.which.co.uk).
[8] See e.g. Mytelka (2008) or Randerson (2008) for the Global South in relation to various emerging technologies, or e.g. Michelson (2006), Invernizzi and Foladori (2006), Invernizzi et al. (2008), Schummer (2007), UN (2008) or Kahwa et al. (forthcoming) for nano S&T and the Global South.
[9] See website at http://www.irgc.org.

be included in risk governance of emerging technologies such as nano S&T, or other global risk issues, such as climate change, which also involves (risk) actions from the whole society.

1.2 Studying the media

1.2.1 Media, science, risks and the public

There is a vast literature on science communication and the role of media in it, and on public understanding of science (some relevant examples include Lewenstein, 1995; Wynne, 1995; Oudshoorn, 1999; Bucchi, 1998, 2004; and Sismondo, 2004). There is no agreement on the exact role of media, but generally the current literature seems to say that on the one hand, media does not determine the views of the various publics on science, it acts more as an information provider, while also having an agenda-setting function, with some responsibilities that come with it. On the other hand, it is increasingly believed among social researchers that augmenting scientific knowledge among the public does not increase public acceptance of S&T, this point arguing against the so-called deficit model (see e.g. Anderson et al., 2009 for a discussion).

Regarding media influence on public perceptions of science, much may depend on the context, and the media may have more influence in some issues than in others. For example, Nelkin (1995) argues that in issues where the public has little prior knowledge – such as emerging technologies - the media defines the reality. On the other hand, a study by Ten Eyck (2005) on biotechnology suggests that the relationship is quite complicated, although the media certainly does seem to be an important information source. However, drawing together a number of different studies, Stephens (2005) concludes that science news reporting tends to present a positive view of science, tends to be uncritical of scientific claims, and does not include wide enough range of relevant actors, for example, activists. On the other hand, when something goes wrong, the press becomes skeptical.

Carvalho & Burgess (2005) include a discussion on the role of media in relation to risk communication, and also on how the producers and consumers of media messages around an issue are together engaged in a dynamic process that constructs risks. The ideologies of newspapers are also important in shaping messages about risk. On the other hand, Dunwoody and Neuwirth (1991) argue that the media may not be determining risk judgements (or risk actions) of people as much as provide information on risk.[10] Media is indeed often seen as having a clear role in risk communication in the related literature.[11]

Inclusion or exclusion of uncertainties makes a crucial difference for risk communication, and here research shows that media mostly tends to make science appear more certain than it is (see Stocking, 1999 for an overview), while sometimes they do the opposite.

[10] Importantly, this present study is not about what people do with media messages (or what risk actions they finally choose), but what the messages themselves are. For example, if the message is to ignore risks related to nano S&T, people may choose to do this or not. The message itself is still relevant, and the alternatives would include there being no messages related to nano S&T, or the message being that we should be concerned about or avoid risks.

[11] Murdock et al. (2003), for example, present a model of mediated risk communication where the media is central, but still only one channel of risk communication.

Generally not much is known about how the various publics make sense of information about complex scientific issues where uncertainties are important (Einsiedel and Thorne, 1999, and Rogers, 1999). However, if newspaper stories exclude uncertainties (and/or risks), they may be unconsciously or consciously advocating 'organized irresponsibility' (Beck, 1992).

Media has also been seen as having other roles in relation to new technologies. Te Kulve (2006) argues that media discourse can act as technology assessment. Arguably, this would only be the case when the discourse is rich enough to include several viewpoints, different topics, and a discussion on risks, and furthermore, the discourse may also have to be analysed first. On similar lines and based on her research, Oudshoorn (1999) believes that media can be an important location for the testing of the "feasibility of a technology". According to Decker and Ladikas (2004), the important impacts of technology assessment include: raising knowledge, forming attitudes and opinions, and initiating actions. If we then consider newspaper discourse as technology assessment, it can certainly be considered suggesting also *risk* actions. A dual meaning for media discourse as technology assessment can therefore be seen: firstly, analyzing the discourse gives us some indication of how a technology is currently perceived, and secondly, the discourse can play a role in public engagement in further societal technology assessment (a position taken by e.g. Petersen et al. 2008).[12]

1.2.2 Media studies on nano S&T

Anderson et al. (2009) argue that nano S&T is a unique topic in relation to media and risk communication for a number of reasons. Firstly, both serious risks and large benefits for the society have been present from the outset, while there has also been emphasis on more ordinary consumer products. Secondly, nano scientists have been both more optimistic about benefits and concerned about risks than the general public. Thirdly, the related risks tend to be 'invisible', and reporting on invisible risks in the current (new) culture of science reporting is a challenge. They also maintain that the press may play an important role in framing emerging technologies, for example by helping to establish the "initial parameters of the debate".

Earlier literature has studied print media related to nano S&T in a number of countries in the Global North (at least in the US, UK, Netherlands, Norway, Denmark, Canada and Germany), but it seems that no country in the Global South has yet been systematically looked at in terms of media discourse on nano S&T, so these countries can be seen as neglected data in this respect. This provides motivation for the present study. There are also calls in the literature for more case studies to see how countries differ (or not) in the treatment of nano S&T in the press (see e.g. Schmidt Kjaergaard, 2008; Anderson et al., 2009; Roco and Bainbridge, 2006; and Lewenstein et al., 2006), so this research adds to the pool of such case studies.

[12] It must be noted that the literature generally used to study media, risk and science communication is mostly from authors based in the Global North, and generalizing it to different cultural contexts, and to countries in the Global South, may not be straightforward.

The present study will provide a different take than the previous studies on the issue of nano S&T discourses by focusing also on the risk actions and complexity of the stories, by looking at discourses outside the Global North, and by comparing these to the previous studies in the North.

Finally, these case studies will be used as an example of risk discourses to be explored, and as a testing ground for experimenting with vocabulary, especially concerning complex, uncertain and ambiguous risks - the 'other' class of risks that are not simple.[13]

1.3 Structure of paper

The structure of the remainder of this paper is as follows. Section 2 will present the research framework by first briefly discussing literature on risk governance, paying special attention to the IRGC framework, and subsequently, by introducing the various elements used in the textual analysis. A typology of risk actions will also be presented, and later, used in the analysis. The practical set-up of this study will be explained at the end of Section 2.

Section 3 will first present a brief systematic analysis of the previous nano S&T media studies in Europe and North America, and then selected results from the analysis of the newspaper articles from four countries, Hong Kong[14], South Africa, Kenya and India.[15] Subsequently, Section 4 will pull the analyses from both the South and the North together, and present some further quantitative analysis of the overall data collected, also linking the findings to the relevant literature. Finally, Section 5 will conclude. The two annexes to this paper give the distribution of the newspaper articles over time (Annex A) and the headlines of the articles referenced in this paper (Annex B).

[13] Simple risks can be defined in the classical way as probability x effect, but complex risks cannot, as the probabilities are not known. As van Asselt (2009) has pointed out, the vocabulary for these risks is not yet stable.
[14] In this paper, the Special Administrative Region (SAR) of Hong Kong is referred to as a country, on the basis that it is independent enough in terms of its developments in science, technology, business and trade, as well as the societal discourse around these areas.
[15] The Master's thesis that this paper is based on includes a detailed analysis of the discourses in these countries.

2. Research framework and methodology

As the main motivation for this paper is related to effective risk governance of complex issues such as nano S&T, this section will first look at some literature on risk governance, focusing on the International Risk Governance Council (IRGC) framework. Subsequently, the elements of the analysis in this paper will be explored, including suggesting a typology of risk actions. It is worth noting here that the typology is not based on the IRGC framework. This typology offers a way to assess approaches to risks in a discourse around an important risk topic. A risk governance framework, such as the IRGC model, could be seen incorporating a risk action, or risk discourse analysis into it to help find out how an issue is assessed within a discourse, and consequently, to help decide the right mode of risk communication.

2.1 Governing risks

Ulrich Beck's (1992) risk society is organized in response to the inherent risks induced by modernisation, and complex technologies in particular. If our society indeed is viewed as a risk society, risk governance is naturally central to organizing such a society.

As risk governance – a broader concept than risk management - relates to emerging technologies, such as nano S&T, and the contents of the present study, a few key ideas are central. Issues of power, stakeholder participation, and decision-making are central to governance in general, and risk governance in particular includes "the totality of actors, rules, conventions, processes, and mechanism concerned with how relevant risk information is collected, analysed and communicated and management decisions are taken" (Renn and Roco, 2006: p. 157). However, as described in Section 1, a significant level of uncertainty, lack of knowledge, and gaps in regulatory systems are currently regular features of the nano S&T risks to be governed worldwide, now and in the near future. Renn and Roco (2006) present a dozen different gaps in current nano S&T risk governance, and Renn and Walker (2008b) list the historical failures in risk governance in general. To help prevent such failures from occurring in the future, the IRGC was established in 2003. The IRGC governance model follows a significant amount of related literature and other earlier models (see discussion in e.g. Klinke and Renn, 2002; Bekkers and Thaens, 2005; and Löfstedt, 2005). This framework is particularly applicable for complex risks with large impacts, good amount of uncertainties and differing values, such as many nano S&T related risks.

The IRGC model includes four risk types: simple, complex, uncertain and ambiguous. Table 2.1 shows the distinctions between the types, following Renn and Walker (2008b). The key idea is that different management strategies and instruments apply to different risks, and different stakeholders should be involved. However, some of the same criticisms about this risk typology already expressed and discussed in Renn and Walker (2008a) is also voiced here: no risks are really just simple, and most risks include some complexities, uncertainties, and value judgements, in particular. The addition of values, for example, only comes at the most extreme end of this typology. But in the present study (and elsewhere), it is argued that even the most seemingly simple risks often involve values.

There is always someone who will disagree about a risk.[16] Although IRGC (2008) does recommend that the most dominant characteristic of a risk is used to categorise it and to help decide the appropriate level of stakeholder involvement, deciding what this characteristic is can still be difficult.[17]

Table 2.1 IRGC framework risk types

Risk type	Characterisation	Explanation
Simple	Cause -> effect	Direct link between the two
Complex*	Causal web	Multiple factors interacting
Uncertain	Causal web + uncertainties	Added difficulties to risk governance from uncertainties
Ambiguous	Causal web + uncertainties + values	Different actors or stakeholders value certain inputs or outcomes differently

*Complexity here is defined as "the difficulty of identifying and quantifying causal links between (…) potential causal agents and (…) observed effects" (Renn and Walker, 2008a: p. 19).

Source: Interpreted from Renn and Walker (2008b).

The IRGC model is based on four consecutive phases: pre-assessment, appraisal, characterization/evaluation and management, and communication which importantly accompanies all four above-mentioned phases (see e.g. Renn and Walker, 2008a). The model has been applied to nano S&T (see e.g. Renn and Roco, 2006; IRGC, 2009, or the Health Council of the Netherlands, 2006).[18]

The IRGC framework gives great emphasis to contextual factors (societal and cultural), and this is indeed particularly relevant for nano S&T governance because of the broad implications of the technology (see e.g. Renn and Roco, 2006). Similarly, *concern assessment* (see Section 2) is an important element of the framework as it applies to nano S&T. On the other hand, the framework could highlight the important role of *life-cycle assessment* of risks more.[19]

[16] A careless driver, for example, will not consider wearing seatbelts necessary, and a suicidal driver will not think driving into a ditch as a real risk! Values are related to even those risk choices which would seem obvious at first hand.

[17] Van Asselt (e.g. 2009) prefers a simpler categorisation, where the level of uncertainty is key to classifying risks. Questions of risk governance apply mostly to the more uncertain risks. Narrower risk management applies to simpler risks.

[18] Nano S&T governance is also discussed in e.g. Barben et al. (2008) and in Marchant et al. 2008. Hansen et al. (2008) also usefully apply the '12 late lessons from early warnings' from Harremoes et al. (2002) to nano S&T governance.

[19] In the context of environmental risks, US EPA defines life-cycle assessment as a "technique to assess the environmental aspects and potential impacts associated with a product, process, or service, by: compiling an inventory of relevant energy and material inputs and environmental releases; by evaluating the potential environmental impacts associated with identified inputs and releases; and by interpreting the results to help you make a more informed decision" (http://www.epa.gov/nrmrl/lcaccess/, site accessed on 15 Sept 2009). This is a particularly relevant concept for nano S&T, where risk assessment is very challenging and the benefits of the technology are not always straightforward.

There is also a considerable body of literature specifically concerning public involvement in governing emerging technologies (see e.g. Jasanoff, 2003). Mostly, public involvement – or so-called upstream engagement - is considered fruitful and often even necessary at least in some stages of the process towards a balanced technology government, and according to Petersen et al. (2008), this appears to also be the view of (nano)scientists themselves.[20]

If a society manages to have a broad approach and include various publics in the risk governance of nano S&T, it may be able to reduce its vulnerability, which may be better than simply reducing certain nano S&T related risks (for which the public might not need to be involved in).[21] A link can be made here between the broad values that Laird (2006) calls for nano S&T governance and the trust in institutions that, for example, Moore (2006) and Priest et al. (2003) advocate as crucial for public acceptance of nano S&T, much more important that scientific literacy. On the other hand, Löfstedt (2005) argues that in some cases public engagement can undermine trust, and that the risk governance (or management in his terms) method should be chosen based on the existing level of trust - in industry or in regulators - so that the more trust there is, the less you need to involve everyone, and vice versa.[22]

2.2 Analytical elements

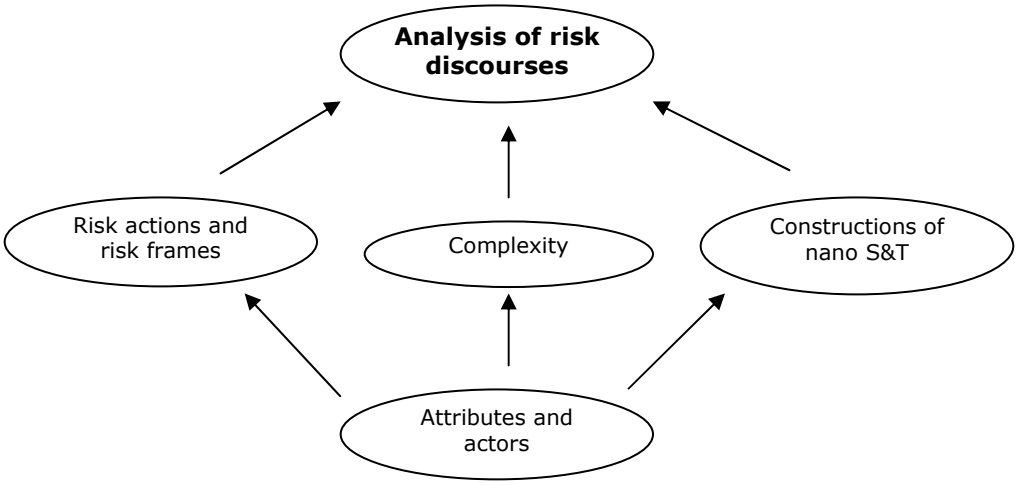
This section will explain a number of relevant analytical elements and concepts – such as actors, attributes, risk actions, risk frames and complexity – and explore further the focus of this study. Figure 2.1 clarifies the connections between the various elements.

[20] Kjolberg (2009) calls attention to is how *upstream public engagement* is defined in practice, should it be spontaneous or organised? Spontaneous engagement involves prior public debate, whereas organised engagement may not do that.

[21] As Bijker (2006) notes, vulnerability refers to a system condition, and risk is a more outcome-oriented concept. Further, Sarewitz et al. (2003) argue that reducing vulnerability is more important and has different consequences than reducing risks. The former can make a system (such as a society) overall more resilient, and the latter concerns a narrower focus on specific risks. A narrow focus on specific nano S&T related risks can also have unintended consequences.

[22] Further, e.g. Joly and Kaufmann (2008), or the feedback chapters in Renn & Walker (2008a), are critical about public involvement in nano S&T governance.

Figure 2.1 Analytical elements in this study (structure of Section 2.2)



Note: As can be seen from the above figure, attributes and actors contribute to several other elements.

2.2.1 Attributes and actors

Attributes and actors are the first specific elements discussed, and a brief step away from the risk context. Attributes denote here the topics discussed in the nano S&T related articles. The full range of topics identified in this study includes topics such as scientific work, discoveries within and applications of nano S&T, discussion on health, safety and environment related issues, nanoethics, governance and regulation of nano S&T, education, business and investment in nano S&T. Most of these topics are similar to those identified in the existing studies on media discourse around nano S&T (see e.g. te Kulve, 2006, Schmidt Kjaegaard, 2008, Stephens, 2005, Zimmer et al., 2008 and Fitzgerald, 2005). Identifying the topics, or attributes, is important for three main reasons. Firstly, they provide a quick way to see where the discourse is in each newspaper or country in question. Secondly, they help understand the complexity of the discourse in the sense that the more topics discussed, the more complex the technology is constructed as. And thirdly, they assist in identifying the risk frame of each article.

The actors engaged in risk actions include various societal groups, for example, policymakers, scientists and engineers, various publics, firms, universities, governments, NGOs and the media itself. The inclusion of actors in the present analysis is firstly, to assist in determining the complexity of the discourse (in addition to the contribution from attributes and various risk actions), and secondly, to look for what is typical in each newspaper discourse, which actors are given prominence and which are in the sidelines. For this reason, also the location of the actors is considered, in other words whether they are domestic or foreign.

2.2.2 Risk actions and frames

What is a risk action?

The notion of risk action can be partly drawn from the various literatures relating to the concept of risk and risk governance (e.g. Renn & Walker, 2008a; Pidgeon et al. 2003), but the treatment here is unique. A risk action is here defined as any action related to risk, and including conscious as well as unconscious actions. By first grouping all actions related to risk together, a way of evaluating these actions on a more levelled way can be achieved. At the same time, this method points out the vast differences between various risk actions. For example, different risk actions have, often critically, different consequences. For example, the difference between *ignoring* a risk from not wearing seatbelts vs. *eliminating* it by wearing them is considerable, or similarly, the difference between buying a product knowing that it has potential risks (*ignoring* risk), or not buying it because of those potential risks (*avoiding* risk).[23]

Risks can be viewed as linked to values. The IRGC scheme of classifying risks into different groups is based on their complexity, and the level of uncertainty and ambiguity involved, with only the last one involving the inclusion of values. However, as mentioned earlier in this section, it can be argued (with e.g. Kahan et al., 2007 and Leiserowitz, 2006) that most risks, in fact, involve value judgements. For some examples related to nano S&T risks: do we care more about the environment or advancements in health care? More about the gap between rich and poor countries or the economic development in our own (rich) country? More about safety or privacy? These are all value judgements, where 'right' and 'wrong' are not easily decidable.

Risks can therefore be seen as something to be avoided, controlled, eliminated etc. when preventing the potential impacts is given high enough value. Alternatively, risks can be seen as something to be (actively) ignored, when preventing the potential impacts is given a low (or 'negative') value, i.e. the impacts are not seen as something to worry about. This value may or may not be a financial value, but it should be viewed as a broader concept encompassing 'valuing' in general. Assuming that most risks are linked to values, the link between risk actions and values becomes clear, as we take action on risks based on value judgements (as well as trust). Related to this, Priest et al. (2003) argue that people do not make risk (action) choices based on assessment of costs and benefits, but based on assessment of the values and trustworthiness of other related social actors. In other words, if the values are shared, we tend to trust more.[24]

[23] Similarly, the contexts that lead to one risk action, rather than another, vary a great deal. For example, not fully considering the potential consequences of being caught when cheating on your taxes may sometimes lead a person to take the risk and cheat. On the other hand, thinking through what could happen (being sent to prison, or losing your job as a consequence), in other words, assessing the risk, will probably make the same person avoid the risk and not cheat.

[24] The literature that discusses the role of trust in technologies includes Wynne (1995), Jasanoff (1996), Priest et al. (2003), Löfstedt (2005), Moore (2006) and Kahan et al. (2008), among others.

Typology

Figure 2.2 presents a typology which divides risk actions into five groups. The first division is into basic and advanced risk actions, with the former including actions that are somewhat simpler to perform (e.g. *avoiding* or *taking* a risk), and the latter including actions that require more effort on the part of the actor (e.g. *attenuating* or *controlling* a risk). A second division within these groups is made between negative, neutral and positive risk actions, with this division referring to how much value is given to preventing the risk impact, for a particular action to be appropriate. The impact of risk actions is different depending on the type of risk in question, so that when we talk about more simple risks fewer risk actions apply than when we talk about more uncertain risks.

For a general example in the basic category, in many circumstances, avoiding risk as a routine measure (*passively avoiding* risk) can be seen as not involving any judgement on the value of preventing specific risk impacts. On the other hand, taking a risk knowingly (*informed risk taking*) can be seen as giving negative (or low) value to preventing the risk impact, i.e. the impact does not matter, although it has been considered. As further examples, *uninformed risk taking* can be considered neutral (as it is not involving any value judgement) and *actively avoiding* risk positive (as it takes place after considering risk impacts worth preventing).

In the advanced category, *amplifying* risks can be seen as 'positive' because preventing the risk impact is given a high value. Other risk actions in the same category are those that can be argued to be the most crucial for handling emerging technologies, such as nano S&T, which include complex and uncertain risks. In shorthand, this group can be referred to as PARAs (positive advanced risk actions). In Figure 2.2, all risk actions which can be seen as part of *risk governance* have been marked in blue. Depending on the definition of *risk management*, some of these fall under this as well (such as *identifying*, *assessing* and *controlling* risks).[25]

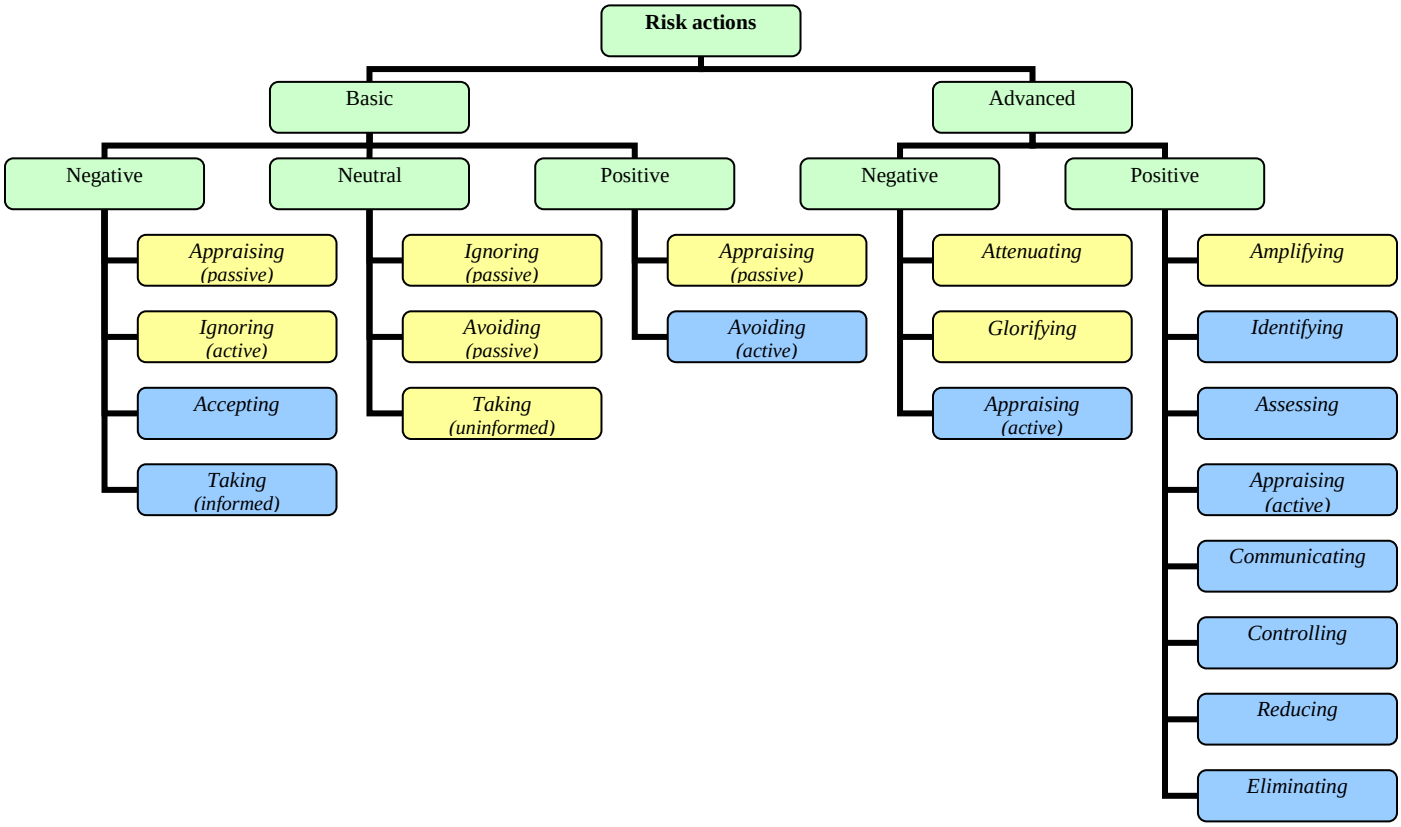
According to the typology, risk governance includes a number of negative risk actions. These apply when the risk impacts can be accepted or the risks taken without further consideration. It is important to note that the negative/neutral/positive categories do not, therefore, indicate a value judgement of the risk actions themselves, they simply indicate the relationship between risk impact and the value given on avoiding this impact. In fact, the least constructive kind of risk actions can be said to be the basic neutral risk actions, as no value judgement has been made in connection with these.

The IRGC framework (see e.g. IRGC, 2008) includes most of the 'blue risk actions' in some form or another. However, this typology is not otherwise based on the IRGC framework. The framework does not use the 'risk action' concept, nor does it include any similar classifications, or make connections between risks and value assessment in the way done

[25] M*anaging* or *regulating* risk are not mentioned separately in Figure 2.2, as they can be seen to cover several risk actions.

here. Sections 3 and 4 of this paper offer examples of how this typology can be used to assess approaches to risks in a discourse (in the media, in public documents etc.) around an important and/or challenging topic, such as nano S&T, or climate change, to give another example. A risk governance framework, such as the IRGC model, could also incorporate a risk action analysis into it (in the IRGC model this could be somewhere within the pre-assessment or appraisal phases) to help find out how an issue is assessed within a discourse, and consequently, to help decide the right mode of risk communication.[26]

Figure 2.2 Risk action typology



Key: The negative/neutral/positive categories are based on what kind of value has been attached to preventing the risk impact: Negative = risk impact is not considered worth preventing, given value is low; Neutral = risk impact has not been valued at all; Positive = risk impact is considered worth preventing, given value is high. The blue colour indicates risk actions which can be seen as part of *risk governance*.

Notes: More risk related actions can be named, for example, another PARA (positive advanced risk action) could be *evaluating*. However, *evaluating* is fairly synonymous to *assessing*, and so, this and other action words similar to those found in Figure 2.2 have been excluded. Even so, there may be other action words that could be incorporated into this frame.

The definition of risk matters in relation to each risk action, in that not all definitions fit all actions. For example, some of the actions are more oriented towards risk being an uncertain consequence (e.g. *avoiding* the risk of accidents), and some of them are more

[26] It could also be seen as something to do alongside government organized public engagement in risk governance. Alternatively, it could be seen as an additional fairly inexpensive method of risk governance for those risk problems that would not necessarily invoke public participation.

oriented towards risk being the uncertainty itself (e.g. *taking* a risk). But since there is no agreed definition of risk, this typology encompasses all useful descriptions and tries to incorporate as many different risk actions as possible. However, a broad definition used by Klinke and Renn (2002) characterizes risk as "the possibility that human actions or events lead to consequences that harm aspects of things that human beings value", and this definition fits the risk actions in Figure 2.2 fairly well.[27]

The following subsections discuss some specific risk actions further.

Appraising risk

If most risks involve values, an important risk action then becomes *appraising* risk, which, when expanding from the financial context, means estimating the value to humans (as low/high/etc.) of preventing the impact of a risk. This is similar to the concept of *concern assessment* within the IRGC framework (IRGC, 2009), but in the IRGC framework, risk appraisal covers the assessment of the risk itself and including its probability, as well as the assessment of the value of (preventing) the impact. Packing all this into the 'appraisal' term is not necessarily helpful. Firstly, estimating the value of preventing the impact is important enough to be given a separate risk action term. This risk action can really be seen as ideally preceding many others, and it is actually integral in the above typology (hence, it appears in several places in Figure 2.2).[28] Secondly, with many risks we are not able to accurately estimate the probabilities of their consequences taking place, especially so with many emerging technologies (see Box 2.1). Therefore, lumping probability estimation together with the other two more manageable actions makes the process of risk appraisal tricky. Thirdly, the term 'appraisal' specifically refers to the value of something, so it may be useful to stick to this meaning.[29]

Ignoring risk

The literatures of social construction of ignorance and sociology of scientific ignorance – which are to some extent linked to risk - offer background to the observations made from reading the newspaper articles in this study, where a range of different kinds of 'ignoring' as a risk action becomes apparent. These can be seen linked to some of the terms in the

[27] See Aven and Renn (2009) for a recent discussion on some of the definitions of risk. They also suggest a new definition for risk referring to "uncertainty about and severity of the events and consequences (or outcomes) of an activity with respect to something that humans value".

[28] Appraising risk is slightly problematic for the typology, as it is the only risk action that appears both under negative and positive categories. This is simply because it precedes the value assessment phase.

[29] Risk appraisal and risk perception also have a crucial link, as the former is about establishing the value of risk impact, and the latter is about viewing a risk with those values in mind, consciously (actively) or unconsciously (passively). Risk actions are generally based on risk perceptions, and a process of risk appraisal mostly takes place before a risk perception is reached. This is often, of course, an unconscious process, and even the resulting risk action may be unconscious, such as ignoring. However, the point is that in the context of risk governance this process should be as conscious and explicit as possible, especially when it comes to governing complex, uncertain or ambiguous risks, such as many nano S&T related risks.

literature.[30] Importantly, Proctor and Schiebinger (2008) argue that the cultural production of ignorance is partly caused by media neglect of certain issues, and the nano S&T discourse seems to serve as a good example of such ignorance, in relation to risk.

Box 2.1 Uncertainties and probabilities

It has been argued that especially in the case of issues which involve a great deal of uncertainty, attempting to estimate the probabilities of certain impacts become less important than evaluating the value of preventing these impacts.

An example of this kind of an issue is climate change, where the range of possible probabilities of certain impacts is still quite large within the current climate science. Appraising a climate change risk means giving value to preventing a possible consequence or impact of climate change. If preventing this consequence is valued enough, the risk will be considered important to deal with, regardless of the exact probability, which is difficult to estimate at the moment. Dessai and Hulme (2004), in fact, question the usefulness of estimating probabilities for climate change policy.

Many emerging technologies also involve a great number of uncertainties regarding their potential negative impacts, even though they may not be as complex systems as the climate system. Variability in the timing of impact assessment of a technology vs. employing this technology can be seen as linked to risk appraisal. For example, in the case of GM food technology, it could be said that avoiding the impacts is not valued very highly in the United States, so GM foods are widely produced there, while the process of figuring out the probabilities of certain impacts is going on. On the other hand, in Europe, avoiding the potential negative impacts (including negative political impacts) has been valued more highly, so GM technology is currently rather limited in Europe. As the uncertainties related to nano S&T are many, appraising nano S&T related risks should be an important, and urgent, part of nano S&T risk governance.

At one end of the range observed from the data in this study is *passive ignoring*, which is done by not incorporating any possible risks or downsides of nano S&T into the discussion. As a comparison, in the climate change debate, journalists have, at least until recently, dutifully been pointing out both sides of the story – the (majority of) believers and the (minority of) non-believers in anthropogenic climate change.[31] In a study by Rogers (1999), the inclusion in the media of the minority view on climate change greatly influenced how controversial people viewed the issue as. A similar 'balanced view' could be, although currently is not, included in the media discourse regarding nano S&T.

Slightly less passive and more active ignoring falls in the middle of the range, and involves making an explicit statement about nano S&T that ignores risk. For example, an article in this study describes new household appliances incorporating nano S&T and explains how "400 billion silver ions are released and penetrate deep into fabric (…) during the washing and rinsing cycles" (SCMP300604-7), with no mention of what happens to those nanoparticles afterwards.[32]

[30] Gross (2007) and Smithson (2008) both include a discussion of various terms related to ignorance. Some of the other relevant literature includes Michael (2004), Wynne (1995), Stocking and Holstein (2009), Stankiewicz (2009), and Proctor and Schiebinger (2008).

[31] Schneider (1996) suggests that socially and economically significant issues such as climate change are particularly prone to such (false) equality of views.

[32] Although this type of ignoring may fall in the middle of the range, in the current analysis, it is still identified as passive.

The ignoring found at the other end of the range can be called *active ignoring*, and it involves making actual statements about risks not being relevant. For another example from the data, a senior consultant is quoted talking about nanoparticles: "Affect our lungs? That's a laugh considering how many pollutants are being dumped into the air worldwide from fossil fuels" (SCMP300604-1), in other words, why worry about a few extra particles?

Although ignorance can have its positive sides (see e.g. Wynne, 1995, Smithson, 2008 or Michael, 2004), the more active, the less helpful ignoring risk would generally seem to be for the long term development, or for the governance of issues such as nano S&T, or climate change. It directly devalues the risk impacts, also for the cases where serious risks are involved. Even when discussing an application of nano S&T which supposedly poses less risk (e.g. involving fixed nanoparticles), it can be argued that there is a place in an extensive newspaper article for a brief discussion or mentioning of risks. This in particular, since many of the readers will not be aware of the differences between risk types and risk levels for various nano S&T applications. They may, however, have heard that nano S&T may carry some significant risks, and may therefore assume that these risks apply to all nano S&T more or less equally, unless journalists bother to explore the risk issues further.

Amplifying and attenuating risk

The two risk actions of *amplifying* and *attenuating* risks are direct derivatives of the concepts of social amplification and attenuation of risk that Kasperson et al. (1988), and later other publications culminating in Pidgeon et al. (2003), have developed to cover those instances where risk levels are either deliberately or accidentally made more significant (e.g. with GM foods) or less significant (e.g. with car accidents) than generally perceived as by risk experts. The actors engaging in this process can include policymakers, NGOs, the media, the public and others. Within the Social Amplification of Risk Framework (SARF), risk signals (images, signs and symbols) interact with various psychological, social, institutional or cultural processes, and therefore lead to either amplification or attenuation of risks. This framework has be criticized by some (see e.g. Anderson et al., 2009, and Petts et al., 2001), especially as it relates to the role of media.[33] However, even with the criticism, the risk actions themselves remain valid as regards the discourse. The IRGC framework also takes social amplification and attenuation of risks (e.g. through media) into account, as something that can complicate risk governance.[34]

Risk frames

As Section 2.3 will argue, the frames in newspaper discourse matter (see e.g. Scheufele and Lewenstein, 2005, Nisbet and Mooney, 2007, Schutz and Wiedemann, 2008). By risk frame here is meant the general approach to a topic regarding risks. In the analysis, a distinction is made between five different risk frames: *concerned*, *confident*, *opportunistic*, *alarmist* and *visionary*. These risk frames follow to some extent the frames used in several of the

[33] For example, Petts et al. (2001) present the argument that the public does not passively absorb media content, but engage in a more active process of sense making.

[34] Interestingly, Frewer (2003) explores the link between trust and SARF and suggests that a high level of trust in those producing risk information may further amplify a message of high risk and attenuate a message of low risk.

existing studies on media discourse on nano S&T (see Stephens, 2005, Anderson et al. 2005 and Schmidt Kjaegaard, 2008),[35] but they are mainly based on the reading of the articles for this study.

The *concerned* risk frame signals that the writer of the article seems to believe that more should be done about identifying, assessing and perhaps controlling risks related to nano S&T. It is therefore not (yet) clear whether benefits outweigh risks or the other way around. The *confident* risk frame also indicates that the writer does consider risks, but believes that they will be taken care of (controlled, reduced, eliminated etc.), and that the benefits of nano S&T outweigh any risks the technology might have. The *opportunistic* risk frame, on the other hand, does not consider risks, and the writer of such an article seems to be only concerned with making use of the opportunities that nano S&T offer. This may be a slightly contentions frame, as the word 'opportunistic' has a negative tone. It is, however, applied to many of those articles that include 'ignoring risk' as their only risk action, as the argument is that these articles actively construct ignorance of nano S&T related risks. The next risk frame, *alarmist*, is quite the opposite in that the writer seems clearly overly concerned that serious risks of nano S&T are being ignored, and not dealt with. To such a writer, the risks may well outweigh the benefits. The last risk frame, *visionary*, indicates that the writer of an article is involved in constructing nano S&T up as a nearly utopian solution to various current issues and problems. This frame does not include concern for nano S&T risks, as no matter what they are, the vast benefits nano S&T will far outweigh them.[36]

2.2.3 Complexity

The concept of complexity in connection with the present study is related to the analytic elements (attributes, actors and risk actions) described in the above sections.[37] Complexity here refers to the inclusion of a number of viewpoints, topics and/or relevant actors, as well as uncertainties. Box 2.2 explains how complexity is evaluated in the present study.

Different consequences may arise from the level of complexity. For example, if a technology is portrayed as straightforward, or in a sense, simple - for example, as beneficial for everyone, with no need to get involved in details; or as risky, involving serious danger to people and the environment - certain risk actions may be promoted by such approaches. A special case of presenting something as simple, is presenting something as overwhelmingly positive, which again may advance certain kinds of risk actions over others. Kjolberg (2009) argues that if risks and uncertainties related to nano S&T are not included in the

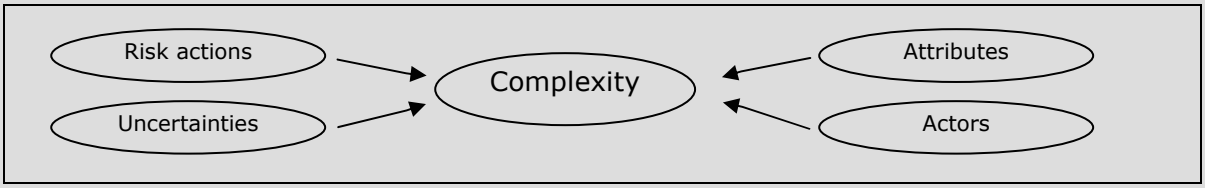
[35] The main categories used in these studies were: (1) benefits outweigh risks, (2) risks outweigh benefits, (3) risks and benefits need to be weighed, but it is unclear which are more important, and (4) other. Category (1) is similar to *confident*, category (2) to *alarmist*, and category (3) to *concerned*.

[36] The visionary frame has been quite a common risk frame for nano S&T. Schummer (2006) argues that it mostly dates back to 2000 and the setting up of the US National Nanotechnology Initiative by President Clinton. According to Schummer, it is often (consciously or unconsciously) used to justify financial or political support for nano S&T.

[37] This is different from the complexity of risks themselves, discussed in connection with the IRGC framework.

media discourse, there is little motivation for a public debate from the public's side.[38] The argument that Elke Weber[39] makes regarding climate change discussion in the media can be applied to nano S&T as well: if issues are not presented as controversial, they do not even enter our 'finite pool of worry'. And without worry people do not take action (Weber 2006).[40]

Box 2.2 Quantifying complexity



Inspired by Rosa and Spanjol (2005), and by Dijk (2008), who quantified complexity by counting attributes used to describe a technology, this study will by looking at:

- How many risk actions, some potentially conflicting, are promoted, either in an individual article, or in the newspaper discourse
- How many attributes of nano S&T are discussed
- How many actors are mentioned in the stories
- Whether uncertainties regarding nano S&T are discussed or implied in the stories.

Following from portraying nano S&T as simple, the risk actions taken may be *ignoring* or taking risks unknowingly, something that could be called *uninformed risk taking*. Such risk taking of course takes place whenever consumers buy products that incorporate nano S&T, as there is no actual way of confirming the presence of nanoparticles, or their risks, and consumers cannot therefore give their "free informed consent" (Shrader-Frechette, 2007) to using nano S&T products at their own risk.

On the other hand, if a technology is presented as very complex, the risk actions that are promoted may become quite contradictory, and therefore the technology becomes 'messy' and difficult to comprehend in terms of its impacts.

It seems then that from the point of view of generating a discussion among the public and other relevant actors, a compromise between not too simple, and not too complex would be ideal. Important of course, is also what is talked about, not just how complex the discussion is. Brian Wynne and his team (Morris et al., 2001) found in their large study regarding biotechnology that the public wants the media "to provide them with neutral and

[38] Priest (2001) argues the same for biotechnology when she says that unidirectional coverage and presenting science as 'ready' neither promotes science nor supports democracy.
[39] New York Times article 'Why isn't the brain green?', published on 19 April 2009.
[40] On the other hand, it could be argued that in the case of something related to nano S&T making people worried would result in an unproductive 'scare', similarly to what happened to GM foods.

objective information, while (…) they [also] wanted to hear a wide variety of arguments" (p. 64).[41]

Issue frames can also, in principle, become simpler or more complex while, for example, a technology matures. Rosa & Spanjol (2005) argue that a simplification of frames happens with most products in a market, between the point of introduction to the point of a product reaching an established status. The same may or may not be true of (emerging) technologies. It could also be assumed that the complexity in framing a technology increases over time as more knowledge about different aspects of the technology is gained.

In addition to potential changes in the complexity of the discourse, it is also likely that newspaper reporting on new technologies increases over the years, when the technology gains more ground. This has indeed been observed by other studies on the nano S&T discourse (see e.g. Kjolberg, 2009; te Kulve, 2006; Stephens, 2005; and Schmidt Kjaegaard, 2008). There can, however, be at least two consequences from this increase in the number of articles. The first of these is the potential increase in complexity, which is discussed above. The more stories, the more different aspects may be discussed. Complexity here can, of course, then be either a positive or a negative development. The second consequence may be what Lazarsfeld and Merton (1975) call *narcotizing dysfunction* of media reporting, which denotes a phenomenon whereby the more media reporting there is, the less people may feel the need for action.[42]

2.2.4 Constructing nano S&T

The data analysis for this paper will look at how newspaper articles define and explain nano S&T, or alternatively, leave it undefined or unexplained. This study will also look at how nano S&T is presented in terms of its meanings and uses in its (country) contexts.

Apart from the inclusion or exclusion of certain areas of S&T within a broad area such as nano S&T (see Box 2.3), a technology may be presented in various different ways. First of all, it may be black-boxed in the sense that the discourse does not in any way explain what is special about it. For example, in the case of nano S&T, the specialty comes mainly from the new chemical and physical properties of matter at nanoscale. However, this point is often excluded from the discourse. Secondly, how a technology is viewed depends on what its uses are. In some contexts, the same technology may be presented as an economic engine, while in others it may be a way to solve basic problems related to illness, pollution and extreme poverty. These aspects will be investigated in the analysis that follows.

[41] Later, this paper will make an attempt to quantify the complexity of a discourse, which may make it also possible to try to determine what a good level of complexity could be from the point of view of public debate.

[42] Acquiring a good level of knowledge about something is mistaken for concrete action in people's minds, or in short, increasing knowledge accounts for 'doing something'. In the case of risk actions, this could lead to e.g. various publics not feeling any need to take up the issue of risks related to nano S&T, regardless of how comprehensively nano S&T is presented in the media, and which risk actions are promoted there.

Box 2.3 Defining nano S&T

Defining nano S&T is an issue firstly, because the most common definition (found in Section 1) in practice excludes the contentious field of molecular manufacturing (Barben et al., 2008), and secondly, because this definition is still very broad. It seems that the biggest benefit for a broad definition has been in getting funding for research, as adding the word 'nano' to a research funding application is generally assumed to increase the changes of approval (see e.g. Erlemann, 2008).

Such a broad definition is, however, challenging in practice when we would like to know whether something specific belongs or does not belong to nano S&T, how much of nano S&T is of particular kind of science or technology, or, how much of nano S&T involves certain kinds of risks (see also Auffan et al., 2009). Bibliometric research has therefore tried to identify the more precise composition of fields under nano S&T (Barben et al., 2008). For example, Porter et al. (2006) identify the following areas: 1) nanodevices and electronics, 2) nanostructure chemistry and nanomaterials, 3) nanomedicine and nanobiology, and 4) metrology and nanoprocesses. Although much of nano S&T discourse still talks about a singular 'nanotechnology', it is often acknowledged that a plural 'nanotechnologies' is a more accurate, and a slightly less black-boxing name for this area of S&T. This study refers to 'nano S&T'.

Erlemann (2008) provides an interesting angle into this definitional discussion in saying that a boundary discussion is currently actually an integral part of nano S&T. According to her study on risk discourse in Germany, most actors see the negotiable definition as beneficial to them. Depending on outside positive/negative reactions to e.g. 'nanomaterials', they actively redefine this area of research. What previously counted as nano S&T might not count as such any more, and vice versa.

Themes

While reading the articles, special attention has been paid to any emerging themes that might be particular to either the chosen newspaper, or the country in question. What seems to be the important aspects of nano S&T in this particular context? What are the particular challenges and particular opportunities? How is nano S&T constructed in relation to the country in question? Are there concerns that might not be shared by other countries to the same extent?

2.3 Methodology for this study

2.3.1 General methods of analysis[43]

The main dataset for this study consists of the articles collected from four newspapers. In the analysis of the articles, a mixture of qualitative and quantitative methods has been employed.[44]

The *quantitative* elements of the analysis consist of content analysis with a coding schedule. The quantitative aspects are in particular related to the counting of attributes, risk actions and actors to assess the complexity of stories and to see what dominates each discourse, also in terms of changes in time. Section 4 will employ some graphs to show certain aspects of the discourses.

[43] The references used for advice on the analysis include Bryman (2008), Rubin and Rubin (2005), Tonkiss (2004), Seale (2004) and Krippendorff (2004).

[44] This is done firstly, because some quantification of qualitative results can give more strength to the analysis. Secondly, mixed methods are used here to answer different research questions. Thirdly, more interesting findings may be presented with mixed methods. Most of the studies done to date on nano S&T media discourse are fairly quantitative. However, these analyses seem to lack 'the story' that makes them more interesting. On the other hand, those studies of media discourse that are (almost) entirely qualitative are difficult to use for comparative purposes.

There are several *qualitative* aspects of the analysis. The process of adjusting the coding schedule with the reality of the articles creates a two-way relationship between the coding and the texts. Further, an important part of the process is looking for meaning and making interpretations while coding, as the analysis mostly does not consist of looking for the actual words in the schedule. Evaluating risk frames and complexities based on the text alone is also a very interpretative process. Qualitative analysis is also used in the thematic analysis, in the sense that the reading process allows for specific themes to emerge from each newspaper discourse. Finally, frame analysis (discussed below), including qualitative and quantitative aspects, is used regarding the overall position of the articles on risks, on the one hand, and on nano S&T, on the other hand. For an example of the latter, is nano S&T seen more as a cure for societal problems, or as an economic engine?

The present study investigates how an article or a newspaper frames nano S&T (intentionally or unintentionally), which risk actions are included in or promoted by this frame, and how complex the framing is.[45] The literature studying media effects generally acknowledges the importance of framing in news stories, also concerning complex scientific issues. For example, Scheufele and Lewenstein (2005), based on their study in the US, suggest that mass media often provide the heuristics for the public views on nano S&T and the risks and benefits of the technology, so that it is less about what the newspapers say, and more about how they say it, in other words, about framing. A link between frames and values is also recognized in the literature, and Box 2.4 gives an example of this related to climate change. Regarding nano S&T, Schutz and Wiedemann (2008) explore how framing affects the perception of nano S&T and associated risks by the various publics, and suggest that with issues where general awareness or knowledge is lacking, such as with nano S&T, the social context in which the technology is embedded matters more, also to risk perception and risk judgment (which is linked to risk actions).[46] Media framing of issues would then play an important role in determining potential media influence, especially in complex scientific issues that involve uncertainties.

The main part of the analysis in this paper consists of coding and analyzing the coded data using Atlas.ti textual analysis programme. Instead of open coding, this analysis uses a coding sheet to ensure that comparative aspects would be looked at in each newspaper article. Around 80 different codes have been included to be considered for each article regarding risk actions, risk frames, actors, attributes etc., as well as an overall assessment of the complexity of each story, and about the 'statement' that each article could be seen as making about nano S&T. Each article was read twice, and coded during the second reading. After inputting the codes to Atlas.ti, several different reports have been run, and further

[45] Some ideas have been adopted from Marc Dijk (2008) and Rosa and Spanjol (2005), as well as other similar studies on print media (discussed later).

[46] The literature on risk perception in general is large (see e.g. Slovic (2000), Douglas and Wildavsky (1983), Nelkin (1989) and Hannigan (1995), but as it applies to nano S&T, it is only starting. The general conclusion from survey based studies so far is that the public is not very knowledgeable, but it tends to have a positive view of nano S&T, and tends to view benefits outweighing risks (see e.g. Schutz and Wiedemann, 2008, Macoubrie, 2006 and Schuler, 2004). Furthermore, Besley et al. (2008) and Anderson et al. (2009) look at expert perception of nano S&T and associated risks.

analysis of some of the data have been conducted by using Excel. Importantly, as with qualitative analysis in general, much of what is found from data is up to interpretation, so that, for example, in the case of textual analysis, one reader may find slightly different results than another reader. The analysis here is based on a thorough, *albeit* only one interpretation of the data.

Box 2.4 Conflicting media frames and values

Nisbet and Mooney (2007) argue that the public screens the media outlets that match their own values and tend to adopt the frames from the news stories there. Nisbet and Mooney present the recent US climate change discourse as a good example here, with the Republican frames of 'scientific uncertainty' or 'unfair economic burden' clashing with viewing the issue as a 'Pandora's box of catastrophe' (some Democrats), as a 'matter of religious morality' (some Evangelical leaders), or a question of 'public accountability' (those opposed to the Bush Administration's approach to interfering with (climate) science).

Because of these conflicting frames, the increasing scientific certainty about anthropogenic climate change during the 2000's did not increase overall public confidence in the validity of the science. This only happened among people who were identified with the corresponding frames, e.g. among Democrats, who were generally more concerned about environmental issues anyway (Nisbet and Mooney, 2007).

It also seems that if an issue has a single dominant frame linked to certain values from the beginning, this frame may continue its domination also later on (Nisbet and Huge, 2006).

The next section will explore further the data collection exercise.

2.3.2 Research set-up

The data for this study consist of articles from four newspapers from Hong Kong, South Africa, Kenya and India. This section will mainly focus on explaining how the countries, newspapers and articles were chosen, and what the process of retrieving the articles consisted of. A second part to the analysis will be comparing results obtained in this study with similar studies done in Europe or in North America, and this will be included in Section 3.

In Section 1, the reasons for selecting countries from the Global South for this project were discussed. Further to this, several countries were included in order to get some more insight than from just a single country. However, in choosing more than one country, a compromise had to be made in the number of newspapers, and therefore only one newspaper was selected from each country. In the end, daily English-language newspapers were chosen from countries that are involved with nano S&T to some extent. Another criterion was that the chosen countries should be considerably different from each other, e.g. in terms of the stage of the economic development, the size of the economy, or the extent to which a country is involved in nano S&T (i.e. not just that it is, but how much).[47]

[47] For example, Maclurcan (2005), Meridian Institute (2005) and World Economic Forum (2007) were used to provide data on these aspects.

The characteristics of potential newspapers were also considered, e.g. in terms of their relative independence, wide readership, and similarity in style.[48]

In the end, the chosen newspapers include the South China Morning Post from Hong Kong, the Hindu from India, the Star from South Africa and the Daily Nation from Kenya. Table 2.2 shows some comparisons between the countries in question. The countries rank rather similarly in several indicators that can be seen to be related to the development of science and technology, and yet very differently in others. Out of these four countries, Hong Kong does best on the indicators overall, reflecting the categorization of its economy as innovation-driven.

Table 2.2 Comparisons between selected countries

	Hong Kong	South Africa	India	Kenya
Economy driven by (WEF, 2007)	Innovation	Efficiency	Factors	Factors
Overall GCI ranking (WEF, 2007)	12	44	48	99
Foreign market size, ranks (WEF, 2007)	8 (large)	28 (medium)	4 (large)	87 (small)
Stage of economic development (Maclurcan, 2005)	Transitional	Developing	Developing	Developing
Activity in nano S&T (Maclurcan, 2005)	National activity	National activity	National activity	Country interest
Press freedom, ranks (RwB, 2008)	51	36	118	97
Capacity for innovation (WEF, 2007)	26	43	31	57
Quality of scientific research institutions (WEF, 2007)	25	27	22	31
Company spending on R&D (WEF, 2007)	23	26	28	31
University-industry research collaboration (WEF, 2007)	21	24	44	47
Availability of scientists and engineers (WEF, 2007)	35	104	4	51
Public trust of politicians (WEF, 2007)	11	48	83	109

Sources: As indicated in the table.

Notes: The figures for World Economic Forum (WEF) indicate the ranks out of 131 countries, and for Reporters without Borders (RwB) out of 173 countries. The Global Competitiveness Index (GCI) considers economies to generally grow from factor-driven to efficiency-driven to innovation-driven (see more in WEF, 2007). Factors here refer mainly to unskilled labour force and natural resources. These GCI rankings are based on an opinion survey with top company managers in each country, except for foreign market size data, which is hard data based on various sources.

In choosing the data, a distinction was made between search criteria and relevance criteria. The search criteria could be formatted relatively easily for the online databases used, but the relevance criteria required reading the articles through to assess their content.

In the search criteria, all articles with any of a number of nano S&T related keywords (see list below) were included, within a certain time frame - from 1 January 2000 to 31 March 2009 - and of a certain minimum length, namely, above 200 words. A longer time period

[48] The press in the country in question should also be relatively free. The 2008 Index of Press Freedom was used as a guide for this (Reporters without Borders, 2008). A small number of people from various countries were also consulted to find out their opinions on the newspapers that best meet the criteria, as well as www.pressreference.com.

was included, firstly, in order to collect enough articles from those countries with less print media discussion of nano S&T, secondly, to potentially see some historic trends, and thirdly, to make sure that individual events (although potentially important) would not dominate the discourse too much. The minimum length criterion was used to roughly exclude articles that would not meet the relevance criteria, which were based on the desire to concentrate on articles that discuss nano S&T in some detail. As discussed below, only about half of the articles did this. The retrieved articles were then divided into 'relevant' and 'less relevant' articles, and this analysis is mostly based on the relevant articles.

The following list of keywords, or search terms, was used:

> nanotechnology nanotech nanoscience nanobot nanoscale nanoparticle nanotube nanoelectronics nanophysics nanomedicine nanoengineering nanomaterial nanobiotechnology (plus plurals and separated words 'nano-technology' etc.)

The Indian and Hong Kong newspaper articles were obtained from the Proquest database, which includes a number of international newspapers. The South African and Kenyan newspaper articles were downloaded from the newspapers' own online archives. As the number of relevant articles was lower for these two countries, any relevant articles shorter than 200 words were also included.

In total, 593 articles met the search criteria, but only 262 of these met the relevance criteria. Table 2.3 shows the distribution of the articles, and Annex A will show the distribution of articles over time. Notably, as the Hindu newspaper had such a large number of relevant articles (201), a sample of 35 articles was chosen from these.[49] All in all, the main dataset for this study consists of 96 articles in total.[50]

[49] Firstly, every third year, starting from 2000 and ending in 2009 (first quarter) was included. However, the years 2005-2008 contain a large number of articles each. Therefore, for 2006, articles for every second month only were included, starting from January of 2006. After this selection, 25 articles were obtained. To test the representativeness of these articles regarding the risk discourse, a small number of risk-related keywords were chosen (risk, harm, safe and danger), and the occurrences were checked to see whether they were used in connection with nano S&T, and if so, how many were in the pool of 25 articles. As a result, only one of these articles was among the 25, however, there were ten other articles where the words 'risk' or 'safe' were used in connection with nano S&T in the entire pool of 201 articles, more or less as would be expected in terms of proportions. As these articles can be considered important for forming a picture of the risk discussion in India, in the end, the 25 articles were chosen to get an idea of the general nano S&T discourse (the 'time sample'), and the ten additional risk articles were chosen as the second part of the sample to look at the risk discourse in particular (the 'risk sample'). Occasionally, all 201 relevant articles will be consulted when necessary to investigate specific themes.

[50] Obviously, one newspaper in a country will not present the whole picture of the newspaper discourse in that country. But neither will the whole newspaper discourse in a country portray a full picture of the media discourse in that country. The line is always drawn somewhere, and in this study it is drawn quite early, in order to be able to look at several countries. These newspapers will hopefully show an important or relevant part of newspaper discourse, and therefore shed some light into the overall discourse in these countries around nano S&T.

Table 2.3 Nano S&T related articles

Newspaper	Total number retrieved	Relevant articles	Articles in the final database
South China Morning Post (SCMP)	82	32	32
The Hindu (H)	460	201	35
The Star (S)	41	24	24
The Daily Nation (DN)	10	5	5
Total	593	262	96

2.3.3 Observations from first round of reading

A rough division into three types of articles could be observed in the whole population of retrieved newspaper articles. Firstly, the 'less relevant' articles form about 50% of the total number of articles obtained with the above search criteria. These articles only mention one or more of nano S&T keywords once or twice and do not talk about nano S&T in any detail. They might say something like 'nanotechnology is vital to our future' or indicate in some other simple way that nano S&T is important and promising great things. However, usually these articles actually just talk about an event – for example, a thesis defense – or a new university course, or something similar. All these less relevant articles are excluded from the analysis.

Secondly, among the 'relevant' articles there are a great number of articles talking about a discovery or an application using nano S&T. These can be quite factual, although there is often some undertone of excitement or promise. These articles are included in the analysis, as they do talk about nano S&T at some length.

Thirdly, the 'relevant' articles talking about nano S&T in depth are obviously the best for this analysis. In the early years (2000 to 2003, or so), although there are fewer articles in total, such in-depth articles are common. This could be expected, as there isn't so much else going on yet in terms of research or education in nano S&T in the countries in question, so the discussion of the technology itself, linked to developments outside, is more prominent. In total, these articles are, however, in the minority.[51]

[51] One further point became obvious after reading a number of articles. This is related to risk frames and risk actions, discussed in Section 2: not every article which passively ignores risk can be categorized as *opportunistic*. Short articles of less than 300 words, which belong to the more passive ignoring kind, are therefore usually excluded from the present analysis when considering the opportunistic risk frame, simply because it may be difficult to incorporate two sides of a matter into such short articles. Instead, if no other risk frame is obvious, these articles are categorized as risk frame 'not apparent'. The downside to this method is that a large part of the stories do not have a risk frame. On the other hand, they will still include at least one risk action, namely *ignoring*. A more extensive story may be assumed to be more inclusive, and even if it only passively ignores risk, it can be categorized as *opportunistic*.

2.3.4 Conclusion

Risks cannot be effectively governed if they are not understood or discussed. Emerging technologies, such as nano S&T, bring with them risks which include a great deal of uncertainties, as well as issues which need to be discussed within society. Examining discourses around such technologies in various contexts is therefore relevant. This study will analyse risk frames and explore the inclusion of various actors, attributes, risk actions and uncertainties in nano S&T discourses, while also paying attention to the complexities of the discourses and special emerging themes. Such risk discourse analysis (or more narrowly, risk action analysis) could be seen as part of a risk governance framework.

Both quantitative and qualitative methods of analysis will be used in the analysis using the main database of 96 newspaper articles from four countries, Hong Kong, South Africa, Kenya and India. Firstly, attributes, actors and risk actions as well as risk frames will be explored with the help of a coding sheet, and the relationship between these and the construction of nano S&T in the stories will be investigated, while considering also the complexity of the stories presented, and changes over time. Secondly, specific emerging themes will be explored. Thirdly, the individual country/newspaper studies will be compared with each other and to the existing studies in the literature. Being that the other studies each have their own methodology – much of it leaning on more quantitative methods - only partial comparisons with these studies can be made.

In the words of Marris et al. (2001) on analyses of media content:

> They are important for understanding the cultural context within which members of the public form and express their views and for analysing the trajectory of public debate, but they cannot be taken as equal to, nor even a proxy for, public views.

Analysing media discourses on nano S&T will not tell us everything we might like to know about perceptions, views and approaches related to an emerging technology, but it should help us along the path of finding out more.

3. Studies on media discourse around nano S&T

This section will first analyse a number of other studies on media discourse around nano S&T in the Global North, and then present results from the analysis of the data for the Global South.

3.1 Previous media studies on nano S&T

Earlier literature has studied print media related to nano S&T in a number of countries in the Global North, and these include: Weaver et al. (forthcoming) and Fitzgerald (2005) for the US, Anderson et al. (2005) for the UK, Te Kulve (2006) for the Netherlands, Kjolberg (2009) for Norway, Schmidt Kjaegaard (2008) for Denmark, Zimmer et al. (2008) for Germany, Stephens (2005) comparing both the US and the UK, and Laing (2005) comparing the US and Canada. A literature search (in journals and the internet) was performed in order to try to find as many similar studies as possible, and the above are likely to cover most of such studies that have reached a wider audience.[52] Table 3.1 shows some of the main features of these studies.

All of these studies perform content analysis using coding, and some include statistical analyses. Interviews are also included in two of the studies. All studies investigate frames or representations of nano S&T, and most studies also look at the discourses from the point of view of benefits vs. risks. Much of the analysis is leaning on more quantitative methods. Finally, none of the studies use risk action or complexity analysis similar to what is developed in the present study. This study is therefore an attempt at a new kind of analysis of risk discourses around emerging issues, such as nano S&T.

To conclude from the individual studies, firstly, all discourses see nano S&T mostly as a positive thing, where benefits outweigh risks. Secondly, scientific progress exemplified in discoveries and applications dominate as topics, and risk related topics are relevant in a minority of the articles. It seems that in the smaller (European) countries, nano S&T is viewed more as a necessary vehicle for scientific and economic progress, and therefore risk discussion matters less. Thirdly, it also seems that in several countries, newspapers have struggled to define and explain nano S&T to their readers. Lastly, in 2004 the coverage increased significantly in many countries.

[52] There are more studies on the US media than those discussed in this study. However, the idea here is to cover all the available countries, so only a couple of the US studies are included.

Table 3.1 Studies on nano S&T discourse in the media

Country/ Study	Years/Trends	Frames/Topics (see notes 1 to 3)	Benefits vs. risks/Risk actions	Explanations and descriptions	General
United States Weaver et al. (forthc.), Fitzgerald (2005)	Weaver et al: 1999-2009 No upward trend in numbers, but this is a 'risk sample'*	Weaver et al: Risk sample:* scientific progress frame 40%, R/B frame 37%, regulation frame 18%, conflict frame (focusing on competing claims or interests among relevant actors) 5% Fitzgerald: scientific progress frame 75-90%, intellectual property issue frame 30%, political frame 2-9%, equity issue frame 0-3%	Fitzgerald: benefits four times more likely to be mentioned than risks; most frequently mentioned risks are related to health and the environment (5% of articles)	Fitzgerald: struggle over meaning of nano S&T, since "the terms of the debate and the range of issues are undefined, uncertain and/or unknown", many actors participate in the struggle	Weaver et al: The more newspapers in a country cover a story, the more frames will be present; each paper has its own preferences Fitzgerald: Techniques advocated by some nano S&T people to engage the public
Comparing the US and Canada Laing (2005)	Only one year covered, 2004	Scientific progress frame 47%, R/B frame 21%, business frame 18%, economic impact frame 5% and regulatory issue frame 1% Canada emphasized applications and research more, and US business and market more	71% of articles included a benefit, 18% included a risk (mostly investment, societal and health) Canada has broader coverage on societal, health and environmental risks than the US, and the coverage is overall more balanced	More than 50% of all nano S&T related articles provide no explanation for the technology, but when science is explained, Canadian articles are much more thorough	More coverage of nano S&T in Canada than in the US
Comparing the US and the UK Stephens (2005)	1992-2004 General upward trend in numbers	Scientific progress frame 27%, R/B frame 17%, business frame 11%, funding frame 9% US more focused on science and business and UK more focused on risk discussion	Ratio of three to one for benefits outweighing risks, more or less the same in both countries, but in the UK more articles call for an assessment of risks and benefits	Not discussed	--
United Kingdom Anderson et al. (2005)	Only one year covered, 2003-2004	Science fiction frame 16%, science fact frame (scientific progress) 16%, business frame 15%, spokesperson frame 11%, R/B frame 9%, funding frame 8%, education frame 8%, medical benefits frame 6%	Spokesperson articles balance risks and benefits, but overall, ratio of three to one for benefits outweighing risks	Defining nano S&T in an understandable way problematic, sci-fi used to help with this	Spokespersons (Prince Charles in the UK case) can play an important role in the newsworthiness of an issue and how it is framed in the media; mostly nano S&T is covered in elite newspapers, not in tabloids; tendency to present "two sides of a story" for apparent balance and impartiality

Netherlands Te Kulve (2006)	1992-2005 Upward trend in numbers, but not for those articles that focus solely on nano S&T, similar to Weaver et al. (forthcoming)	First period (1992-99): scientific progress frame 65%, science fiction frame 14%, policy frame 9% Second period (2000-02): scientific progress frame 47%, science fiction frame 24%; policy frame 15%, R&D and investment 6%, R/B frame 1% Third period (2003-05): scientific progress frame 32%, policy frame 19%, R&D and investment frame 18%, science fiction frame 10% R/B frame 9%	Discourse on risks started from non-existing, and gradually evolving into a debate where scientists are the main discussants	Not discussed	Dual repertoire between 1992 and 2009 with great promise on the one hand, and modest expectations on the other hand (hype and realism), chances to an antagonistic pattern with opponents and proponents
Germany Zimmer et al. (2008)	2000-2007 A peak in 2004	Scientific progress frame 37%, ICT-related progress 25%, economic impact frame 17%, R/B frame 12%, medical benefits frame 8% Generally nano is viewed as a field of science, sometimes as an economic factor, and rarely ethical or critical views are expressed strongly	70% of actors in the discourse see nano S&T as positive; discourse is almost exclusively focused on the benefits, when risks are mentioned they focus on military, ethical/moral and social risks Only 8% of articles make demands regarding risks, mainly regarding assessment, control, reduction and elimination of risks, a third of these demands are by scientists	Lots of technical terms used; only 21% of articles include positive descriptions, and 8% include negative descriptions	Nano S&T may not become an "issue of critical public debate" in Germany unless a crisis of some sorts takes place. However, even the sealant (Magic Nano) recall in 2006 did not have much impact on the discourse.
Norway Kjolberg (2009)	2000-2007 Upward trend in numbers	Three main frames: positive frame (60%), future importance of nano – frame, and nano is under control – frame (here control refers to both technological control of materials and societal control of the technology, plus the opposite, nano is out of control)	Conflicts or uncertainties rarely discussed 'Control' is significant whenever risks are discussed	Not discussed	Discusses defining 'ready for public engagement', and the 'public engagement paradox'. Thick in STS style qualitative analysis, open coding.
Denmark Schmidt Kjaergaard (2008)	1996-2004 Upward trend in numbers, jump in 2004	Policy frame 20%, scientific progress frame 18%, education frame 14%, science fiction frame 6%, R/B frame 6%, globalization frame 5%, business frame 5%, funding frame 5%	Ratio of ten to one for benefits outweighing risks, and the stories about risk outweighing benefits mostly concentrate around 2000-2001 and relate to sci-fi scenarios	Not discussed	Nano S&T mostly covered in opinion making newspapers directed at well-educated people; it seems that nano S&T is taken for granted in Denmark, hence the positive coverage; wide range of actors; main narrative about how a small country can be a relevant player in global markets

Notes:

1) The phrasing of the topics and frames in the original studies is modified slightly here, in order to make comparisons possible between different studies.

2) 'R/B frame' refers to the articles presenting both risks and benefits of nano S&T, but not necessarily taking sides in the issue of what is more important, and not necessarily being balanced between presenting risks and benefits.

3) The scientific progress frame is similar to the discoveries and applications attribute included in the present study.

* Risk sample here refers to the articles all including some reference to risks (similar to the risk sample for the Hindu in the present study).

3.2 Some results from data analysis

This section will present a brief summary of results for each country, including some of the most interesting features from each country.[53] First, however, Table 3.2 shows some examples of discussed topics in all the four newspapers. They are chosen here for being interesting, and not necessarily the most typical of each discourse. Annex B lists the headlines of the referenced articles from these newspapers.

Table 3.2 Examples of discussed attributes

Article	Attribute	Example
SCMP171101	Business and investment	Dr Leung laid the blame for limitations in research on nanoscale materials on poor government support for research and development. "You need to have a fertile environment before seeds can be sown," he said.
SCMP300604-1	Health, environment and safety	The CRN also warns that the tiny scale of nanomanufactured machinery could lead to the creation of very small products which could easily turn into nanolitter that would be hard to clean up and could cause health problems.
	Regulation/ governance	Environmentalists, research institutes and other cause-oriented organisations worldwide are calling for the development of international safety measures and legal standards to prevent molecular nanotechnology from causing societal and environmental damage.
SCMP260806	Education	"Hong Kong is losing on all fronts for research, in funding, infrastructure, capable students, all fronts. Taiwan is losing its best scientists to China too. Academics in the mainland get more funding and better students, a larger pool of good students. Good students in Hong Kong tend to go to medical school, into business or become lawyers."
S280505	Discoveries and applications	According to a new study (...) several nanotechnology applications will help people in developing countries tackle their most urgent problems - extreme poverty and hunger, child mortality, environmental degradation and diseases such as malaria and HIV/Aids.
	Ethics	The challenge is to ensure that a nano-divide doesn't further exacerbate the inequalities between the developing and developed world.
S160209	Ethics	Some think nanotechnology is "messing" with nature's building blocks, and therefore unethical.
	Health, environment and safety	But is nanotechnology safe? Skeptics are worried about unpredictable health and environmental risks. It is possible that nanoparticles will penetrate cells more readily than larger particles. There is concern, for example, that carbon nanotubes already used to reinforce plastic materials could affect the lungs in ways similar to asbestos.
H090904	Regulation/ governance	The public must be involved from the start. Now, while nanotech is still in its infancy, is the time to start a proper public debate, with all of these questions on the table. Public views can then shape the direction of research in a meaningful way.
H240906	Business and investment	In order to give a big thrust to nanotechnology, the Department of Science and Technology will spend over Rs. 1,000 crore on emerging cutting-edge technology in this sector, and a Rs. 180- crore plan has already been submitted to the Cabinet for approval. During the past two years, over Rs. 70 crore was spent to set up research centres on nano-science across the country.

[53] This paper is based on a Master's thesis, and full descriptive results are given there.

	Education	Lamenting the lack of an adequate number of science graduates in the country, [Mr. Sibal] said there were only 10 million science graduates, which constituted just one per cent of the total population of 1.1 billion. It was the responsibility of the Government to educate the youth and make them aware of what science could do.
H141206	Regulation/ governance	[B]ut scientists must also look for ways to become more engaged in the shaping of a technology as it unfolds.
	Ethics	In the case of nanotechnology, there have been discussions of, for example, its likelihood of increasing the gap between rich and poor nations, its impacts on surveillance and privacy, and the social effects of nanotech- enhanced longevity.
H180307	Business and investment	Many of the so called developed nations are setting apart considerable funds for nanotech. The U.S. is a leader in this venture and its effort for this technology may even surpass that for landing on the moon.

3.2.1 Hong Kong

As Annex A shows, the Hong Kong newspaper South China Morning Post (SCMP) contains a steady stream of articles, although the numbers of relevant articles - those talking about nano S&T in some detail - are not so numerous.[54] The years 2004 and 2006 seem to be peak years for the nano S&T discourse in this newspaper.

The typical stories discuss new discoveries and applications, such as carbon nanotubes as superconductors, bulletproof vests, energy-producing nanowire, light-emitting diodes, semiconductors, silicon chip brain implants, gel that stops bleeding, wastewater treatment, self-cleaning clothes, air purifiers, antimicrobial silver nanoparticles, bacteria-filtering masks, antimicrobial toys, bacteria-free household appliances. Other topics discussed include nano S&T investment and new research projects, nano S&T in Hong Kong, personal stories of Hong Kong researchers, as well as molecular manufacturing, which is touched upon in several stories.

As a general observation, it could be said that the discourse on nano S&T in this newspaper includes a certain excitement of nano S&T in the world, but especially in Hong Kong. Risks, although touched upon in a small number of articles, are not central in the discourse, and therefore the most common risk action promoted by the stories is *ignoring* risk, although in most cases this is fairly *passive ignoring*.

A number of themes emerge as particular to this newspaper and perhaps to Hong Kong. Firstly, in terms of the usefulness of nano S&T applications, a certain affinity with cleanliness becomes apparent on the one hand, and the importance of applications in electronics comes through on the other hand. Secondly, there is discussion on the internal (Hong Kong government) and external (China and surrounding countries) circumstances. Thirdly, Hong Kong scientists are seen as pioneers making discoveries in an exciting new field. A fourth theme can be seen as related to risks: nano S&T is seen as non-risky – apart from molecular manufacturing. A fifth theme is related to the way nano S&T is described,

[54] See Section 2 for an explanation of 'relevance' in this context.

as extraordinary - and very important to the future of Hong Kong - when at the general level, and as useful when at the level of specific applications (see also next section).

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Regarding the descriptions used for nano S&T, it seems that when general descriptions are given, many superlatives are used (for example, 'revolutionary'), but when very specific benefits, or applications deriving from the use of nano S&T are described, the adjectives are much more subdued (for example, 'better').[55] An exception might be products advertised (most likely) for women (see e.g. SCMP300604-6 and SCMP300604-7), where somewhat stronger adjectives are used to describe products incorporating nano S&T. Table 3.3 shows a sample of adjectives used for nano S&T in general, and another sample of adjectives used for describing individual applications.

Table 3.3 Descriptions of nano S&T and its applications in SCMP

Article	Descriptions of nano S&T in general	Descriptions of specific benefits /applications
SCMP051001	Wealth of new opportunities; unique; unprecedented; laying the foundations for future generations of…	Better image quality; ideal for…
SCMP240802	Revolutionise many areas of science	Increase the competitiveness of…; inexpensive and bright
SCMP100705	Distinctly unique phenomenon; boundless applications for almost every industry; threshold of a new technological age; biggest investment opportunity of the century	Resistant to scratches and damage from ultraviolet rays; improving or upgrading existing technologies and goods
SCMP260806	Encompasses all walks of science and technology	Smaller, better and more cost efficient; can generate power and store energy
SCMP220109	Revolutionise; breakthrough; huge potential	Recyclable; affordable; very cost effective

Note: Each piece of text separated by a semi-colon represents one descriptive text in the article in question.

Some of the articles describing applications of nano S&T (see e.g. SCMP300604-7, or SCMP300604-6) although appearing modern in style, content-wise resemble stories about home appliances, e.g. gas or electric refrigerators, when these were first introduced in the United States in the early 20th century (see e.g. Tichi, 1991). The products are, for example, directed at parents, who would presumably like to shelter their small children from any potential dangers. One of these articles discusses products of a Hong Kong company using nano S&T developed in Sweden for the coating of plush toys, with promises of 99.9% clean toys:

[55] This is somewhat similar to the dual pattern which Dupuy (2009) refers to regarding the "double language of science", whereby when scientists describe their field, a grand picture is painted regarding the possibilities, but when related risks are referred to by critics, these same scientists reverse their position and state how modest their research really is.

> These value-added features are essential these days in view of parents' increasing concerns about health and hygiene following the SARS incident last year. (SCMP300604-6)

Associating the SARS epidemic with cuddly toys, and suggesting that such toys should be germ free is an interesting way of amplifying risks related to the immediate environment of Hong Kong children, on the one hand, and ignoring any risks related to using such new and untested technology on something these children will be in very close contact with, on the other hand.

If the articles are considered as giving more general statements regarding nano S&T, or even science and technology in general, these statements are very positive. They include a strong conviction that Hong Kong must keep abreast of the developments and take advantage of opportunities to get ahead. Although sometimes scientific development can be slow, it is important (to Hong Kong in particular) and often very exciting. Risks related to (nano) S&T are not a real worry, as they can and will be taken care of. We should not be afraid of progress.

3.2.2 South Africa and Kenya

The discourse around nano S&T in the South African Star newspaper picks up in 2005 from a very low level, and increases again in 2008, so only very recently. The discourse in Kenya has only recently started (see Annex A for both).[56]

Typical stories in the Star include descriptions of applications of nano S&T. This is less in terms of non-essential consumer products (e.g. better cosmetics, more efficient cleaning products or advanced electronics), and more in terms of medical or other health related applications, such as better drug delivery or inexpensive drinking water purification. Applications for energy generation (e.g. better solar panels) or pollution prevention (e.g. cleaning mine waste water) are also discussed. Additionally, nanobots and human enhancement are featured in the Star nano S&T stories.

Although South Africa has been active in nano S&T for years, this has been on a modest scale compared to some other countries involved in nano S&T.[57] Perhaps reflecting this, most of the stories are from outside South Africa, including discussions about business and investment. However, there is also discussion on the national nano S&T strategy, which was launched in 2006, and in connection with this, also some discussion on developments in South Africa takes place. Three significant additional features of the discourse are: firstly, a discussion on risks - perhaps surprisingly, especially in the years following the launch of the national strategy. Secondly, the articles contain thorough details on the science behind

[56] As the numbers of nano S&T articles for Kenya are so low, some comments about the articles from the Kenyan Daily Nation newspaper will be included in this section, but no separate section is provided.

[57] According to the national strategy, the South African government has invested around 40 M euro over three years from 2006, which is not so far from some small countries in the Global North, e.g. the Finnish government invested 38 M euro in 2008 (from http://www.nanotechnologydevelopment.com/investment/nanotechnology-programs-in-finland.html, accessed on 15 June 2009). However, big economies invest far more, with the US leading at around 1 billion euro already in 2006 (http://www.nanotechproject.org/news/archive/ehs-update/, accessed on 15 June 2009).

nano S&T - both on why nano S&T is special, and how the applications work. Thirdly, the importance of gold (to both nano S&T and to South Africa) becomes apparent.

The Star articles seem to present nano S&T as a potential cure for a lot of ills that South Africa and other countries in the Global South face, but to balance this, risks also form an important part of the discourse in this newspaper, even if *ignoring* risk is still the most common specific risk action (see also next section). Therefore, the discourse in the Star could be seen as a form of technology assessment, similarly to what Te Kulve (2006) and Oudshoorn (1999) have argued (see discussion in Section 1). Section 4 will discuss this issue further.

As regards the Kenyan articles in the Daily Nation, these articles could be seen as forming a start of a discourse in this country, of a technology that is moving in, planned or unplanned. Similarly to South Africa, nano S&T is seen as potentially helping with a number of problems Kenya faces, and there may also be an element of risk awareness developing in the discourse. The Daily Nation articles talk about discoveries and applications, and with a similar attention to benefits in the area of health care as in South Africa. A Kenyan scientist also makes headlines with his discovery in this area. Discussion on risks is included in one article out of the five, an editorial from 2008 which is very critical of nano S&T, to the point of being alarmist.

Risk actions and risk frames in South Africa

As defined in Section 2, risk actions include all actions related to risks, including inaction in the form of passive or active ignoring. Almost all risk actions included in this study – apart from *appraising* risk - can be found in the Star articles. However, the most common, accounting for about 40% of the risk actions advanced in the discourse, is *ignoring*, although much of it is *passive ignoring*, i.e. the omitting of inclusion of a risk discussion. Eleven percent of the articles get an *opportunistic* risk frame, in which no apparent concern is shown regarding risks related to nano S&T. The year 2006 seems to be a dividing year. Before and in 2006, most risk frames which can be identified can be called *visionary* and the period itself the *visionary period*, in that nano S&T is seen as enabling South Africa and other African nations to get rid of some of their most burning problems related to poverty and environmental degradation, and it is therefore seen as combating other risks. After 2006, however the discourse becomes much more risk aware in terms of nano S&T itself, and therefore this period can be called the *risk period*. Half of the risk frames of individual stories from this period which can be classified, have been classified as *concerned* (with concern regarding how nano S&T risks are dealt with), with one classification as *confident* (with confidence that risks will be dealt with).

Table 3.4 gives examples of the specific risk actions included in the Star discourse. The second most common risk action in these articles is *identifying*, followed by *assessing*, *attenuating* and *amplifying*. The word risk is used 13 times in the 24 articles, one of these being a reference to a more financial risk. Six separate articles (25%) use the word risk in a non-financial sense, which is fairly remarkable in the nano S&T context.

Table 3.4 Risk actions in the Star

Risk action	Examples of text which the risk action originates from
Accepting	We should recognise that there will be mistakes, and there will be hazards; we already enjoy too many benefits from nanotechnology to be able to straightforwardly stop now
Amplifying	Future threatened by minuscule, self-replicating machines that could devour the world in a form of "grey goo"
Assessing	Royal Society (...) concluded that there is serious cause for concern. It recommended that the government should take action by funding research into the potential risks; plan for studying the risks of nanotechnology
Attenuating	Potential benefits just around the corner far outweigh any possible risks; the risks are hypothetical, and it would be a mistake to stop without harder evidence that the risk is real
Avoiding (active)	We have managed perfectly well so far without nanotechnology, so why take the chance?
Communicating	Public dialogue on the subject
Controlling	Close oversight; ensure that consumers are properly protected against products and materials containing nanotechnology
Eliminating	Should there be an hiatus on the use and development of nanotechnology?
Ignoring (active)*	The [US] Food and Drug Administration, however, announced in July that drugs, cosmetics, or other products manufactured with nanotechnology do not require special regulations or labelling because it said there was no scientific evidence they pose any major safety risks; gold nanoparticles have big pharmaceutical implications and can be used in medication for target delivery because gold is not a harmful metal; the risks are hypothetical, and it would be a mistake to stop without harder evidence that the risk is real
Reducing	Ensure that consumers are properly protected against products and materials containing nanotechnology
Taking (informed)	Balance close oversight against the risk of stifling new development

*Most risk actions classified as *ignoring* cannot be pinpointed to be originating from any one piece of text. Instead, they are visible in the totality of an article. Such ignoring as a risk action belongs to *passive ignoring* discussed in Section 2.
Note: Each piece of text separated by a semi-colon is a separate quote from either the same article or from a different article.

The first example given in Table 3.4 for *active ignoring,* related to the US Food and Drug Administration's (FDA) announcement, is an obvious example of the exclusion of the precautionary principle, according to which, if there is a possibility of considerable harm related to a certain risk, this risk should be avoided to the extent practical, even though proof of harm does not yet exist.[58] It is argued here that ignorance of the precautionary principle constitutes active ignoring of (potential) risks. There are two examples of the implicit *inclusion* of this principle into the Star discourse on nano S&T:

> The [UK] Royal Commission found no evidence of harm to health or the environment from nanomaterials, but this "absence of evidence" is not being taken as "evidence of

[58] The second example in Table 3.4 for active ignoring relates to gold nanoparticles. It sounds harmless at first sight, but considering that bigger than nano-sized and nano-sized gold particles behave differently from each other, this remark becomes another example of active ignoring, in that it does not take this crucial difference into account.

absence". In other words, just because there are no apparent problems, this is not to say that there is no risk now or in the future (S141108-1)

If there is any doubt at all, it would do no harm to call a temporary halt until we know more (S141108-2)

Inclusion or exclusion of uncertainties is another risk related aspect that can be observed in the articles. Twenty-five percent of the Star articles include implicitly or explicitly risk related uncertainties, but in the risk period (after 2006), this proportion rises to almost a half.

3.2.3 India

There are many more relevant articles in the Indian Hindu newspaper than could be analysed in the time available for the project. Therefore, as explained in Section 2, a sample of 35 from all the articles has been chosen for the main analysis. Additionally, as the analysis progressed, it became clear that certain themes, obvious from the first quick reading of all the articles, would not be adequately represented in the sample. Therefore, to get a better idea of these themes, the whole pool of relevant articles was used on occasion.

As can be seen from the table in Annex A, apart from a dip in 2002 and 2003, the total number of articles related to nano S&T in the Hindu has been growing at quite a pace from 2000 onwards, with a large jump in 2005. The number of relevant articles for this study has been more moderate in growth, however with a similar jump in 2005, and these numbers seem to have settled for the last few years. The main database of analysed articles includes the *time sample* (every three years from 2000, except every second month for 2006), and the *risk sample* (all those articles that either use the word 'risk' or the word 'safe' in connection with nano S&T).[59]

The stories in the Hindu are typically about discoveries and applications related to nano S&T. These are related to pharmaceuticals and healthcare, electronics, ICTs, renewable energy, mining, space research, new high-tech fabrics, security and military. In other words, the discourse talks about applications potentially meeting the needs of both more developed parts of India, as well as focusing on the needs of the vast numbers of Indians living in poverty. Applications that are related to traditional Indian strengths, such as textiles, are also covered, as well as things that could be considered important for India as a global player, such as space and military applications.

Apart from the usual focus on discoveries and applications, background to India in terms of nano S&T is also rather well covered. Related to this, the importance of education, both for the development of India and for nano S&T as a particularly crucial field, or as a career choice for the young, is emphasized. Nano S&T is certainly seen as an important area for India to pursue, but there are two kinds of related concerns: that India is not doing as much

[59] Importantly, as only a small number of all articles are covered for most of the analysis, direct comparisons with the other newspapers included in this study have to be made with some caution.

as it could on the one hand, and that the technology itself is not entirely positive (nor can it be made entirely safe), on the other hand, but the latter concern gets easily buried under the rest of the discourse.

Some further special themes to the discourse in the Hindu also emerge. Firstly, there are two important Indian spokespersons for nano S&T, the former President Abdul Kalam and a nanoscientist C.N.R. Rao. Based on the Hindu articles, these two men have been critical in building the Indian nano S&T.[60] Secondly, comparisons between nano S&T and other technologies or issues, such as biotechnology, asbestos, mobile phones, nuclear power or climate change, are common. The points of comparison are related to for example, controversy, complexity, questions on safety, ignorance of risks, uncertainties. Thirdly, a (limited) discourse on the social construction of technology as it relates to nano S&T can be found, uniquely in the context of this study. And lastly, in many instances nano S&T is presented as either an old technology or as something that is natural, i.e. something where scientists are trying to mimic nature (see also next section).

The overall complexity of the articles, based on analyzing both the time sample and the risk sample, seems quite low, and as such, not so useful for generating public interest, concern or discussion. On the other hand, if the reader comes across one of the risk sample articles, he or she will be exposed to a rather different viewpoint on nano S&T.

Nano as old and natural in India

One interesting feature of the Hindu discourse as regards the portrayal of nano S&T, is that many of the articles present nano S&T as either something that is not new to humans, or as something that is found in nature with humans only trying to mimic nature.[61]

Firstly, nanoparticles have actually been used in ancient times, although unknowingly, for example, by Indian doctors in treating their patients (H110109), and by Inca metal-smiths in creating objects from gold (H130206). So, nano S&T could perhaps be seen not so much as a new and strange technology, but as a newly discovered, old and trusted technology. Although the reference to doctors or Incas only appears once each, there are a few other references to nano S&T being 'old' or 'not new'. These also link to seeing nano S&T as natural: "Nanotechnology (...) is a very old subject which has evolved naturally over a billion years and has become the most important topic of current times, [Nobel laureate Robert Curl Jr.] said" (H050108). This is a rather frequent way of presenting nano S&T, and the following quote from President Kalam is another example of this:

> "WHEN I go for a morning walk in the Mughal Gardens of the Rashtrapati Bhavan, I see peacocks dancing during this season. When I look at the deep and beautiful colours on

[60] The concept of spokesperson here is similar to the Latourian spokesperson, i.e. that who sets up a network, and makes him/her/itself the so-called obligatory passage point (see e.g. Latour, 1987). In this context, a spokesperson represents nano S&T to the other relevant actors in society, and while doing this they do become obligatory passage points of a kind, as it is tempting – and sometimes inevitable - to include one of them in any story about nano S&T in India. In the Global North, there are individuals, such as Eric Drexler, Michael Crichton or Prince Charles, who can be identified with the construction of nano S&T in one way or another.

[61] This sub-section uses the entire pool of relevant articles from the Hindu.

> their feathers, I often wonder how the colours do not fade. I recall as a young boy, I used to keep peacock feathers in my books. This long lasting original colours have come from God's creation of nano materials coated on peacocks' feathers." (H011104)

Some articles also present nano S&T as something that is, although perhaps not ancient, but certainly established, with comments such as: "Nanotechnology has been around for a long time, enabling the manufacture of objects measurable at an atomic scale" (H170403), already appearing in 2003. Of course, nano S&T may actually be more established in industry than most people realize. One recent article also talks about the 'nano age' which we are already all living in, nano age is not just for the future, and it is a continuation from passing through the "stone, copper, iron and polymer ages" (H060309).

4. Wider analysis and points of comparison

This section pulls together analysis of the discourses included in this study (in Hong Kong, South Africa, Kenya and India), as well as makes some comparisons between these and the previous media studies. A more descriptive part is intercepted and followed by discussion and references to literature discussed earlier in this paper. Finally, some potential implications for the risk governance of nano S&T will be considered.[62]

4.1 Nano S&T discourses in the North and the South

Overall, it can be said that the discourse in the Global South and the Global North include the same pattern of increasing attention to nano S&T.[63] However, in the North the discourse started considerably earlier (in the 1990's), as compared to the South where it started mostly in the early 2000's. In both groups, a clear rise in numbers of articles can be observed around year 2004. This is probably partly due to several events taking place around this year - e.g. the strong position taken by Prince Charles on nano S&T, the UK 'Royal Society report' on nano S&T risks, or the Drexler/Smalley debate on the limits of the technology[64] - combined with increasing research and firm activity building up excitement, and sometimes worry, about nano S&T.

4.1.1 Attributes and actors

The topics vary to some extent between countries, although everywhere (both in the Global South and in the Global North) science and its applications are the most important attributes of nano S&T discussed. Apart from that, at the individual country level, characteristic topics include business for the US, science fiction and risks for the UK, policy and education for Denmark, and science fiction and policy for the Netherlands (and more recently also risks). In the South, after science and its applications comes business for Hong Kong, risks for South Africa and education for India. In South Africa the focus is on direct benefits from nano S&T to the people of South Africa, whereas in Hong Kong the focus is mostly on economic benefits coming, for example, from exports. In India the focus seems to be on both direct and indirect benefits. Finally, in the North, most countries focus on the economic benefits, as might be expected, but this seems to be especially so for the smaller (European) countries.

In terms of the actors in the discourses, this aspect has not been analysed in detail for the Global North, but in the Global South, scientists dominate in South Africa (and in Kenya)

[62] For a better flow of text, some temporary generalizations will be made, so that the analyses included in this study will be referred to as for the Global South, and the analyses in the previous studies will be referred to as for the Global North. Similarly, the fact that for the Global South, only one newspaper is included from each country is ignored, and references will be made to countries, rather than newspapers. It is important however, to remember that in reality such generalizations cannot be made between a single newspaper (even if relatively representative of the newspapers in a particular country) and a country, or between a few countries and a whole 'half' of the world. Additionally, for India, it must be kept in mind that only a small proportion (less than 20%) of the relevant articles in the Hindu have been analysed in detail.

[63] The only observable exceptions are Hong Kong, where the number of articles is fairly steady apart from peaks in 2004 and 2006, and Germany, where the number declines somewhat after 2004.

[64] See more for this debate e.g. in Kaplan and Radin (2009).

and in India. For Hong Kong, there are three equally dominant groups of actors: firms, scientists and universities. After scientists, various groups of the public come next in South Africa, and then come countries and governments. Firms come last in South Africa. In India, the risk sample - which forms only 5% of the relevant nano S&T articles in the Hindu - is not dominated by scientists, but by governments, and NGOs also feature in the risk sample. The role of spokespersons is notable for India, and also for the UK (see Table 3.1 on p. 31 for Anderson et al., 2005, for the UK). Differences can also be found in terms of location of nano S&T in the discourse, in Hong Kong and in India the action is mostly domestic (except in the Indian risk sample), whereas in South Africa foreign actors dominate, which could be expected, as nano S&T is not yet very far along in South Africa.

4.1.2 Risk discourses and frames

Much of the concern related to nano S&T everywhere has related, consciously, and sometimes unconsciously, to molecular manufacturing, probably due to the science fiction like elements in this area of nano S&T, and also in relation to the 'grey goo' discussion which started from Eric Drexler's book *Engines of Creation* published in 1986.[65] In 2000, another major event took place in the fledging nano risk discourse, when Bill Joy published his article on the risks of nano S&T to humanity in the *Wired* magazine.[66] Yet another notable step was the report Canadian NGO, the ETC Group, published in 2003 critical of nano S&T also in terms of immediate health effects. According to Lewenstein et al. (2006), by early 2004, research questioning the safety of some areas of nano S&T was beginning to appear. In the Global South, media risk discourse has started slightly later than in the Global North, with first newspaper articles referring to risks appearing from around 2004 (within the analysed data). In 2004, came the Royal Society report mentioned earlier, as well as the other events that year.

At the country level, as Table 3.1 indicates, the UK has had a relatively early focus on risks (possibly due to the spokesperson effect), the Netherlands has had a later focus, and in Denmark and Norway there has been little risk discussion. In Germany, risk discussion exists, but it seems to be at a lower level than could be expected. Canada has also had some focus on risks, but in the US the discussion has been quite limited.

For the countries in the Global South, comparable numbers are available (for the occurrences of the words 'risk' and 'safe' in a non-financial nano S&T context), and they show large differences between the countries: 5% of articles in India, 10% of articles in Hong Kong, and 25% of articles in South Africa include some discussion on risks. In South Africa the concerns have been increasing recently, while especially in India the much lower level of concern is fairly constant.[67] Interestingly, at first hand the media concern in South Africa seems conflicting, considering that nano S&T is seen there as such a powerful tool to solve many of the most pressing problems the country faces. But as Zeiss (2009) suggests,

[65] In his book, Drexler writes, among other things, about the threats molecular manufacturing with self-replicating nanorobots might bring.
[66] See 'Why the future doesn't need us', *Wired*, April 2000.
[67] Similarly, a low but constant level of concern has been observed for the US in several studies.

perhaps this is precisely because nano S&T is seen as so fundamental in South Africa, also the potential risks therefore have to be taken seriously. In Hong Kong, on the other hand, the approach to risks is much more casual, as there the technology is a more detached tool for growth. India seems to be somewhere in between, the level of risk discourse is very low, but there still is a clear discourse of potentially serious risks. Similarly, nano S&T has a dual role in India, optimally catering for both the more developed parts of the country and for those living in poverty. The actual risk frames that the discourse in these countries seems to have follow the same pattern, in Hong Kong many more articles get an *opportunistic* risk frame, South Africa has the smallest number of articles falling within this risk frame and India is somewhere in between.

Risk actions

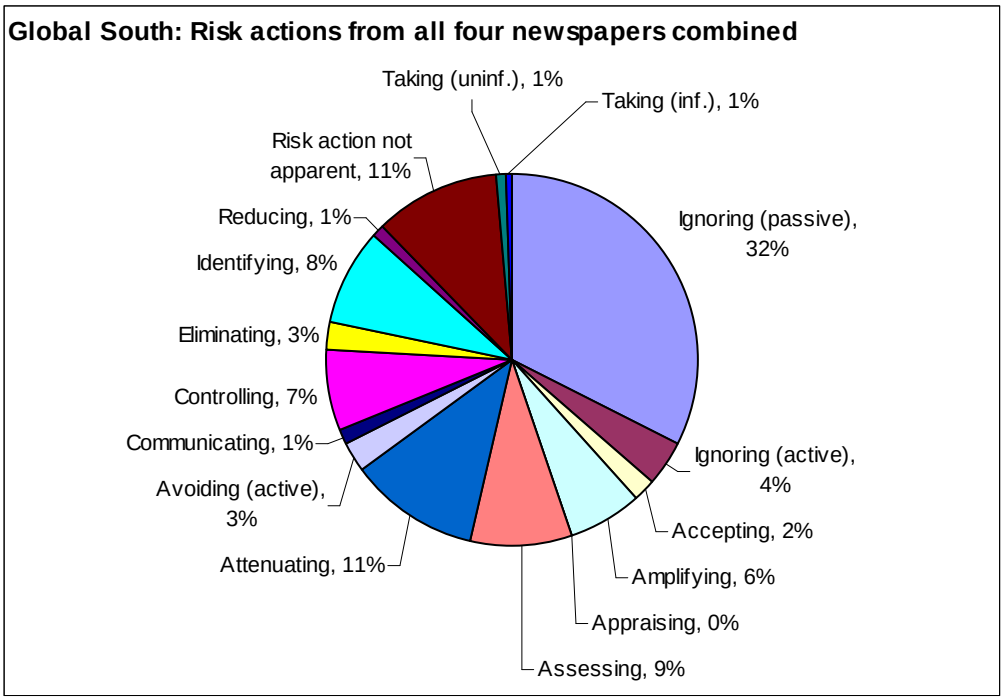
Not being able to look at the actual data used in the studies in the Global North, it is difficult to say much about the included risk actions, as this aspect has not been analysed in detail in these studies. However, based on reading the reports, it seems fairly obvious that the most commonly included risk action is ignoring (see also Table 3.1 on p. 31). Three studies do look at some risk related actions, with Stephens (2005) concluding that UK articles include a call for risk assessment more often than US articles, and Zimmer et al. (2008) stating that only 8% of the German articles make demands regarding risks, with the associated risk related actions being assessing, controlling, reducing and eliminating.[68] Finally, based on Kjolberg (2009) it appears that, although risks are rarely discussed in the Norwegian newspapers, when they are, controlling risks surfaces as the most common risk related action.

As for the Global South, Figure 4.1 shows all risk actions combined for the analysed countries according to the typology given in Figure 2.2 on p. 16. Here we can see that ignoring (mostly passive ignoring) can again be considered the most common risk action, accounting for over a third of all risk actions. At the country level, ignoring accounts for a half of risk actions in India, and for only a quarter in South Africa. Hong Kong is in between with 40%. After ignoring, attenuating risks is the second most common single action. Overall, the average number of risk actions per newspaper article ranges from 1.1 for India (barely anything but ignoring) to 2.0 for South Africa. As for the Indian risk sample, the average is as high as 3.7.

As Proctor and Schiebinger (2008) argue, the cultural production of ignorance is partly caused by media neglect of certain issues, and the nano S&T discourse seems to serve as a good example of such ignorance, as it relates to risk. One of the findings from this study is therefore that media – at least for the newspapers analysed for the Global South - does indeed seem to largely participate in constructing ignorance of nano S&T risks. Only in South Africa do we see a clear risk discourse that is not buried under ignorance.

[68] Interestingly, a third of these demands are made by scientists.

Figure 4.1 Risk actions in the Global South



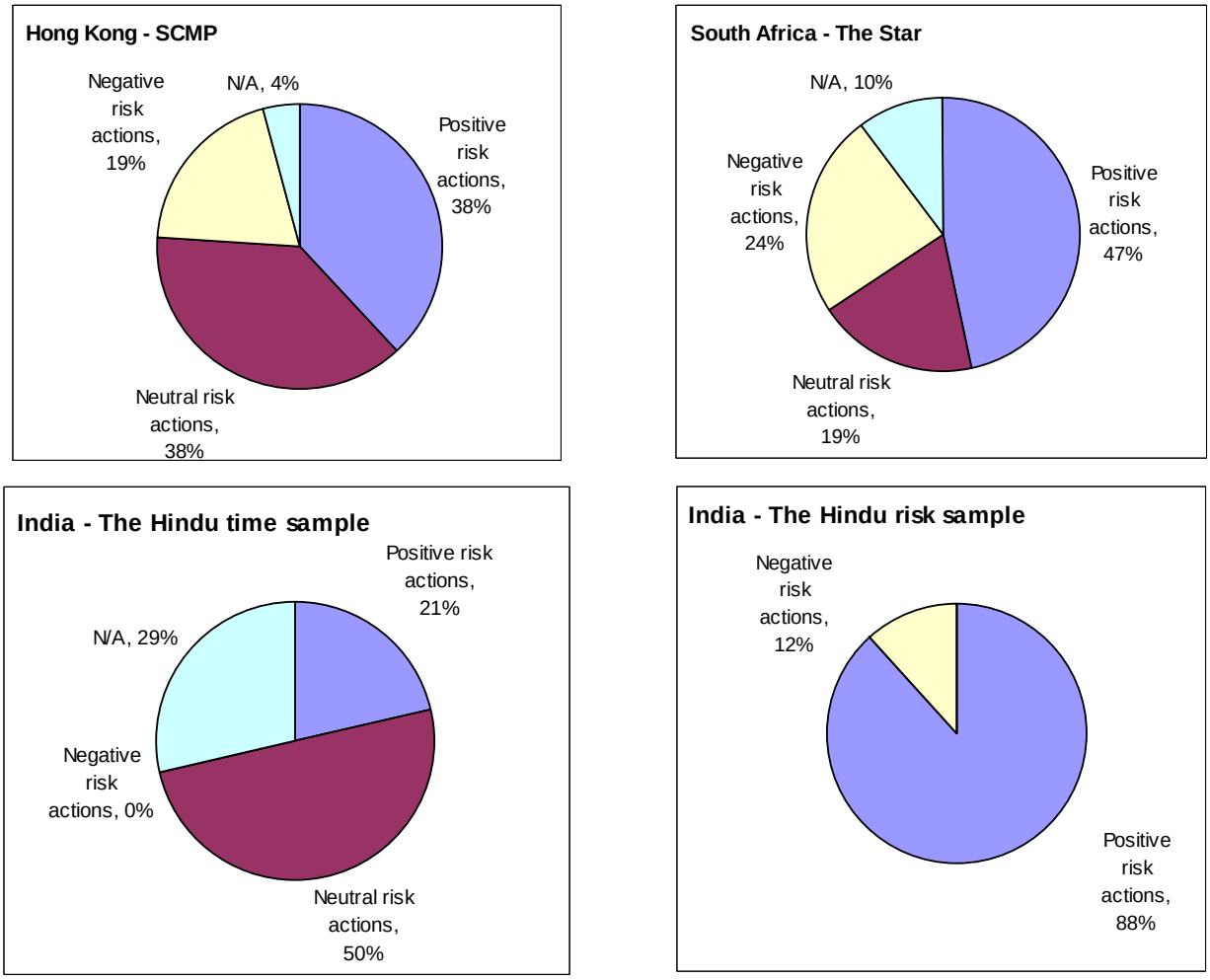
Note: This figure combines 158 risk actions from 86 articles from all four countries (thus including Kenya), but excludes the Hindu risk sample, which cannot be combined with the Hindu time sample (as the time sample is a random sample, and the risk sample a non-random sample).

The typology in Figure 2.2 is also based on value judgements regarding the potential impacts from risks. Therefore, Figure 4.2 below shows the analysed risk actions in terms of the negative, neutral[69] or positive values that are given to *preventing* the impacts from nano S&T related risks. Significant differences can be seen between the countries, with South Africa leading with positive risk actions - such as assessing or controlling risks - and a large portion of the Indian (time sample) articles showing a lack of valuing the impacts, in other words, largely ignoring them (neutral risk actions). On the other hand, the Indian risk sample - representing only 5% of the articles - takes a very strong stance for positive risk actions.[70]

[69] 'Neutral' here refers to the value judgement not having been made.

[70] All the above analysis refers to non-explicit valuing, but interestingly, also two references of risk appraisal can be found in the Indian risk sample articles. As described in Section 2, *appraising* risk involves giving some (mostly non-financial) value to risk impacts. It seems to be fairly uncommon at least in the newspapers chosen for this study.

Figure 4.2 Comparing risk actions in terms of value judgements



Note: N/A (not apparent) indicates that risk actions in a certain article are not clear and cannot therefore be classified.

4.1.3 Complexity

As explained in Section 2, complexity in this study is measured by looking at the number of actors, attributes and risk actions included, as well as taking into consideration the inclusion or exclusion of uncertainties in the discourse.

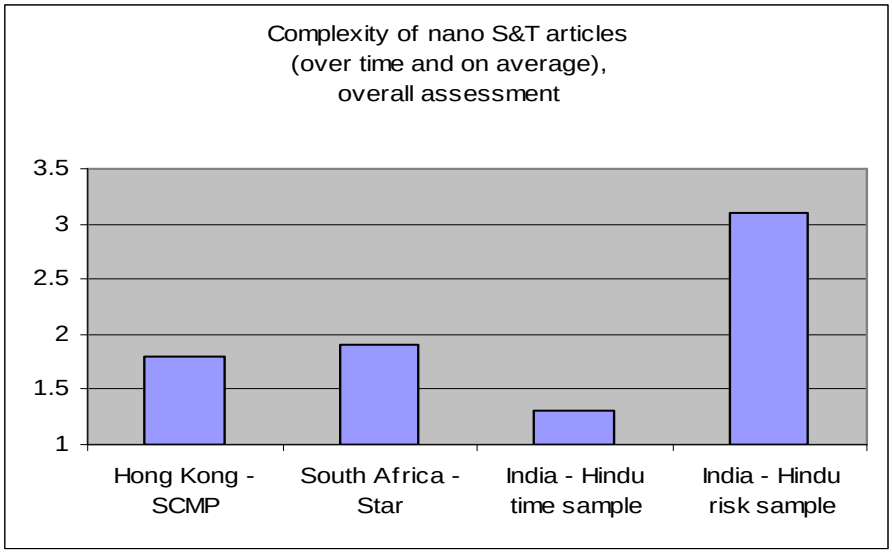
As in the case of risk actions, complexity is not analysed as such in the included studies for the Global North. However, some indicators can be seen (see also Table 3.1 on p. 31). For example, the proportion of risk/benefit discussions ranges between countries in the North from 1% to 21% of the articles.[71] This indicates that some discourses may be more complex than others. Similarly, for example for the Netherlands, complexity must have been increasing over time, as both the number of frames (or topics) and the proportion of risk/benefit articles has increased (Te Kulve, 2006). Finally, for Norway, Kjolberg (2009)

[71] This range does not include the 37% for the US 'risk sample' in Weaver et al. (forthcoming), nor does it include the first period of study in Te Kulve (2006) from 1992 to 1999 with 0% of risk/benefit discussion, as this period was before people really discussed nano S&T risks. See Table 3.1 on p. 31.

observes that conflicts or uncertainties are usually excluded from the articles. Therefore, complexity must be less than it would otherwise be.

For the Global South, Figure 4.3 shows an estimation of the complexity of the nano S&T discourses for Hong Kong, South Africa and India. As can be seen, the Indian discourse (apart from the risk sample) is the least complex, while the discourse in Hong Kong and South Africa is more or less equal in complexity. The Hindu risk sample is close to the value which suggests potentially an equal distribution of complexity among all articles, and in comparison, it points to the low levels of complexity in the overall discourses.[72]

Figure 4.3 Quantifying complexity



Notes:
The above figure is based on an overall assessment, with one estimated number (from 1 to 5) given for each article.[73]
Value of 1 indicates the lowest possible level of complexity for all articles, and value of 5 the highest possible level, while 3 suggests potentially an equal distribution of all levels of complexity among the articles (e.g. so that if five articles each get a different value from 1 to 5, the average for these articles is 3). Other distributions are, of course, also possible, e.g. so that half the articles are very simple (1), and half very complex (5).

The trend towards simpler framing observed by Rosa and Spanjol (2005) in discourses about new products in the market does not seem to hold for nano S&T as a new technology in the Global South, at least not yet. In both Hong Kong and India, the discourse gets somewhat more complex over time, and in South Africa the level of complexity stays the same. In the Global North, stories also seem to get more complex in terms of attributes and actors. This trend is clear at least from the studies in the Netherlands (te Kulve, 2006) and in the US (Weaver et al., 2009) which cover longer stretches of time.

[72] Whether this level would be ideal for generating public debate, or perhaps too high, is an open question.
[73] Another method used to estimate complexity in this study, summing up the average number of actors, attributes and risk actions, does not in itself include the uncertainty aspect; however, this can be calculated in. A similar pattern emerges from this calculation, although there the SCMP complexity is slightly higher than that in the Star.

4.1.4 Defining and constructing nano S&T

As mentioned in Table 3.1 (on p. 31), in the Global North, journalists seem to have some trouble defining and explaining nano S&T to their readers, a phenomenon referred to in four studies (for the US, Canada, UK and Germany). Similarly for the Global South, both Hong Kong and India seem to have similar trouble in that the definitions are very general, and the science behind nano S&T is not really explained.[74] The exception here is South Africa, where the articles do contain detailed and relatively clear explanations.

An overall impression of the discourse indicates that Hong Kong believes that, although it has been slow in getting on with nano S&T, the country is making progress. Hong Kong needs nano S&T for combating economic troubles: for staying competitive and for restructuring industry, as well as for obtaining high-tech products for the citizens. Mainland China and other neighbouring countries are threatening Hong Kong's chances in nano S&T.

On the other hand, South Africa seems to believe that nano S&T offers great promise in solving many of its domestic problems related to poverty (or underdeveloped formal and informal institutions), and the more South Africa can be involved in the global developments, the better. Nano S&T is for combating social (and environmental) troubles, so mainly for improving human and environmental health and wellbeing.[75]

Finally, India seems to believe that it needs nano S&T for both its global position and for making life better for its people, but it is still a relatively new player (as compared to big players in the Global North), and therefore it is not yet far enough in terms of investments, despite the huge potential it has in its people. India has perhaps highest aspirations regarding nano S&T among the studied countries, as it wants to use the technology as one of the means to make India a developed country (see e.g. H270707). For India, nano S&T is for combating both social and economic troubles.

Specific themes

Perhaps the most interesting themes emerging from the discourses in the Global South arise from India, and there especially the view of nano S&T as old or natural is worth noting (see more in Section 3). This is in contrast with the Global North, where nano S&T is all about either scientific progress (science fact) or science fiction.[76] Other noteworthy themes in India include the role of spokespersons (President Kalam and nanoscientist Professor Rao) in building appreciation and awareness of nano S&T among the public, and the fledgling social constructivist discussion of nano S&T, also unique in the context of this study.

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[74] One could say that explaining nano S&T is not necessary, and therefore journalists do not have to go into the details. However, being that even those working in some form with nano S&T have some difficulties defining it, this argument does not seem reasonable. And, even assuming that the formal definition was clear, its practical meaning might not be clear to many newspaper readers.

[75] Another African country, Kenya is only just getting acquainted with the possibilities of nano S&T and it sees the opportunities the technology can offer its people, especially related to problems with poverty, but the country does not yet have much capacity for developing its own nano S&T.

[76] See e.g. Bowman et al. (2007) for the science fact – science fiction discussion.

In South Africa, a specific theme can be seen in how nano S&T is presented there as a means to counter risks from poverty and environmental degradation. The importance of gold for both South Africa and for nano S&T is also apparent in the discourse.

Lastly, in Hong Kong one emerging theme is related to the relationship Hong Kong has with China, in that it fears losing its nano S&T scientists and students, and therefore, the edge of its future competitiveness to China. Another theme emerges regarding the importance given to nano S&T applications related to cleanliness. This might be influenced by the recent SARS and bird flu epidemics there.

4.1.5 Conclusion

In conclusion, it can be said that the discourses in the Global North and the Global South express some similarities, although the analyses are not done with the same methods, so fewer comparisons can be made. Many differences between countries can be seen, however, also within the countries in the South. It seems that the meaning of nano S&T is constructed according to whatever is important for each country. With some exceptions (mainly the UK, Canada, South Africa, and perhaps the Netherlands), risks related to nano S&T feature only weakly in the discourses. Finally, what Stephens (2005) observes for science news reporting in general (see Section 1) seems to also hold for the Global South: nano S&T is seen as mostly positive, the articles do not usually criticize the science, and the range of actors included is limited.

4.2 Governance issues

Governance issues and the related question of public engagement are touched upon in some of the studies on media discourses in the Global North, as well as other related literature. The discussion that follows will include some of this discussion, while considering the issues in the context of the present study.

For example, te Kulve (2006) argues that perhaps any debate about an emerging technology will eventually be cast in an "antagonistic mould", with proponents and opponents, and he observes that in the Netherlands a shift from a dual repertoire of hype and realism about nano S&T has indeed changed to an antagonistic pattern more recently. Rip and Talma (1998) argue that new technologies threatening certain values are generally viewed like this in the Global North, but that other technologies that do not threaten values to the same extent (e.g. ICTs) are not viewed antagonistically.[77] Nano S&T could certainly be seen belonging to the first category. Rip and Talma argue further that antagonistic patterns can in fact help to clarify issues related to a technology and therefore result in better understanding of the technology.[78] Presumably, this would also lead to a better public debate.

[77] ICTs may threaten certain values related to, for example privacy or social relationships. But Rip and Talma (1998) refer more to values related to health, safety or ecological sustainability. They also make a distinction between technologies that are in everyday use (less threatening) and technologies that seem more distant (more threatening).

[78] This is actually similar to x referring media discourse as technology assessment.

Based on the present analysis of the discourses in the Global South, the media is mostly not (yet) framing nano S&T antagonistically. Critical voices do exist, and proportionally in South Africa they are also significant, but overwhelmingly the framing is still very positive in the included countries. What might be of concern, is that there seems to be a trend for more media reporting on nano S&T in general,[79] while the level of critical reporting stays more even, this being the case especially in India.

Further, Anderson et al. (2005) observe that in the UK, there is a tendency to present "two sides of a story" for apparent balance and impartiality regarding nano S&T.[80] Interestingly, the question of balance has been significant in the climate change debate, with e.g. Rogers (1999) concluding that the inclusion in the media of the minority view on climate change has greatly influenced how controversial people have viewed the climate change issue as. With the possible exceptions of the UK and South Africa, in both South and North discourses, there is mostly no balance between presenting risks and benefits of nano S&T, and as noted earlier, the most common risk action is ignoring risks altogether.

The analysed discourses in the Global South include concerns that nano S&T is sneaking in by being introduced by multinationals for their own benefits without any regulatory framework existing in the host countries (see e.g. H010205-1 for India and DN231208 for Kenya[81]). This may actually be a common sentiment in these countries regarding other technologies as well, for example, with biotechnology (see DN231208). But in fact, no country in the world actually currently has a regulatory framework specifically for nano S&T, so we are all in the same 'mess', so to speak. Countries in the Global North, however, are discussing the issue more, have made more concrete plans - e.g. to govern nano S&T through the REACH framework in Europe[82] - and may be more able to implement such frameworks, if and when decided.

For everyone's benefit, countries in the Global South will also need to govern nano S&T. As Bijker (2009) argues, they should develop their own style of risk governance of emerging technologies, such as nano S&T. Here especially contextual factors - such as organizational capacity, social climate, political and regulatory culture and the network of relevant actors – vary greatly, and are therefore very importantly also included in the IRGC framework (see e.g. Renn and Walker, 2008b: pp. 359-361 and Fig. 3).

The relationship between media discourse and risk governance is somewhat controversial. However, as argued in Section 1, at least in some circumstances, we can consider a dual

[79] However, the possible phenomenon of narcotizing dysfunction (see Section 2) of media reporting (Lazarsfeld and Merton, 1975) is not relevant for these countries, as the levels of reporting on nano S&T are low in both Hong Kong and in South Africa. In India, there is more reporting, and in principle people might start to see references to nano as very commonplace. However, risks related to nano S&T are not yet commonly discussed.

[80] This can be seen as different from the antagonistic presentation, as one does not have to oppose a technology to consider also its negative aspects.

[81] Similarly an article titled 'Nanotechnology: How prepared is Uganda?' dated for 28 June 2009 in a Ugandan newspaper The Monitor (www.monitor.co.ug, accessed 19 July 2009) questions the same point.

[82] However, the process will probably still take some time. See e.g. http://www.rsc.org/chemistryworld/News/2009/June/16060901.asp (accessed on 19 July 2009) for an article titled 'Nanomaterials cause classification headache for Reach', dated 16 June 2009.

meaning for media discourse as technology assessment since: firstly, analyzing the discourse gives us some indication of how a technology is currently perceived, and secondly, the discourse can play a role in public engagement in further societal technology assessment (for the last point, see e.g. Petersen et al., 2008).[83]

There are some elements of a risk discourse found in both the studies on the Global North and the present study on the Global South, although, for example, Zimmer et al. (2008) are concerned about the low level of media risk discourse in Germany not being able to generate "critical public debate", unless there is an actual crisis related to nano S&T. Similarly, Kjolberg (2009) is concerned that nano S&T is presented too positively and not as complex enough of an issue in Norway for any public risk discourse to take place.

As noted earlier, Brian Wynne and his team (Morris et al., 2001) found in their large study regarding biotechnology, that the public, at least in Europe, actually wants the media to provide them with a wide range of arguments. Therefore, the UK style of more balance might actually be desirable from the points of view of both the public and nano S&T risk governance.

In the Global South, India is the only country included in the present study where the concept of early warnings regarding risks of an emerging technology is discussed to a considerable extent, although this is within the included risk sample, which covers only 5% of all the relevant articles. Nonetheless, many comparisons between nano S&T and other technologies are made to illustrate the point. South Africa also includes some similar discussion, but to a more limited extent (although in general, a risk discourse on nano S&T can be found there), and Hong Kong does not engage in such discussion at all.[84]

As discussed in Section 1, the inclusion or exclusion of uncertainties makes a crucial difference for risk communication, and it is also considered one of the components of complexity in discourse in the present study. Research shows that media mostly tend to make science appear more certain than scientists themselves would see it as (see e.g. Stocking, 1999), while sometimes they do the opposite. For the Global North, the studies mostly do not look at this aspect. An exception, Kjolberg (2009) notes that uncertainties are rarely discussed in the Norwegian press. In the Global South, there is some variability regarding the issue. In Hong Kong and in India, the discourse mostly does not include uncertainties (except in the Hindu risk sample, where uncertainties are there in almost every article). The South African discourse, on the other hand, does include uncertainties to an extent. These observations confirm arguments by e.g. Stocking (1999) in that although exceptions exist, mostly media tends to make science appear more certain than it is.

Section 2 discusses trust in institutions as being important for public acceptance of nano S&T (see e.g. Moore, 2006 and Priest et al., 2003). An indicator of such trust, in terms of trust in politicians, can be seen in Table 2.2 on p. 26, from where it is obvious that the level

[83] At least, if we consider that the public has a role also outside government directed public engagement, i.e. in the form of more spontaneous engagement (see Kjolberg, 2009).

[84] See more for the topic of early warnings, late lessons, in Harremoes et. al (2002) and Hansen et al. (2008) as applied to nano S&T. Most important lesson to be learned: Do not ignore early warnings!

varies greatly for the countries included in the present study. It is then interesting to note that, on the one hand, in Hong Kong and in South Africa, where the level of trust is either high or at a medium level, there are very few, if any, references to trust issues regarding nano S&T within the analysed data. On the other hand, in India, where the level of trust is fairly low, there is some critical discussion on the topic as regards nano S&T, and at the same time, the use of spokespersons for the technology can be seen as potentially increasing the level of trust. Löfstedt's (2005) argument that public engagement is important when public trust is low seems to fit well the case of nano S&T in India.[85]

Assessing the discourses in the Global South in general, however, it can be said that, although the level of complexity of the discourse is more or less the same in both South Africa and Hong Kong, this is largely due to the inclusion of more actors in Hong Kong, and so, there is clearly more risk discussion in the media in South Africa.[86] The South African discourse might, therefore, be more fitting for creating public debate and for public technology assessment. India is somewhere in between the other two countries, as the majority of stories are very simple and do not consider risks, but nonetheless, a rather rich risk discourse does exist, even if somewhat overwhelmed by the general excitement about nano S&T. These points are also reflected in Figure 4.4, which pulls together analysed risk actions based on the typology presented in Section 2.[87]

Regarding this typology, in comparison, the IRGC model of risk governance does not use the 'risk action' concept, nor does it include any similar classifications, or make connections between risks and value assessment in the way done in the present study. If it is seen important to assess approaches to risk in a discourse (in the media, for example) about a topic, such as nano S&T, with broad implications, the typology used in the present analysis suggests a way to do this. A risk governance framework, such as the IRGC model, could also incorporate risk action analysis, or broader risk discourse analysis, into it to help find out how an issue is assessed within the discourse, and consequently, to help decide the right mode of risk communication.[88] Such analysis could also be seen as something to do alongside government organized public engagement in risk governance. Alternatively, it could be seen as an additional inexpensive method of risk governance for those risk problems that would not necessarily invoke public participation, provided that they are still reported on in the media.

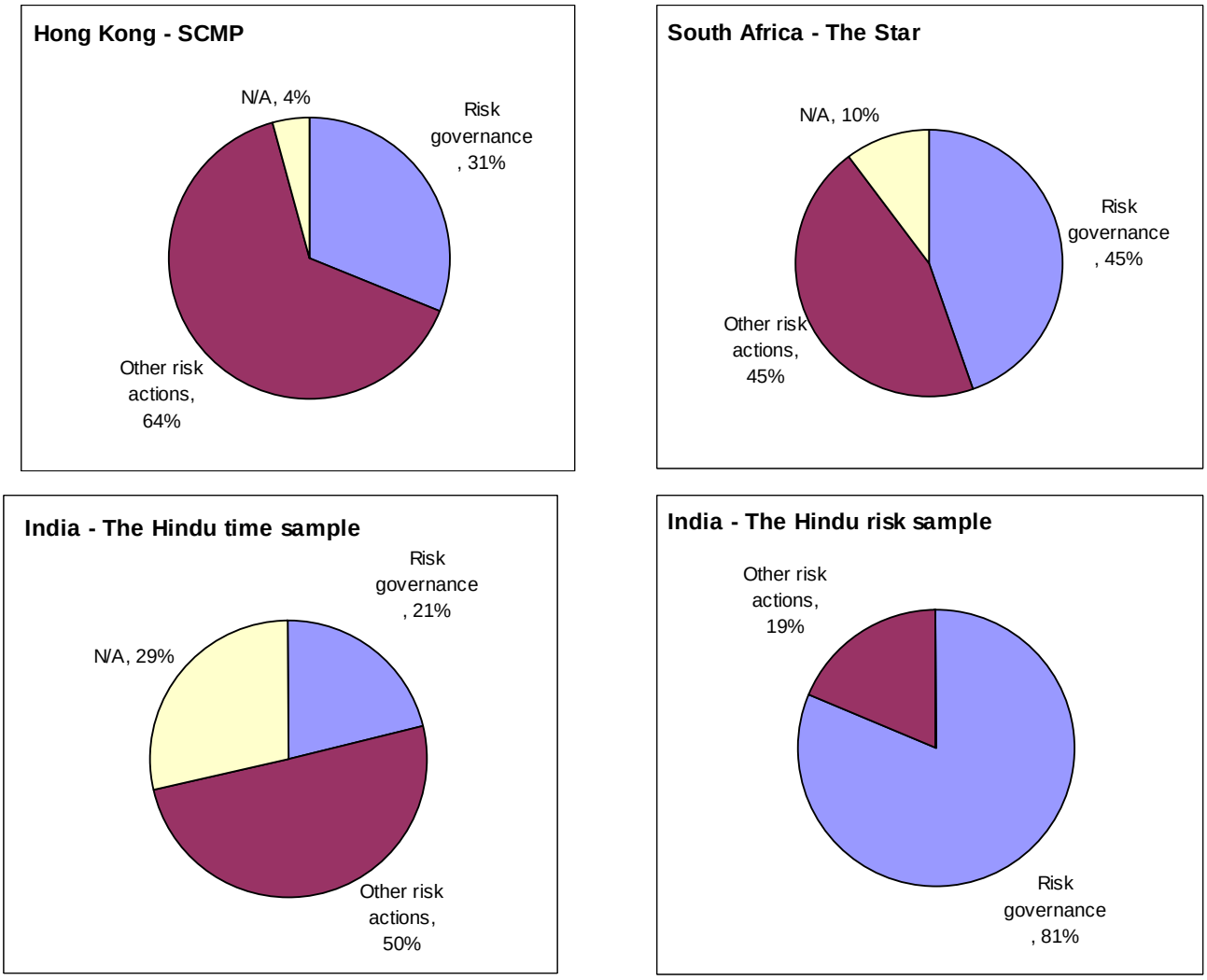
[85] Also considering the strength of civil society in India, i.e. the readiness of the various publics to engage (see e.g. Sheth and Sethi, 1991), India could be ready for some public engagement on nano S&T.

[86] Therefore, it is obvious that complexity alone cannot be used to gauge a discourse. But alongside assessing the content of the discourse, the level of complexity can help, as a discourse being very simple does not seem helpful, and neither is a very complex discourse probably constructive either.

[87] Comparing Figures 4.4 and 4.1, what can be seen as working against risk governance, is the proportion of ignoring as a risk action. Ignoring can be seen as undermining risk discourse and therefore also the potential for risk governance.

[88] In the IRGC framework, such risk discourse analysis could fit somewhere within the pre-assessment or appraisal phases.

Figure 4.4 Comparing risk actions in terms of risk governance



Note: N/A (not apparent) indicates that risk actions in a certain article are not clear and cannot therefore be classified.

5. Final conclusions

As Bryman (2008) notes, "the social researcher is always providing his or her own 'spin' on the texts that are analysed" (p. 526). This paper has presented one such spin on the media discourses on nano S&T in four countries in the Global South: Hong Kong, South Africa, Kenya and India.

In summary, the discourses seem to vary to a considerable extent. In both Hong Kong and South Africa, the discourse is relatively simple, but in Hong Kong, nano S&T is presented much more certain and risks are mostly not touched upon, whereas in South Africa, a clear risk discussion exists, and increasingly so. In India, the general discourse is quite simple and does not present risks as something to be concerned about. On the other hand, from 2004 onwards, there has been a small proportion of Indian articles with a much richer discussion on various topics, and in addition to risks, also the governance of nano S&T has been discussed. In Kenya, the media discourse on nano S&T is only beginning, as the country has not yet been involved much in developing nano S&T. However, there may already be some seeds of a risk discourse there. For the studies done earlier in the Global North, it can be said that the discourses vary considerably between countries there as well. This observed variability overall is an important point highlighting the significance of performing a number of country studies.

At the level of risk action analysis, in all the four countries included in the data for this paper, the most common risk action is *ignoring* risk, which, one the one hand, does not seem helpful in generating public discussion on nano S&T risks or in building consensus about the relevance of risk governance, and which, on the other hand, works against balanced reporting of complex issues such as nano S&T. Balance between proponents and opponents is something that journalists seem to have considered important when reporting for example, on climate change, so perhaps such balance would be called for also here between the benefits and risks of nano S&T. This balance is also missing from the discourses in the Global North, with the UK coming probably closest to achieving it.

Overall, nano S&T is seen as a mostly positive thing in all the countries studied to date in both the Global South and the Global North, with each country attaching somewhat different meanings to it. For example, in the small European countries, nano S&T is seen as a necessary vehicle for scientific and economic progress, in Hong Kong as a road to required economic restructuring, in South Africa, a solution to a number of serious problems facing the country, and finally in India, as a (one of the) means to lift the country to the group of economically and socially developed nations.

As regards the question on whether these risk discourses are rich enough to generate public debate, within or outside of a risk governance framework, South Africa would seem the most likely candidate for a public debate in the Global South.

Some words are added here about the ongoing dialogue about risk terminology among risk professionals. As van Asselt (2009) has noted, while it is useful to develop new terms, such as simple and complex risks, it is difficult to get rid of the older risk vocabulary of *assessing*,

managing, and *communicating* risk, or even a term such as *risk perception*, which carries some less helpful connotations about it being a term traditionally reserved for the public, rather than for experts. However, in relation to the concept of risk action, perhaps it is not necessary to replace the older terms with new ones,[89] but it could be useful to view them in a new light, with all possible risk actions next to each other (as in Figure 2.2 on p. 16). This would hopefully help to also see their similarities – for example, their link to values - and their differences – for example, the impact of value assessment on the choice of risk actions.

Regarding methodology in this paper, using a combination of qualitative and quantitative methods for evaluating risk discourses has been useful and interesting. Firstly, it has strengthened the analysis and made it possible to answer fairly different types of research questions.[90] Secondly, it strikes a balance between fairly dry quantitative descriptions, and rich, but not comparable qualitative descriptions of media discourses.

In terms of the exact methods used, this has been an experiment. Therefore in hindsight, some more theoretical consideration could be given to the concept of risk frame (e.g. between a prevalence of *ignoring* risk and the opportunistic risk frame), or to the quantification of complexity, on the one hand, and the relationship between complexity and a risk/benefit balanced discourse. With these points in mind, it would be interesting to apply similar methods to countries in the Global North, or to other complex, but crucial issues, such as climate change, which also involves (risk) actions from the whole society. Similarly, investigating further the issue of social construction of ignorance in the context of risks of emerging technologies would be interesting.

Te Kulve (2006) argues that media discourse can be seen as technology assessment. This may be so, but media discourse as potential technology assessment may actually have a dual meaning, as firstly, analyzing the discourse gives us some indication of how a technology is currently perceived (at least by some societal actors), and secondly, the discourse (if it is rich enough) can play a role in public engagement in further societal technology assessment.

In light of the above, the inclusion of a risk discourse assessment – for example, in terms of risk actions - into the risk governance of complex and uncertain issues such as nano S&T in any part of the world seems potentially useful, and this study has suggested a way to do this. In the Global South in particular, whatever the risk governance model for countries there might entail, context is no doubt important, and the existence or absence of a risk discourse is part of that context.

[89] As Renn and Walker (2008b) say: these components (assessment, communication etc.) of risk governance or management are "theoretically sound and empirically proven" (p. 354).
[90] The specific questions can be found in Section 1 on p. 6.

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Annex A

The distribution of newspaper articles over time

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009 (first q)	Total
South China Morning Post											
Relevant articles	0	3	4	3	11*	1	7	1	1	1	32
Less relevant articles	3	2	4	4	8	6	12	7	4	0	50
Total for SCMP	3	5	8	7	19	7	19	8	5	1	82
Star											
Relevant articles	N/A**	N/A	0	1	0	4	5	5	7	2	24
Less relevant articles	N/A	N/A	0	0	0	5	1	1	7	3	17
Total for Star	N/A	N/A	0	1	0	9	6	6	14	5	41
Daily Nation											
Relevant articles	0	0	0	0	0	0	0	1	4	0	5
Less relevant articles	0	0	0	0	0	1	1	1	2	0	5
Total for DN	0	0	0	0	0	1	1	2	6	0	10
Hindu											
Relevant articles in the main database	4	0	0	2	1	2	12	2	4	8	35
Relevant articles NOT in the main database***	0	11	0	0	12	43	24	31	44	1	166
Total number of relevant articles	4	11	0	2	13	45	36	33	48	9	201
Less relevant articles	0	0	0	6	9	42	57	61	64	20	259
Total for Hindu	4	11	0	8	22	87	93	94	112	29	460
Grand total	7	16	8	16	41	104	119	110	137	35	593

* Although there are 11 relevant articles in 2004, seven of these are in the same issue, and therefore, actually only 5 issues carried relevant articles in 2004.

** N/A (not available): The Star online archives start from 1 January 2002, so articles from 2000 and 2001 cannot be searched. Additionally, there may be up to ten more inaccessible articles from 2002 onwards. As they cannot be screened for relevance, they are not included in these numbers. It could be estimated that the missing, but probably relevant, articles would add about half a dozen articles to the dataset.

*** Even though these Hindu articles have not been analysed in detail due to their high number, some aspects of the analysis have been obtained from these articles, as the main database would not contain enough data for certain topics.

Annex B

Headlines of newspaper articles referenced in this paper

Newspaper and date*	Title of article
South China Morning Post (SCMP) Hong Kong	
SCMP051001	Shrink-wrapped and ready to go
SCMP171101	Beam up funds for research, urge nano experts
SCMP240802	ITF takes new road in call for nanotech projects
SCMP300604-1	Breakthroughs spell new dangers; Researchers believe the potential benefits are immense, but so are the social and environmental risks
SCMP300604-6	Toy sector looks; to gain from; coating process
SCMP300604-7	Samsung's Silver Nano products ensure a germ-free environment Household appliances are coated to kill bacteria and fungus, and prevent them from breeding
SCMP100705	Thinking small puts new spin on growth industry
SCMP260806	Thinking small puts scientist in big picture of nanotechnology
SCMP220109	Nano breakthrough to revolutionise waste water management
The Star (S) South Africa	
S280505	The nano-state is coming
S141108-1	Could these Engines of Creation devour Earth?
S141108-2	Is it time for a moratorium?
S160209	The science of the tiny is big news; From medicine to media, this will revolutionise our lives
The Daily Nation (DN) Kenya	
DN231208	There's real danger in untested technology
The Hindu (H) India	
H170403	Small is smarter**
H090904	Will nanotechnology go the GM way?**
H011104	Nanotechnology: small is big
H010205-1	All about nanotechnology**
H130206	The nanoworld of corrosion
H240906	Centre to set up nano-centre at JNCASR**
H141206	Is there such a thing as a 'harmless technology'?**
H180307	Other side of nanotech**
H270707	Kalam back to his first love: teaching
H050108	Medicine trying to make wide use of nanotechnology
H110109	'Future belongs to nano technology'**
H060309	Stress on tapping alternative energy sources**

* The publishing dates of the articles are visible in the codes, e.g. SCMP300604 was published on 30 June 2004. When the code includes, for example, '-1', this means that there have been several nano S&T articles in that particular issue (only some of which may be relevant for this analysis).

** These articles belong to the Hindu articles analysed in detail ('time sample' and 'risk sample')

Note: The articles were accessed through the following websites:

- South China Morning Post: http://proquest.umi.com
- Star: http://www.thestar.co.za
- Daily Nation: http://www.nation.co.ke
- Hindu: http://proquest.umi.com

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